

**GFELLER LINE CONCENTRATORS**  
**49-9-2, 49-11+1-2, 49-12-2**  
**DETAILED CIRCUIT OPERATION**

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**1. GENERAL**

1.01 This is one of a group of sections covering the Gfeller line concentrator. This section contains a detailed circuit description, sequence charts, operational sketches and reference material.

1.02 This section is reissued to include information on the Gfeller line concentrator models 49-11+1-2 and 49-12-2 and the title has been changed accordingly. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The basic equipment element used in the Gfeller line concentrator is a crossbar type switch. The function of this switch is to permit a circuit connected to any one of the 49

horizontal bars to be closed through to any one of the circuits connected to the vertical bars. There are two switches associated with each line concentrator, one in the central office unit and the other in the remote unit.

1.04 The Gfeller line concentrator enables 49 telephone lines, individual or multiparty, to be served by central office line equipment over nine cable pairs in the case of the 49-9-2, eleven cable pairs in the case of the 49-11+1-2 or twelve cable pairs in the case of the 49-12-2. These are the maximum capacities of the concentrators, but other combinations less than these can be utilized.

1.05 The remote unit is powered from the central office unit and two cable pairs are required for power feeding and circuit control functions. See Fig. 2 attached.

**2. SWITCH FUNCTIONS**

2.01 The switch at the remote unit has 49 horizontal bars for connecting to 49 customer lines. The switch at the central office unit has 50 horizontal bars, 49 of which can be connected to line equipments. The 50th bar provides a sleeve connection to battery for certain trunk selection circuit functions. There are vertical bars on each switch to which the trunks are connected.

2.02 Each horizontal bar has sets of wire contact fingers which are arranged so that a set is in line with each of the vertical bars. In the central office unit each set consists of three contact fingers: tip, ring, and sleeve. They are multiple wired at the rear of the horizontal bar, that is, each of the tips are wired together, as are the rings and sleeves. The remote unit is arranged in the same manner except that the sleeve connection is omitted. The horizontal bar

and its sets of two or three contact fingers is moved to the right whenever its associated coil T- is energized. See Fig. 3 attached.

**2.03** The vertical bar extends from the first to last horizontal bar and is aligned with the 49 or 50 sets of contact fingers (one set per bar). It is made of transparent plastic in which three metal contact strips, extending the length of the bar, are partially embedded. Each contact strip has 50 triangular projections cut out and bent to the left. These are called flag contacts. The flag contacts coincide with the horizontal bar and will engage the horizontal bar contact fingers after the circuit operations of moving the horizontal bar to the right and dropping the lifted vertical bar. The vertical bar is raised whenever its lift magnet is energized and falls when the magnet is de-energized. Fig. 4 attached, illustrates the switch, rear view, of the 49-9-2 concentrator and is indicative of all three models.

**2.04** When the vertical bar descends and makes contact with the particular set of contact fingers it will push the horizontal bar contact fingers still farther to the right due to the shape of the flag contacts. This action is shown in Fig. 5 attached, which shows the rear of one flag contact and its associated contact finger. This movement of the contact fingers will push the disconnect bar, which is part of the horizontal bar assembly, to the right operating the horizontal bar cutoff contacts TR-. This additional follow also assures a good contact between flag and finger.

**2.05** At the central office unit one pair of operated TR- contacts opens the circuit to the T- coil, which releases the horizontal bar and its unused sets of contact fingers. The other pair opens the path for operating the line relay TN-. At the remote unit both pairs of TR- contacts open the path for operating the line TN- relay from the customer's loop.

**2.06** The equipment is so arranged that circuit operations for controlling the switches cause the same numbered horizontal bar contact fingers and vertical bar flag contacts to be engaged at both units.

**2.07** There are also sets of contacts associated with each vertical bar. They are designated to correspond with their lift magnets.

These contacts remain open until the lift magnets are operated.

**2.08** In the central office unit the leads from the horizontal and vertical bars are wired to a terminal strip. In all models of the concentrators, tip, ring and sleeve of the 49 horizontal bars are wired to this strip. The vertical bar leads are wired to this strip as follows: 49-9-2, the tip and ring are connected, 49-11+1-2 and 49-12-2, the tip, ring and sleeve of the numbered bars are connected. They are then cabled from this terminal strip to a terminal strip on a distributing frame. This provides a flexible method of cross-connecting the horizontal bars to the assigned line equipments and the vertical bars to the assigned trunk cable pairs. The sleeve leads of the vertical bars of the 49-11+1-2 and 49-12-2 may be cross-connected as required for applique circuits. See Section 067-201-103.

**2.09** In the remote unit the tips and rings of the 49 horizontal bars and the vertical bars are wired to the lugs of a protector mounting within the unit. This provides protection against accidental contact of outside plant with foreign high voltages, lightning or sneak currents that might damage the concentrator equipment. They are then cabled from the protector mounting to an external cross-connection terminal that permits flexible connection with the distributing cable pairs.

### **3. SEQUENCE CHARTS AND OPERATIONAL SKETCHES**

**3.01** Sequence charts and operational sketches are included as an aid in understanding the circuit operation of the Gfeller line concentrator.

**3.02** Sequence charts, abbreviated SC, indicate the relative order in which various relay and switch functions occur. The action progresses from top to bottom on a chart. Where more than one action takes place as a result of a function, horizontal line or lines are used to indicate this. Slow release relays are designated SR. The symbol × is used to show a relay or a magnet operated and the symbol — for released.

**3.03** A sample section of a sequence chart with an explanation is shown on page 3.

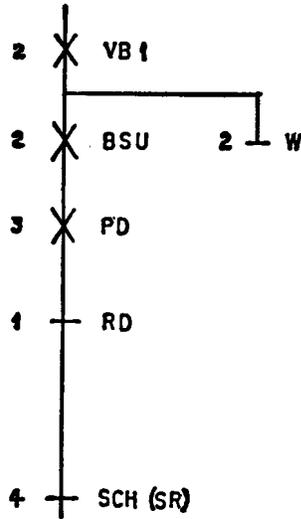


TABLE A

	OS SYMBOL	ATTACHED CONTACT DRAWING EQUIVALENT
RELAY WINDING		
SLOW RELEASE RELAY		
NORMAL CONTACTS		
OPERATED CONTACTS		
TRANSFER CONTACTS		
FIXED RESISTOR		
VARIABLE RESISTOR		
CAPACITOR		
METALLIC RECTIFIER		
TEST JACK		

This is interpreted as follows: The VB1 relay operates followed by the release of the W relay and the operation of the BSU relay. The operated BSU relay causes the operation of the PD relay, which in turn causes the release of the RD relay. The released RD relay causes the release of the SCH relay which is slow in releasing. Although contacts of the W relay are used later in the circuit, no attempt is made to indicate this by drawing a vertical line to these points since to do so would unnecessarily complicate the chart. The number to the left of a contact on SC charts refers to an OS drawing number where the designated relay may be found.

**3.04** Operational sketches, abbreviated OS, are simplified circuit representations that enable the reader to better understand circuit functions. The operating paths of relays and magnets are shown from battery to ground using *detached contacts* of relays, jacks, keys, and other apparatus. This arrangement makes a clear, concise drawing permitting particular functions to be isolated and considered individually. Shown in Table A are typical symbols used on the OS drawings. Adjacent to the symbols will be found the equivalent attached contact symbol.

**Note:** Relay contacts are individually numbered by groups and a group may consist of two contacts (make or break) or three contacts (transfer).

**3.05** Equipment troubles can usually be isolated by a combination of observing the equipment in operation and referring to the appropriate SC chart. The exact point of failure of a circuit may then be found by use of the OS drawings and the circuit description.

**4. INITIAL CIRCUIT OPERATION AND TRUNK PRESELECTION**

**4.01** Before the line concentrator is turned over for customer service a line-up procedure is followed. This includes various tests to assure reliable operation of the equipment. The line-up procedure is covered in Section 067-201-201. The following explanation presumes this line-up of the equipment has been completed and that the point of putting the units in service has been reached.

**4.02** Prior to making the equipment available for service calls all vertical bars must be loaded on the 50th horizontal bar at the central office unit. Loading as used in this section refers to the engaging of vertical bar flag contacts with horizontal bar contact fingers. It is accomplished electrically as explained under switch operation. Manual loading consists of manually moving a horizontal bar to the right to its operated position, and then in turn lifting and dropping a vertical bar. The horizontal bar is now released, leaving the flag contacts engaged with the contact fingers. To load all vertical bars on horizontal bar 50 manually necessitates holding horizontal bar 50 to the right until each of the vertical bars has been, in turn, raised and then dropped. This will provide battery on the sleeves of the vertical bars, simulating an idle sleeve indication. This is necessary for the functions of preselecting the vertical bars. After the vertical bars have each been used once to serve a call, the sleeve indication will be provided by the connected line equipments.

**4.03** The functioning of relays when power is applied and during the initial selection of vertical bar 1 is shown on SC1. An explanation of these functions will be found in the paragraphs that follow.

**4.04** The application of ac potential at the central office unit causes relays RA to RF to operate in both units. These two sets of RA to RF relays are part of the marking circuit and, when they are operated or released in identical combinations, will cause the operation of the same numbered vertical bar or horizontal bar in both units. Tables B and C, respectively, show the various combinations of RA to RF relays along with the control and lead cut-in relays used for the selection of particular vertical and horizontal bars.

**4.05** The principle of operation for these marking relays can be followed by referring to Fig. 1. This shows two of the six pairs of relays with their rectifier elements. The normal contacts of only four of the marking control relays are used in the figure. Actually more control relays are used in the circuit in order to control the required number of selections.

**4.06** The 115-volt alternating current from the commercial power supply is stepped down to 70 or 80V ac by a transformer whose secondary is grounded on one side. The remote end of the circuit is grounded so that circuit continuity is achieved using one metallic conductor and a common earth return. The amount of ac current

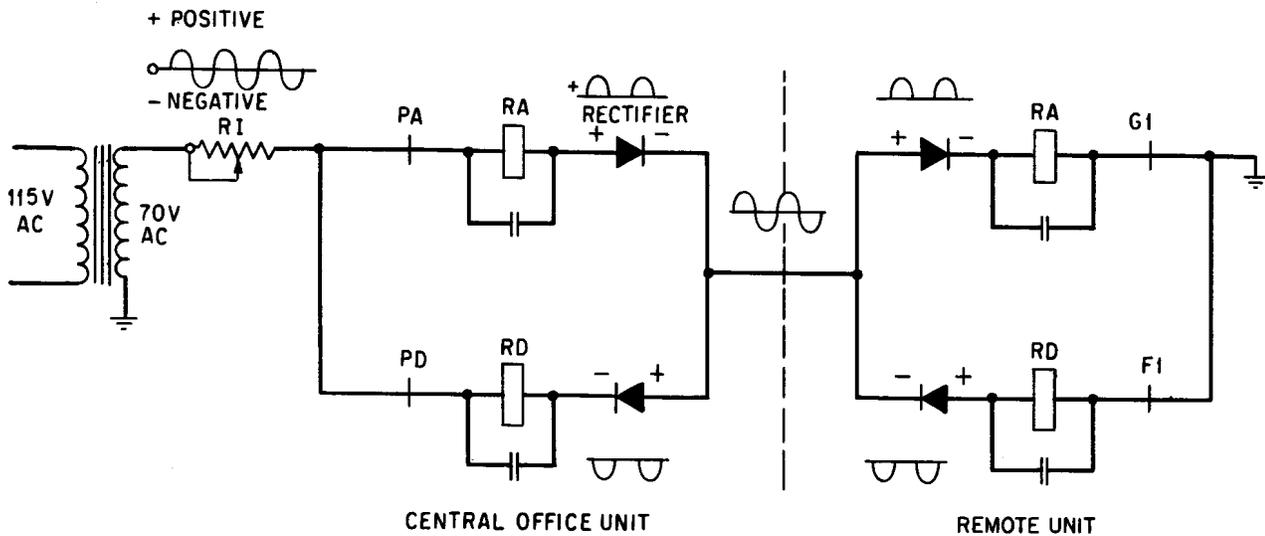


Fig. 1

applied to the circuit can be varied by adjustment of a variable resistor, RI.

**4.07** Alternating current has the characteristic of changing from a positive to a negative polarity during each cycle. The commercial power supply makes 60 complete cycles each second and several are shown graphically in Fig. 1. One cycle of ac can then be considered to contain one positive half cycle and one negative half cycle or in one second, 60 positive half cycles and 60 negative half cycles.

**4.08** Rectifiers or diodes have the property of presenting a very low resistance to a current of one polarity and a very high resistance to a current of the opposite polarity. Therefore, these diode (two-electrode) devices may be used in a circuit to pass one polarity of current while effectively blocking the opposite polarity. The manner in which the electrodes are connected in a circuit determines the polarity of current, positive or negative, that will be passed and inversely that which will be blocked.

**4.09** The rectifier symbol as designated in Fig. 1 shows the arrow side as positive. This conforms with the original theory that current flow was from positive to negative. Consequently the arrow of the rectifier symbol points in that direction. Although this is contrary to the present day electronic theory, that states electron flow is from negative to positive, it does not alter the circuit objective of discriminating between positive and negative current. Regardless of which theory is used the results achieved will be the same.

**4.10** The ac current applied through the RI resistor divides between the RA relay in series with its rectifier and the RD relay in series with its rectifier because the rectifiers are poled exactly opposite. The positive half cycles of current operate the RA relays and the negative half cycles of current operate the RD relays, one in the central office unit and one in the remote unit.

**4.11** If the above established circuits are now interrupted at either end by the operation of the PA or G1 relay no current will flow through the RA relays and both will be released. The negative half cycles of current will still keep

the RD relays operated. When the PA or G1 relay, depending on which was considered operated, is released, positive half cycles of current will flow, reoperating the RA relays in both units. This circuit arrangement is unique inasmuch as it provides control of two sets of relays, one set in the central office unit, the other at the remote unit over one cable conductor. The other pairs of relays, RB, RE and RC, RF with their rectifiers and cable conductors, function in the same way.

**4.12** The winding of each relay RA through RF is shunted by a capacitor whose purpose is to smooth out the half cycles of ac current, thus preventing armature chatter. The capacitors tend to make the relays somewhat slower in operating and slightly slower in releasing, due to the respective charging and discharging effect. This side effect, however, does not adversely affect the relays' circuit functions.

**4.13** The initial application of dc voltage to the central office unit causes various relay functions that lead to the selection and operation of the No. 1 vertical bar (trunk). At the point of dc voltage application, as shown on SC1, the following relays operate in the central office unit:

**49-9-2** serial nos. 2 to 447

AB, AB1, M, SCH, UB, W, and X

**49-9-2** serial nos. 448 and up

AB, M, SCH, UB, W, and X

**49-11+1-2**

AB, AB1, M, SCH, UB, V2, V3, W, and X

**49-12-2**

AB, M, SCH, UB, W, and X

The T50 magnet coil is also energized, operating horizontal bar 50. The operated AB relay, closes battery to control lead 4, operates the SCH relay and charges the 3500 MF capacitor in the remote unit, and operates the C relay in the central office unit.

**4.14** The circuit function of marking the vertical bar (trunk) 1 for selection proceeds with the M relay operating relay N. Relays M and W operate relay VB1, which closes a circuit from ground through the winding of the BSU relay through the previously loaded vertical bar 1

SECTION 067-201-102

TABLE B VERTICAL BAR (TRUNK) SELECTION RELAYS

TK NO.	MARKING CONTROL				LEAD CUT-IN			MARKING					
	PA	PB	PC	PD	RS1	RS2	RS3	RA	RB	RC	RD	RE	RF
1	-	-	-	x	-	x	x	x	x	x	-	x	x
2	-	-	x	-	x	-	-	x	x	-	x	x	x
3	x	-	-	x	-	x	x	-	x	x	-	x	x
4	x	-	x	-	x	-	-	-	x	-	x	x	x
5	-	x	-	x	-	x	x	x	-	x	-	x	x
6	-	x	x	-	x	-	-	x	-	-	x	x	x
7	x	x	-	x	-	x	x	-	-	x	-	x	x
8	x	x	x	-	x	-	-	-	-	-	x	x	x
9	-	-	x	x	-	x	x	x	x	-	-	x	x
10	x	-	x	x	-	x	x	-	x	-	-	x	x
11	-	x	x	x	-	x	x	x	-	-	-	x	x
12	x	x	x	x	-	x	x	-	-	-	-	x	x

Note: 49-9-2 uses trunks 1 to 9 only  
 49-11+1-2 uses trunks 1 to 11 only  
 49-12-2 uses all twelve trunks

TABLE C HORIZONTAL BAR (CUSTOMER) SELECTION RELAYS

LINE	MARKING CONTROL		MARKING						LEAD CUT-IN
	G-	F-	RA	RB	RC	RD	RE	RF	RT-
1	5	1	-	x	-	-	x	x	1
2	6	1	x	-	-	-	x	x	1
3	7	1	-	-	-	-	x	x	1
4	8	2	x	x	x	x	-	x	2-3
5	1	2	-	x	x	x	-	x	2-3
6	2	2	x	-	x	x	-	x	2-3
7	3	2	-	-	x	x	-	x	2-3
8	4	2	x	x	-	x	-	x	2-3
9	5	2	-	x	-	x	-	x	2-3
10	6	2	x	-	-	x	-	x	2-3
11	7	2	-	-	-	x	-	x	2-3
12	8	3	x	x	x	-	-	x	4-5
13	1	3	-	x	x	-	-	x	4-5
14	2	3	x	-	x	-	-	x	4-5
15	3	3	-	-	x	-	-	x	4-5
16	4	3	x	x	-	-	-	x	4-5
17	5	3	-	x	-	-	-	x	4-5
18	6	3	x	-	-	-	-	x	4-5
19	7	3	-	-	-	-	-	x	4-5
20	8	4	x	x	x	x	x	-	6-7
21	1	4	-	x	x	x	x	-	6-7
22	2	4	x	-	x	x	x	-	6-7
23	3	4	-	-	x	x	x	-	6-7
24	4	4	x	x	-	x	x	-	6-7
25	5	4	-	x	-	x	x	-	6-7
26	6	4	x	-	-	x	x	-	6-7
27	7	4	-	-	-	x	x	-	6-7
28	8	5	x	x	x	-	x	-	8-9
29	1	5	-	x	x	-	x	-	8-9
30	2	5	x	-	x	-	x	-	8-9
31	3	5	-	-	x	-	x	-	8-9
32	4	5	x	x	-	-	x	-	8-9
33	5	5	-	x	-	-	x	-	8-9
34	6	5	x	-	-	-	x	-	8-9
35	7	5	-	-	-	-	x	-	8-9
36	8	6	x	x	x	x	-	-	10-11
37	1	6	-	x	x	x	-	-	10-11
38	2	6	x	-	x	x	-	-	10-11
39	3	6	-	-	x	x	-	-	10-11
40	4	6	x	x	-	x	-	-	10-11
41	5	6	-	x	-	x	-	-	10-11
42	6	6	x	-	-	x	-	-	10-11
43	7	6	-	-	-	x	-	-	10-11
44	8	7	x	x	x	-	-	-	12-13
45	1	7	-	x	x	-	-	-	12-13
46	2	7	x	-	x	-	-	-	12-13
47	3	7	-	-	x	-	-	-	12-13
48	4	7	x	x	-	-	-	-	12-13
49	5	7	-	x	-	-	-	-	12-13
AK	6	7	x	-	-	-	-	-	12-13

sleeve flag contact and horizontal bar 50 sleeve contact finger to 600-ohm battery through the AK key normal. Relay VB1 operated also releases relay W.

#### 49-9-2 and 49-12-2

The operation of relay BSU operates relay PD, one of the four marking control relays used for vertical bar selections. The PD relay opens the path for the negative half cycles of current to the RD relays, releasing them in both units. Continued at 4.15.

#### 49-11+1-2

The operation of the V2 relay (4.13) opens the path for the negative half cycles of current to the RF relay to the remote unit and transfers the current through R17 to ground. The release of the RF relay in the remote unit releases the SCH. This prevents any operation from an originating call interfering with the operation of the central office unit until a vertical can be preselected. The operation of relay X, (4.13) operates relay V. Although relay X releases almost immediately due to the operation of relay UB, the V relay is held operated from ground, through normal D relay contacts, operated C relay contact, operated contacts of the V2, BSU, V2 relays, released K, operated SCH through the winding of the V relay to battery. The V relay operates the V1 relay and the operation of the V1 relay, releases relay V2. The release of relay V2, closes the path for the negative half cycles of current to the RF relay in the remote unit reoperating the RF relay. The RF relay operates the SCH. Relay V2 released, opens the ground for relay V and prepares an operate path for relay PD. The time interval for the operation of the PD relay is determined by the slow release of relay V. With the release of relay V, relay PD operates, slow release relay V1 starts to release but relay PD establishes a locking path so that relay V1 will not release. The release of the V2 relay also operates relay V3. The operation of relay PD opens the path for the negative half cycles of current to the RD relays, releasing them in both units.

**4.15** The release of relay RD, at the central office end of the marking circuit, releases relay SCH which in turn operates relay PIRS, RS2 and RS3. The RS2 and RS3 relays cut

through the odd-numbered leads from the 56-ohm windings of all odd-numbered S-lift magnets to the contacts of the RA relay. The combination of RA, RB, and RC relays operated closes through battery operating lift magnet S1 to ground on the operated PIRS relay. Relay PIRS also operates relay KO. Relay KO prevents false operation of relay A2 until the vertical has been operated and checked.

**4.16** The release of relay RD, at the remote end of the marking circuit, releases its SCH relay which in turn operates relays PIRS, RS2, and RS3. The RS2 and RS3 relays cut through the windings of all the odd-numbered S-1 magnets in the remote unit. The combination of RA, RB, and RC relays operated close through battery to operate lift magnet S1 via the operated PIRS relay to ground on the normal contacts of the A relay.

**4.17** The vertical bar (trunk) 1 is now lifted at both units. No. 3 contact of the S1 lift magnet in the remote unit closes through a path to operate relay ABS from battery through R2 resistance, normal SCH, operated No. 3 contacts of S1 lift magnet, through the winding of relay ABS, operated PIRS to normal A relay contacts to ground. On models of the 49-9-2 with serial nos. 2 to 234 and 270 to 331, the remote unit was not equipped with an ABS relay. The function of the ABS relay is to remove battery to the line TN- relays until a vertical bar has been lifted, checked and ready to serve an originating call.

**4.18** The operation of these connector bars is now checked in both units as follows. The A1 relay in the central office unit is operated through the operated contact of lift magnet S1, the S1 magnet 300-ohm winding to ground through the operated M relay contacts and normal contacts of the A2 relay. This provides a supplementary path to hold this lift magnet operated. Battery through the winding of the A relay in the central office unit is closed through R14 resistance, test jack MC5, operated C relay to the S1 contacts.

**4.19 49-9-2:** The path continues through No. 2 contacts of the S1 lift magnet to the ring side of the cable pair associated with the No. 1 vertical bar to the remote unit. The path con-

tinues through the No. 2 operated contacts of the S1 lift magnet, the S1 magnet 300-ohm winding to ground through the A relay winding, thus operating the A relay in each unit.

**4.20 49-11+1-2 and 49-12-2:** The path continues through the No. 1 contacts of the S1 lift magnet to the tip side of the cable pair associated with the No. 1 vertical bar to the remote unit. The path continues through the No. 1 operated contacts of the S1 lift magnet, the S1 magnet 300-ohm winding to ground through the A relay winding, thus operating the A relay in each unit.

**4.21 All models:** The operating path just described also provides a holding path for the S1 magnet in the remote unit. The central office lift magnet S1, is provided with a second holding path to ground through the operated contacts of the A relay in that unit. The two lift magnets have now been checked operated.

**4.22** The remote unit A relay opens the path to the 56-ohm operating winding of the S1 lift magnet and releases cut-in relays RS2 and RS3, and relays PIRS and ABS.

**4.23** The central office unit A1 relay operates relay V which releases the marking control relay PD, re-establishing the negative half cycles of current to the RD relays, reoperating them. Relay V, in the 49-9-2 model with serial numbers 448 and up, all 49-12-2 models, operates relay V1. Relay V1 on the above models, operates relay AB1. The RD relays operate their respective SCH relays. The A1 relay also provides a path to hold the UB relay, which is one of the trouble detecting features of the line concentrators. It will be covered in detail later under trouble detecting features.

**4.24** The release of the PD relay in the central office unit also releases the PIRS, M, and cut-in relays RS2 and RS3. Relay M released, operates relay VB2, part of the vertical bar walking circuit. The VB2 relay operated release VB1 and allows the BSG relay to operate to 600-ohm battery on the sleeve of connector bar 2. This vertical bar will be used on the second call that is handled by the concentrator.

**4.25** The released PIRS relay in the central office unit releases relay KO which, with relay SCH, operates relay A2. A2 operates relay U. The U relay operated closes through battery to the winding of the U1 (originating call) relay which is connected through the operated contacts of the S1 magnet to the trunk number 1. On the 49-9-2 models the path just mentioned is connected to the tip conductor of the trunk. On the 49-11+1-2 and 49-12-2 models, the connection is to the ring conductor of the trunk. The remote unit is now in a condition to serve an originating call. The operation of the A1 relay in 4.18 closed through the path for operating the K (terminating call) relay which permits a terminating call to be served.

## 5. ORIGINATING CALL

**5.01** SC2 assumes a call being made by a customer connected to horizontal bar 2 and assumes vertical bar (trunk) 1 has been pre-selected and operated as shown on SC1. The relays found operated in both units as this call begins are designated at the top of SC2.

**5.02** The station short operates horizontal bar relay TN2 in the remote unit. This closes a circuit from ground through normal contact 2 of the G1- G5 relays, the winding of relay G6, contact 1 of relay TN2, resistor RTN-2, through both windings of relay F1, through normal contact 1 of F2 through F7, MC4 test point to the S1 lift magnet operated contacts.

**5.03 49-9-2:** The path continues through contact 1 of the S1 lift magnet, over the tip cable conductor of trunk 1, through contact 1 of the S1 lift magnet in the central office unit.

**5.04 49-11+1-2 and 49-12-2:** The path continues through contact 2 of the S1 lift, over the ring cable conductor of trunk 1, through contact 2 of the S1 lift magnet in the central office unit.

**5.05 All models:** The circuit from the S1 lift magnet contacts continues through the 1-2 winding of relay U1, through variable resistor R-12, operated contact 1 of relay U, test point MC4, operated contact 2 of relay AB1, operated contact 5 of relay A2, through resistor R4 to battery.

**5.06** Due to the combined circuit resistance, only relay U1 operates. The U1 relay locks to its 3-4 winding. The 1-2 winding is short-circuited by its operated contact 3. This decreases the circuit resistance by 3200 ohms which increases the current flow in the circuit, allowing relay F1 to operate. The F1 relay short-circuits its 3-4 winding by contact 1 thereby further increasing the current flow permitting relay G6 to operate.

**5.07** The G6 and F1 marking control relays operated in the remote unit now function to condition the two sets of marking relays RA to RF. Relay F1 opens the circuit for the negative half cycles of ac current to the RD relays and they release. The G6 relay opens the positive half cycles for the RB and RC relays and they release. The released RB, RC, and RD relays release the SCH relays in their respective units. The SCH relays released, close battery through the windings of the PIRT and RT1 relays in series to ground through the normal contacts of relay RD and operated contacts of relays RE and RF in their respective units. The RT- relays close through the leads from the horizontal bar magnets T1 to T49 in each unit. The RT1 relay closes through the leads for magnets T1, T2, and T3. Only T2 magnet will be operated at each unit, however, due to the combination of RA operated and RB, RC relays released. The PIRT relay in the central office unit operates the KO and KO1 relays. The KO, KO1, and PIRT relays open the operating path of all RA to RF marking relays, preventing, in this case, the possible reoperation of relays RB, RC, and RD until this call is established. The operated RA, RE, and RF relays are locked through their own contacts.

**5.08** At the remote unit magnet, T2 is operated through contacts of the operated RA, normal RB and RC relays, operated PIRT relay to ground through the winding of the D relay. This operates relay D which in turn locks on its 3-4 winding under control of the operated contacts of the S1 lift magnet. The D relay removes the battery supply from all TN- relays, releasing TN2 and any other TN- relay that might be operated on a call waiting to be served basis. The released TN2 relay releases the marking

control relays F1 and G6. The marking relays RB, RC, and RD remain released due to operated relays PIRT, KO, and KO1.

**5.09** At the central office unit, magnet T2 is operated through contacts of the operated RA, normal RB and RC relay contacts, operated relay KO1 contacts to ground through the winding of relay D. Relay D operates and in turn releases magnet T50 and relay C. Relay KO1 operated releases relay AB1 which in turn releases relay U1. The T50 magnet releasing restores horizontal bar 50. This will prevent the sleeve of bar 50 from becoming engaged when the vertical bar is dropped.

**5.10** Relay C released opens the circuit to relay A1 and lift magnet S1 in the central office unit, releasing relay A1 and lift magnet S1. The released lift magnet drops vertical bar 1 which engages the contact fingers of operated horizontal bar 2. The mechanical movement resulting from the flag contacts engaging the contact fingers moves disconnect bar 2 opening the cutoff contacts TR2. The contacts TR2 open the path for operating relay TN2. This prevents a false operation of relay TN2 when the sleeve becomes grounded by the central office line equipment. The other set of TR2 cutoff contacts opens the circuit for the T2 magnet and relay D in series, releasing them.

**5.11** Relay C released also opens the circuit for the remote unit S1 lift magnet and the A relay in both units, releasing them. The S1 lift magnet releasing drops vertical bar 1 which engages the contact fingers of operated horizontal bar 2. This causes disconnect bar 2 to operate opening its two sets of cutoff contacts TR2, which removes the TN2 relay winding from the ring side of the station loop and the ground from the tip side.

**5.12** The customer station is now closed through the remote unit switch over trunk 1 through the central office unit switch to the line equipment, which now functions in the regular manner. The line concentrator proceeds with recycle functions, as discussed below, that lead to preselecting the vertical bar (trunk) to be used on the next call.

**5.13** At the remote unit, the released vertical bar S1 contacts open the circuit for relay RT1 which in turn releases horizontal bar magnet T2. The S1 contacts opened also open the circuit to slow release relay D.

**5.14** At the central office unit the released D relay reoperates relay C and magnet T50. It also opens the circuit to lead cut-in relay RT1 and slow release relay PIRT, releasing them. The released PIRT relay releases relays KO and KO1. These three relays released close through the ac current to marking relays RB, RC, and RD, respectively, reoperating them. Released relay KO1 also operates relay AB1.

**5.15** All the marking relays RA to RF operated in both units operate their respective SCH relay. The SCH relay operated in the remote unit releases relay PIRT in that unit. At the central office unit the operated SCH relay releases the slow release A2 relay. Released relay A2 releases relay U.

**5.16** When the A1 relay in the central office unit releases it starts the release of the V relay by removing ground from its windings. The V relay is slow in releasing due to an RC network which consists of an R3 resistor, V capacitor and its three windings. The release time varies directly with the product of total resistance times capacitance. This RC network maintains a current flow through the V relay windings while the V capacitor is discharging. The release time can be decreased by strapping out one or two windings. This slow releasing of the V relay allows time to recharge the 3500 MF capacitor when the battery is reconnected by the released D relay. The V relay released closes the circuit to the marking control relays PA to PD.

**5.17** *49-9-2 and 49-12-2:* Relay V also releases slow release relay V1. On models of the 49-9-2 with serial nos. 2 to 447, the line concentrator was not equipped with a V1 relay.

**5.18** *49-11+1-2:* Relay V also starts to release relay V1 but the operation of relay PC, as explained below, prevents V1 from releasing. Relay PC locks relay V1 through its No. 5 contact.

**5.19** The function of preselecting a vertical bar, in this case bar 2, proceeds. The vertical bar walking circuit which controls the selection of vertical bars on a rotational basis had been partially conditioned after vertical bar 1 had been operated. As shown on SC1, the VB2 and BSG relays operated indicate that VB2 was the next vertical bar to be selected and that it is idle. With relays V and D released and relay C operated, ground is closed through the operated BSG relay to battery through the winding of relay PC. Relay PC operates and opens the circuit for marking relays RC and they release. The RC relays released open the circuit for their respective SCH relays. The released SCH relays operate their PIRS and RS1 relays, closing through lift magnet leads 2, 4, 6, 8. The S2 lift magnets will be operated due to the RA to RF and RS1 relay operated and released combination.

**5.20** *49-9-2:* At the central office unit, the operated contacts of the S2 lift magnet closes a path from the A relay winding over the ring side of the trunk to the remote unit through its operated contacts S2, the 300-ohm winding of lift magnet S2 to the winding of the A relay.

**5.21** *49-11+1-2 and 49-12-2:* At the central office unit, the operated contacts of the S2 lift magnet closes a path from the A relay over the tip side of the trunk to the remote unit through its operated contacts S2, the 300-ohm winding of lift magnet S2 to the winding of the A relay.

**5.22** Both A relays operate, thus checking that the same numbered lift magnets have operated at each end. The vertical bar 2 operating opens its sleeve circuit, releasing relay BSG.

**5.23** At the remote unit, the S2 lift magnet contact 3 closes through a path to operate relay ABS. Relay A releases the PIRS, RS1, and ABS relays. At the central office unit, relay A operates as does the A1 relay from the S2 lift magnet contacts. Relay A1 operates the V relay. Relay V operated, releases marking control relay PC which closes the circuit for marking relay RC in both units and they reoperate. Relay V also operates relay V1 in the 49-9-2 and 49-12-2 units. Released relay PC also releases relay RS1

and slow release relay PIRS. The RC relay operated in each unit operates its SCH relay. The PIRS relay releasing, releases relay KO and the combination of operated relay SCH and released relay KO operates relay A2 which in turn operates relay U, closing through the winding of relay U1 to the trunk conductor of trunk 2. The remote unit can now serve the next originating call.

**5.24** The connection established on this call will remain closed through the switches after the customer station and line equipment restores to normal at time of disconnect. The connection will be released only when this vertical bar is next operated during the rotational selection of trunks as explained below. Until that time the customer will be connected through to the central office equipment.

**5.25** When relay PC released, it started the release of slow release relay N of the walking circuit. Relay N released operates relay M which operates relay VB3 and reoperates relay N. VB3 relay operated releases relay VB2 and closes a circuit to operate relay BSU. The BSU relay, in this instance, operates from battery on the sleeve of horizontal bar 50.

**5.26** *Walking Circuit:* The walking circuit, as mentioned above, consists of relays M, N, W, BSU, BSG, and VB- numbered relays in each central office unit. They function to rotate the selection of vertical bars (trunks) and to check their sleeves for an idle or busy condition, passing over any that indicate busy (ground on the sleeve).

**5.27** M and N are slow release relays that function together to alternately operate the odd and even VB- relays. One of the odd VB- relays will be operated with relay M operated and one of the even VB- relays with relay M normal. Relays BSU and BSG are connected through to the odd and even vertical bar sleeves respectively. If the vertical bar is idle (battery on sleeve) relay BSU or BSG will operate. Relay BSU or BSG operated stops the walking circuit with a VB- relay operated. The VB- relay operated will be used during the recycle function which occurs after the next call is served. If a vertical bar that tested idle to the walking circuit becomes busy because of a previously estab-

lished connection (see 5.24) during the interval before it is operated, application of ground over the sleeve will release BSU or BSG. This will advance the walking circuit until the next idle vertical bar is found, as indicated by battery on the sleeve to operate and hold relay BSU or BSG.

**5.28** *49-9-2:* After the walking circuit has advanced and operated the VB9 relay, the next release of relay M will release VB9 which in turn allows relay W to operate through contacts of all VB- relays normal. Relay W closes the circuit to operate relay VB1. This will start the whole sequence of rotation over again at relay VB1 when relay M reoperates.

**5.29** *49-11+1-2:* After the walking circuit has advanced and operated the VB11 relay, the next release of relay M will operate relay W through operated contact 2 of relay VB11. The operation of relay W opens the lock path of VB11 and VB11 releases. Relay W also closes a path to operate relay VB1. This will start the whole sequence of rotation over again at relay VB1 when relay M reoperates.

**5.30** *49-12-2:* After the walking circuit has advanced and operated the VB12 relay, the next operation of relay M will close a path to operate relay VB1 through contact 2 of relay VB12. VB1 operated releases VB12 by opening VB12 relay lock path with its No. 2 contact. This will start the whole sequence over again at relay VB1.

**5.31** If all trunks are busy, the circuit will continue to walk until a trunk becomes idle (BSU or BSG operated).

**5.32** Sequence Chart 3, for the walking circuit, continues from a point on SC2 immediately following the V relay operated. It shows the relay functions that result when the next preferred vertical bars are busy with established service calls. The chart assumes vertical bars 3 and 4 are in this condition and that No. 5 is idle.

**5.33** The release of marking control relay PC, due to the V relay operating, removes ground from slow release relay N. Relay N released operates relay M which in turn operates relay VB3 and relay N. Relay N removes ground

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from slow release relay M. Relay VB3 closes its vertical bar sleeve to the winding of relay BSU and releases relay VB2. In this case, the sleeve of vertical bar 3 is grounded due to the busy condition and BSU remains nonoperated. Relay BSU not operating to provide a holding circuit for relay M, allows M to release.

**5.34** When relay M releases it operates relay VB4 which in turn releases relay VB3. Relay M released, removed ground from slow release relay N starting its release. Relay VB4 closes its vertical bar sleeve to the winding of relay BSG. Due to the sleeve being grounded from the busy condition, relay BSG remains nonoperated. Relay BSG not operating to hold relay N, causes its release. Relay N released reoperates relay M.

**5.35** Operated relay M operates relay VB5 and relay N. Relay VB5 closes its vertical bar sleeve to relay BSU which will operate to battery on the sleeve (idle condition). Relay BSU operates and holds relay M and the walking action ceases.

### 6. TERMINATING CALL

**6.01** SC4 assumes a call being terminated over trunk 2 to a customer whose telephone is connected to horizontal bar 1. It also assumes that the central office line equipment provides a ground on the sleeve when it is activated or if not, that an applique circuit provides this ground.

**6.02** When the central office line equipment is activated, prior to signaling the associated customer station, a ground is placed on the sleeve of horizontal bar 1. This operates relay TN1 from battery through its winding to the grounded sleeve. Relay TN1 operated, operates relay K from battery through resistor R4, operated contacts of relay AB1, winding of relay K, operated contacts of relay A1, normal K relay contacts, through both windings of relay F1, operated TN1 relay contacts, winding of relay G5, normal contacts of relays G4, G3, G2, and G1 to ground.

**6.03** Due to the total resistance of the circuit, relays G5 and F1 do not operate. Relay K locks to its operated No. 1 make-before-break

contact. The K relay operated releases relay U which in turn removes battery from the U1 relay 1-2 winding which is connected to the tip side of trunk 2 on model 49-9-2, or the ring side of trunk 2 on models 49-11 + 1-2 and 49-12-2, through contacts of magnet S2.

**6.04** Relay K in operating also opens the path for slow release relay AB1. The release of relay AB1 releases relays K, F1, and G5. Relay K released reoperates relay U.

**6.05** Relay U1 normally operates to ground at the remote unit on an originating call. Consequently any originating call will be locked out at the point of operating relay U1. The originating call would wait with a TN- relay operated until circuit functions, on the terminating call, progress and operate relay D in the remote unit. Relay D removes battery from all TN-relay windings. The average over-all time for completing a call is within two seconds, so that any consequent delay is negligible.

**6.06** The released relay U closes battery from the R4 resistor through contacts of operated relay A2, and relay AB1, normal contacts of relay U, contacts of operated relay K, through resistor R11 and the F1 and G5 relay windings. This lower resistance path for the circuit allows relay F1 to operate. Relay F1 operating short-circuits its 4300-ohm winding, causing an increase of current which operates relay G5.

**6.07** Relay F1 operated releases marking relays RD. Relay G5 operated releases the RA and RC marking relays. The released marking relays release relay SCH in each unit. Relays SCH released operate their respective RT1 cut-in relays and PIRT relays.

**6.08** In the remote unit the RT1 and PIRT relays operated close a path from magnet T1 through the operated and released combination of marking relays RA to RC and the D relay winding to ground at resistor R4. Magnet T1 and relay D operate. Relay D operated removes battery from the 3500 MF capacitor.

**6.09** At the central office unit relay PIRT operated, operates relays KO1 and KO. Relays KO1, RA to RC, and RT1 operate horizontal magnet T1 and relay D in series. Relay D oper-

ated releases relay C and horizontal bar 50. Relay C released, releases relay A1 which in turn starts the release of relay V.

**6.10** Released relay C, in the same manner as in 5.10, also releases the S2 lift magnets and relays A and A1. The dropped vertical bar in each unit moves the disconnect bar 1 opening its TR contacts. This action releases relay TN1 at the central office unit and the remote unit removes relay TN1 and ground from the ring and tip to the customer loop. The released S2 magnet contacts in the remote unit, also releases relays RT1, PIRT, D, and magnet T.

**6.11** At the central office unit relay D released reoperates magnet T50 and relay C and releases relays RT1 and PIRT. Relay PIRT released reoperates the RC marking relays and releases relays KO and KO1. Relay KO released reoperates marking relays RA and RB and relay KO1 released reoperates marking relays RD and AB1.

**6.12** The reoperated marking relays reoperate relay SCH in their respective units. Relay SCH reoperated in the remote unit releases relay PIRT. At the central office unit, relay SCH reoperated releases relay A2 which in turn releases relay U.

**6.13** When the slow release relay V releases, it operates marking control relays PA and PD, which in turn release marking relays RA and RD in both units. The RA and RD relays released, release relay SCH in their respective units, which in turn operate their PIRS, RS2, and RS3 cut-in relays. These relays operated, in combination with the marking relays operated and released, operate lift magnet S3 in each unit. This establishes vertical bar 3 for use on the next call. Relay PIRS at the central office unit reoperates relay KO.

**6.14** The vertical bar (trunk) 3 operated, through contacts of S3, operates relay ABS in the remote unit. On models of the 49-9-2 with serial numbers 2 to 234 and 270 to 331, the remote unit was not equipped with an ABS relay. Contact 3 of lift magnet S3, in the central office unit, operates relay A1. Contacts of S3 also operate the check relays A in both units. The A relay in the remote unit, releases

relays ABS, PIRS, RS2 and RS3. The A relay in the central office unit locks the A1 relay operated. The A1 relay operates relay V. Relay V operated, releases relays PA and PD, and operates relay V1 on model 49-9-2 with serial numbers 448 and up.

**6.15** Relay PD released reoperates marking relay RD and releases relays PIRS, RS2, RS3, and M. Relay PIRS released, releases relay KO which in turn reoperates marking relays RA. Relay RD operated in the remote unit operates its SCH relay. Relay RA operated in the central office unit operates its SCH relay which in turn operates relay A2. Relay A2 operated, operates relay U.

**6.16** Relay M released functions the walking circuit, causing relay VB4 to be operated. Relay VB4 operated releases relay VB3. Relay VB4 operated extends its vertical bar sleeve to relay BSG which operates in this case to the No. 50 bar sleeve battery.

## 7. TROUBLE DETECTING AND TEST FEATURES

**7.01 *AB Relay Timing for Horizontal Bar Magnet Operation:*** The slow release AB relay is used to check the function of operating a horizontal bar magnet in the central office unit. As shown on SC5, relay functions start from a point on SC4 (terminating call) immediately following the operation of relay PIRT in the central office unit and assumes relay D does not operate. Relay D not operating allows relay AB to release.

**7.02** Relay AB released opens the battery supply to the magnets and relays in the remote unit. This causes the T- magnet and any operated relays to release. Relay AB released also releases relay C in the central office unit. Relay C released, releases the preselected S- magnet in both units, and operates T50 magnet. At the remote unit, no switch connections will be established when the vertical bar drops due to the prior release of the T- magnet. At the central office unit, however, a sleeve connection will be established to bar 50. Relay C also releases relays A and A1. Relay A1 releasing, releases relays PIRT and RT1. Relay PIRT released, operates relay AB which recloses the battery supply to the remote unit over control lead 4.

Relay PIRT also closes through the path to reoperate marking relay RC in both units. Relay PIRT also releases relays KO and KO1 which in turn reoperates the marking relays RA and RD in both units. Relay KO1 released, operates relay AB1. Relay SCH reoperates through operated marking relays RA to RF in each unit. The reoperation of relay SCH releases relay A2 which in turn releases relay U. As mentioned above, the AB relay reoperated will operate relay C.

**7.03** The recycle function of selecting the next vertical bar now takes place and can be followed on SC4 starting at the released V relay and proceeding to relay A2 operated. Relay A2 operated permits the F- and G- marking control relays to be operated and a second attempt can be made to complete this call.

**7.04** The circuit action, due to the released AB relay, takes place any time relay D does not operate in series with the T- magnet of the central office unit. In the case of an originating call that fails in this manner, similar functions will take place which lead to a recycle operation and operation of the next idle vertical bar. All subsequent attempts to complete a call, whether originating or terminating, must compete in the F- and G- relay preference chain circuits with other demands for service.

**7.05** *AB1 Relay Timing for Marking Relay Lock-in:* At the central office unit slow release relay AB1 starts to release when relay K operates for a terminating call or relay U1 operates for an originating call. When relay AB1 releases, it in turn releases relay K or U1. If, at the time relay K or U1 releases, relay KO1 has not operated, relay AB1 will be reoperated. Relays KO1 and KO are operated when relay PIRT operates and these three relays operated open the operating paths for the marking relays RA to RF. The RA to RF relays that were operated prior to this remain locked, while any that were released are prevented from being falsely reoperated on this call.

**7.06** The operation of relay KO1 can therefore be considered the point of marking relay lock-in. Relay AB1 reoperates when relay KO1 remains unoperated due to some circuit malfunction. This in turn allows relay K or relay U1 to

reoperate and the call will start over again from this point.

**7.07** SC6 picks up from a point on SC4 immediately below relay PIRT operated. When relay AB1 releases, it in turn releases relay K and relays G5 and F1. Relays G5 and F1 reoperate relays RA and RD, which in turn operate relay SCH in their respective units. Relays SCH operated release their associated PIRT and RT1 relays.

**7.08** Relays K and KO1 released reoperates relays U and AB1. Operated relay AB1 in turn reoperates relay K. The functions can now be followed on SC4 at a point immediately below relay K operated and continues in the same manner as for the first attempt. This failure occurring on an originating call would result in a similar action with relay U1 substituted for relay K.

**7.09** *UB Relay Timing for Vertical Bar Operation:* The UB relay is normally operated at all times. When relay PIRS operates for vertical bar operation, as shown on SC1, it opens the circuit for relay UB and it starts to release. However, the UB relay 3-4 winding is shunted by a resistor-capacitor combination which delays its release. When the lift magnet S-, associated with the selected vertical bar, is operated, its operated contacts close through a path to operate relay A1. Relay A1 operates and in turn provides a circuit to hold relay UB. Thus relay UB not releasing is indicative of successful vertical bar operation.

**7.10** We will assume that relay A1 does not operate due to a nonoperated lift magnet or other circuit fault and that relay UB releases as shown on SC1. Relay UB released operates relay X. SC7 shows the resulting relay action and the walking circuit progress that leads to the selection and operation of the next idle vertical bar. In this case vertical bar 2 is next preferred and is idle.

**7.11** Relay X operated, operates relay V and on serial numbers 2 to 4 of the 49-9-2 it also operates relay UB. Relay V operated, releases marking control relay PD and relay V1 on 49-9-2 models with schematic S10460-4. Relay PD released, reoperates marking relay RD and

relay SCH in both units, releases relays RS2, RS3, PIRS in both units and relay M in the central office unit. Relay PIRS released, releases relay KO. In 49-9-2 serial nos. 2 to 4 only, relay M released, releases relay X and operates relay VB2. In all other models and serial nos., relay PIRS released, operates relay UB which in turn releases relay X. Relay M released, operates relay VB2.

**7.12** Relay VB2 operated, releases relay VB1 which in turn releases relay BSU. Relay VB2 operated, closes the sleeve of vertical bar 2 to the winding of relay BSG and it operates to the 600-ohm battery on the sleeve of bar 50.

**7.13** Relay X released, releases relay V which in turn operates relay PC and releases relay V1 on schematic S10460-4. Relay PC operated, releases marking relay RC in each unit, which in turn releases its associated relay SCH. Relays SCH released in each unit reoperate relays PIRS and RS1, which in turn close through the S2 lift magnet lead and magnet S2 operates. The circuit action can now be followed on SC2 from a point immediately following lift magnet S2 operated.

**7.14** *AK (DISENGAGEMENT) Test Key:*  
Test key AK provides a mean of testing vertical bar operation by loading them on bar 50 in the central office unit. Any vertical bars that are idle will be closed to bar 50 in the following manner when key AK is depressed.

**7.15** Holding key AK operated in the central office unit will close through a path to operate relays K, G6, and F7 in the same manner as on a terminating call. The relay functions are similar to a terminating call except relay D does not operate. This allows magnet T50 to remain operated until the vertical bar is dropped. This circuit action will be repeated until all idle vertical bars that had been engaged with horizontal bars are loaded on bar 50. The walking circuit will continue to step as long as key AK is operated, even though all idle connector bars become loaded. The walking circuit action, however, will not disturb the vertical bars loaded on bar 50 because the 600-ohm sleeve battery for bar 50 is opened at the operated contacts of the AK key.

**7.16** Any vertical bar that is idle and does not load on bar 50 may have become unloaded, that is, not connected to a horizontal bar. This condition puts the associated trunk out of service until the vertical bar is manually loaded on bar 50.

**7.17** At the remote unit the circuit action resulting from the central office unit AK key operated, causes the associated numbered vertical bars to become unloaded.

**7.18** Holding key AK operated in the remote unit will close through a path to operate the associated G6 and F7 relays over the tip side of a trunk through the winding of relay U1 in the same manner as on an originating call. The relay functions are similar to an originating call except that no horizontal bar magnet will be energized in the remote unit and bar T50 will be operated in the central office unit. When the vertical bars are dropped they will be unloaded in the remote unit and loaded on bar 50 in the central office unit.

**7.19** The operation of either of the AK keys will affect service calls because of their position in the F- and G- relay chains. In addition the ATB register, if provided, will tabulate as the battery supply to horizontal 50 is removed by the operation of this key giving the appearance that all trunks are busy.

## **8. ALL-TRUNKS-BUSY FEATURE — 49-11+1-2**

**8.01** This model of the Gfeller line concentrator has a feature that enables the central office unit to return overflow tone to a terminating call in the event that all eleven trunks are busy. This tone is connected to the terminating call by the operation of the vertical bar designated BES located on the cross-bar switch in the central office unit.

**8.02** Upon completion of connecting a terminating call through to the station the concentrator will attempt to preselect the next idle trunk as explained in 6.13. For this explanation of the all-trunks-busy feature, it is assumed that no trunk is idle and as indicated on SC4, the sequence of operations is shown on SC8-A.

**8.03** Slow release relay V1 will release because marking control relays PA-PD did not operate to indicate that a vertical bar (trunk) is idle. Relay V1 released, operates relay V2. Relay V2 operated, opens the path for the negative half cycles to control lead 3 which causes the release of relay RF in the remote unit. Relay RF released, releases relay SCH. Relay SCH released, prevents the remote unit from setting up a call until the all-trunks-busy condition is removed. In the central office unit, the operation of relay V2 prevents the release of relay RF by transferring the negative half cycles from control lead 3 to ground through R17, releases relay V3 which is made slow release. The combination of an operated V2 and slow release V3 will give a tabulation on the all-trunks-busy register, if provided.

**8.04** Relay V2 operated operates relay A1 from battery through the winding of relay A1 through operated contacts of relay C, 250-ohm resistor R8, released contacts of magnet BES, operated relay V2 contacts to ground.

**8.05** Operated relay A1 operates relay A2 which in turn operates relay U. The central office unit will now remain in this condition until either a terminating call (incoming) is placed into the concentrator, or one of the eleven trunks becomes idle. It is assumed that a terminating call is placed to line 3.

**8.06** Ground on the sleeve lead from the line equipment operates line relay TN3 which in turn operates relay K. Relay K operated, starts the release of slow release relay AB1, releases relay U. Relay U released, operates relay F1. Relay F1 short-circuits its 3-4 winding by contact 1 lowering the resistance thereby increasing the current flow permitting relay G7 to operate.

**8.07** Relay F1 operated releases marking relays RD. Relay G7 operated releases RA, RB, and RC marking relays. The released marking relays release relay SCH in the central office unit. Relay SCH released operate the RT1 cut-in relay and PIRT relay.

**8.08** Relay PIRT operated, operates relays KO1 and KO. Relays KO1; RA to RC, and RT1 operate horizontal magnet T3 and relay D in

series. Relay D operated releases relay C and magnet T50. Relay C released, releases relay A1.

**8.09** Relay C released also closes through the path to operate (lift-up) vertical bar BES. The construction of this vertical bar is such that the crosspoints are closed through when the vertical is lifted rather than when it is dropped. This is opposite to the manner of closing the crosspoints on trunk verticals. The path for operating vertical bar BES is from battery through the winding of BES lift magnet, released V3 contacts, operated D contacts, released C contacts to ground.

**8.10** Lift magnet BES contacts operated, close through a ground path to start an overflow tone circuit if required, operate the disconnect bar contacts, and close through a path to operate relay PR. Relay PR operates from ground on the sleeve lead from the line equipment through released V3 contacts to battery through the winding of relay PR. Relay PR locks up vertical bar BES, under control of the sleeve lead. Disconnect bar contacts operated, release relays TN3, D, and horizontal bar magnet T3. The tip and ring of vertical bar BES is wired to the cathode and control anode of a 313C cold cathode tube. The purpose of this tube is to fire on receipt of ringing current causing a short to appear between tip and ring to trip the ringing cycle. Attached to the ring conductor of the BES vertical, capacitor C313C permits overflow tone to be transmitted to the calling party.

**8.11** Relay D released reoperates magnet T50 and relay C and releases relays RT1 and PIRT. Relay PIRT released reoperates the RC marking relays and releases relays KO and KO1. Relay KO released reoperates marking relays RA and RB and relay KO1 released reoperates marking relays RD and AB1.

**8.12** The reoperated marking relays reoperate relay SCH. Relay SCH reoperated releases relay A2 which in turn releases relay U.

**8.13** When the customer hangs up, the ground on the sleeve lead will be replaced with battery from the line equipment. This battery opposing the battery on the winding of relay PR causes relay PR to release. Relay PR released, releases vertical bar BES. The release of BES removes ground start to the overflow tone source

if required, releases the disconnect bar TR3 contacts, and operates relay A1. Relay A1 operated, operates relay A2 which in turn operates relay U.

**8.14** Each time a terminating call is received by the central office unit, the above sequence will be repeated starting with 8.06. The sequence of operations when a trunk becomes idle is shown on SC8-B.

**8.15** As mentioned before, an idle trunk has battery on the sleeve lead. During the all-trunks-busy condition, the walking circuit has been testing for an idle trunk by sampling each sleeve lead for battery. SC8-B assumes that vertical bar 3 becomes idle. Relay VB3 of the walking circuit operates and, because of sleeve battery, will operate relay BSU. Relay VB3 also releases relay VB2. Relay BSU operated, stops the walking circuit by holding relay M operated, and operates relay V. The path for operating relay V is battery through the winding of relay V, operated contacts of relay SCH, released contacts relay K, operated contacts relay V2, operated relay BSU contacts, operated V2 relay

contacts, operated C relay contacts, through released D relay contacts to ground.

**8.16** Relay V operated, operates relay V1 which in turn releases relay V2. The release of relay V2 re-establishes the negative half cycles on control lead 3 operating marking relay RF which in turn operates relay SCH in the remote unit. The release of relay V2 also operates relay V3 and releases relay A1.

**8.17** Relay A1 releases slow release relay V which in turn operates marking control relays PA and PD. Relays PA and PD operated open the path for marking relays RA and RD, releasing them in both units. Relays RA and RD released, releases relay SCH in their respective units, which in turn operate their PIRS, RS2 and RS3 cut-in relays. These relays operated, in combination with the marking relays operated and released, operate lift magnet S3 in each unit. This establishes vertical bar 3 for use on the next call. Relay PIRS at the central office unit reoperates relay KO. The sequence continues as given in 6.14.

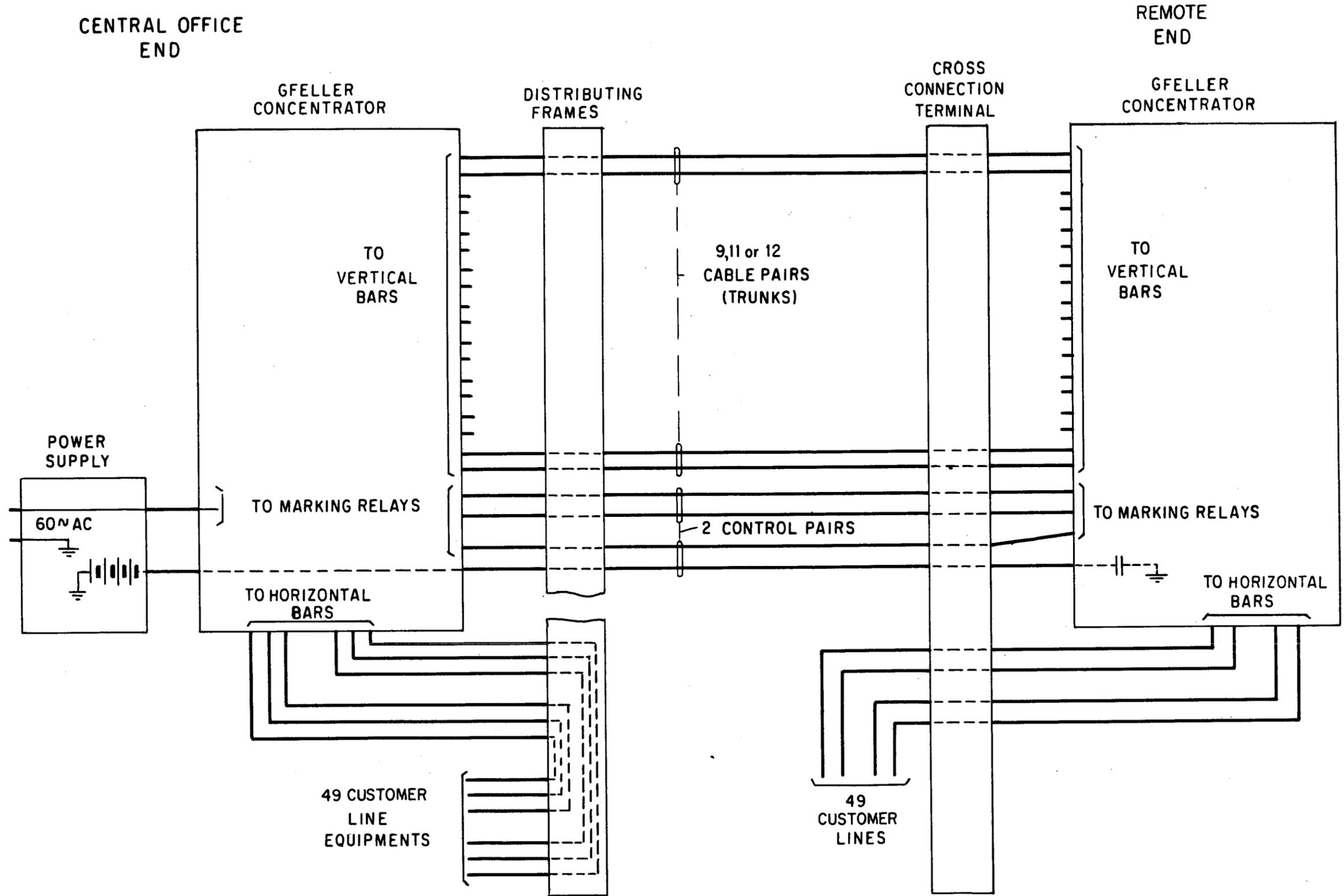


Fig. 2 - Block Diagram of Typical Layout

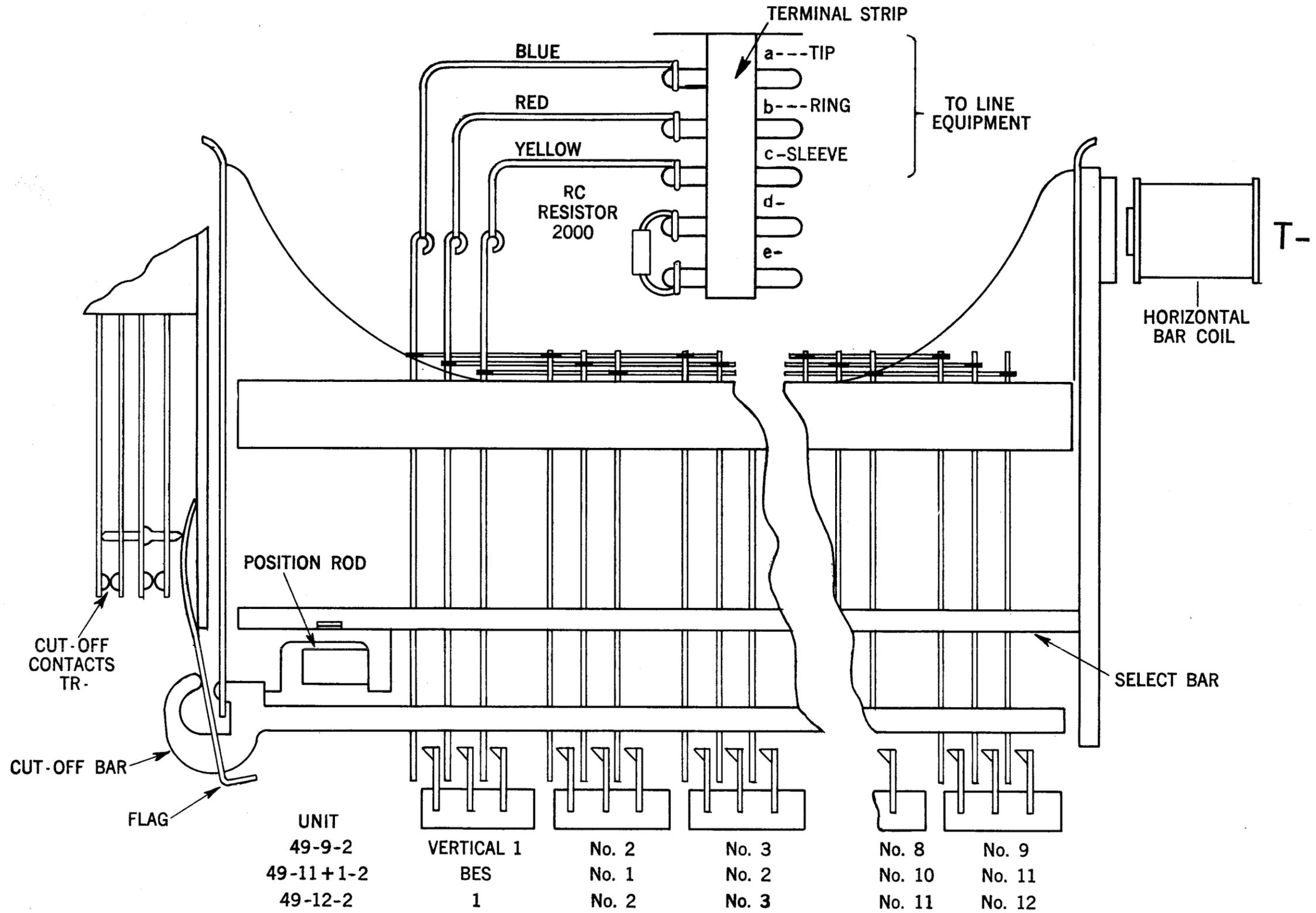


Fig. 3 - Horizontal Bar Multiple Wiring

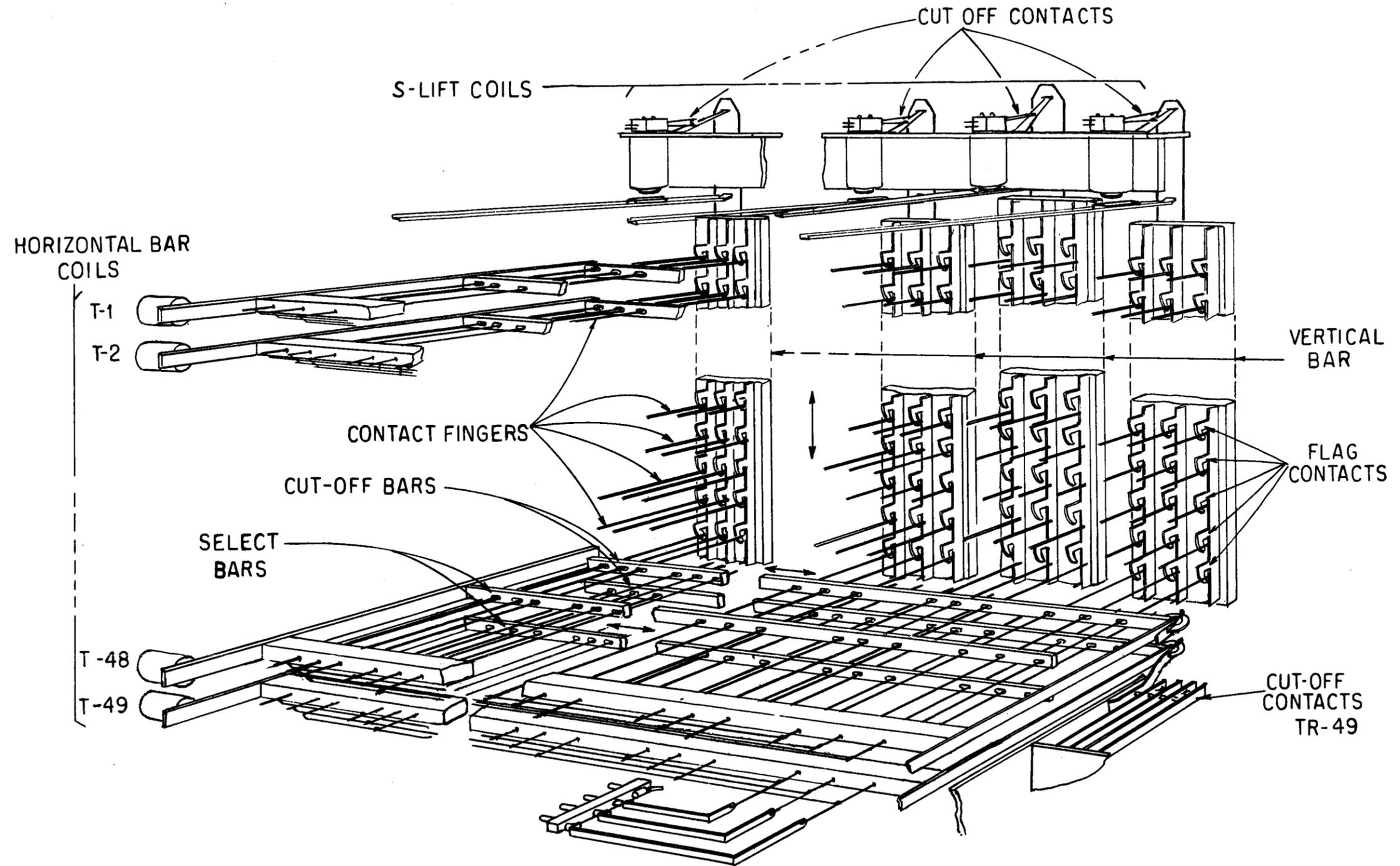


Fig. 4 - Switch, Rear View

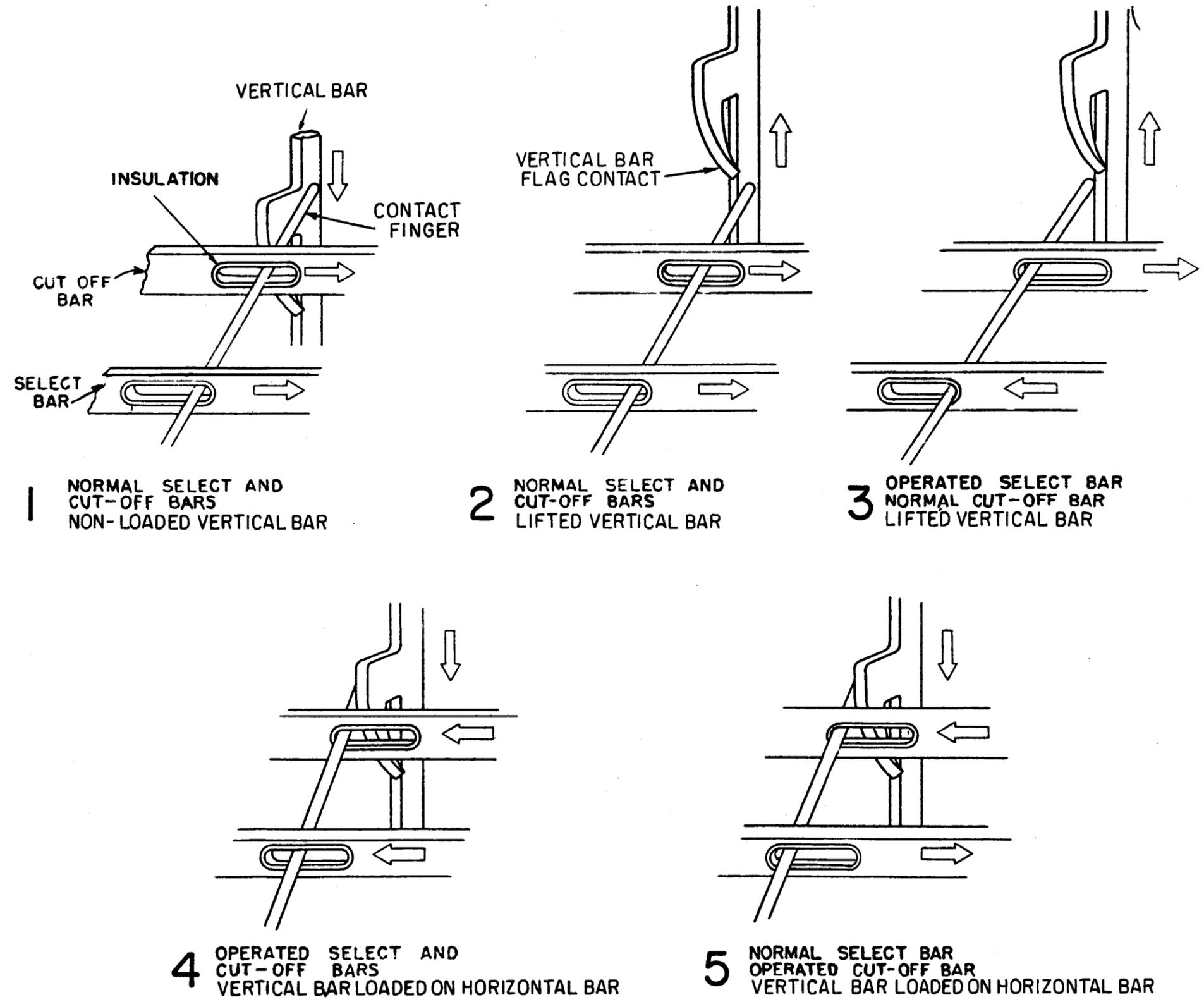
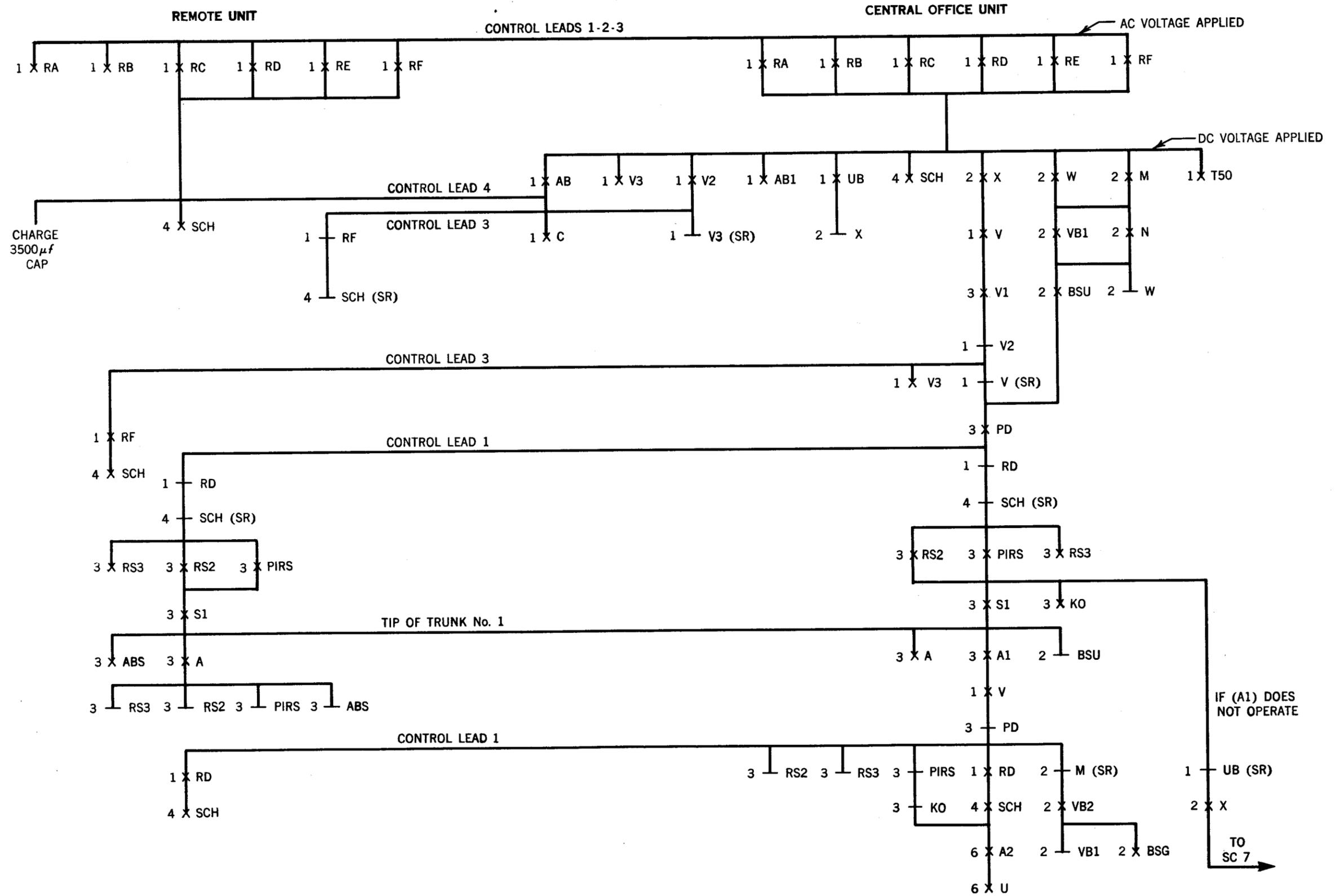
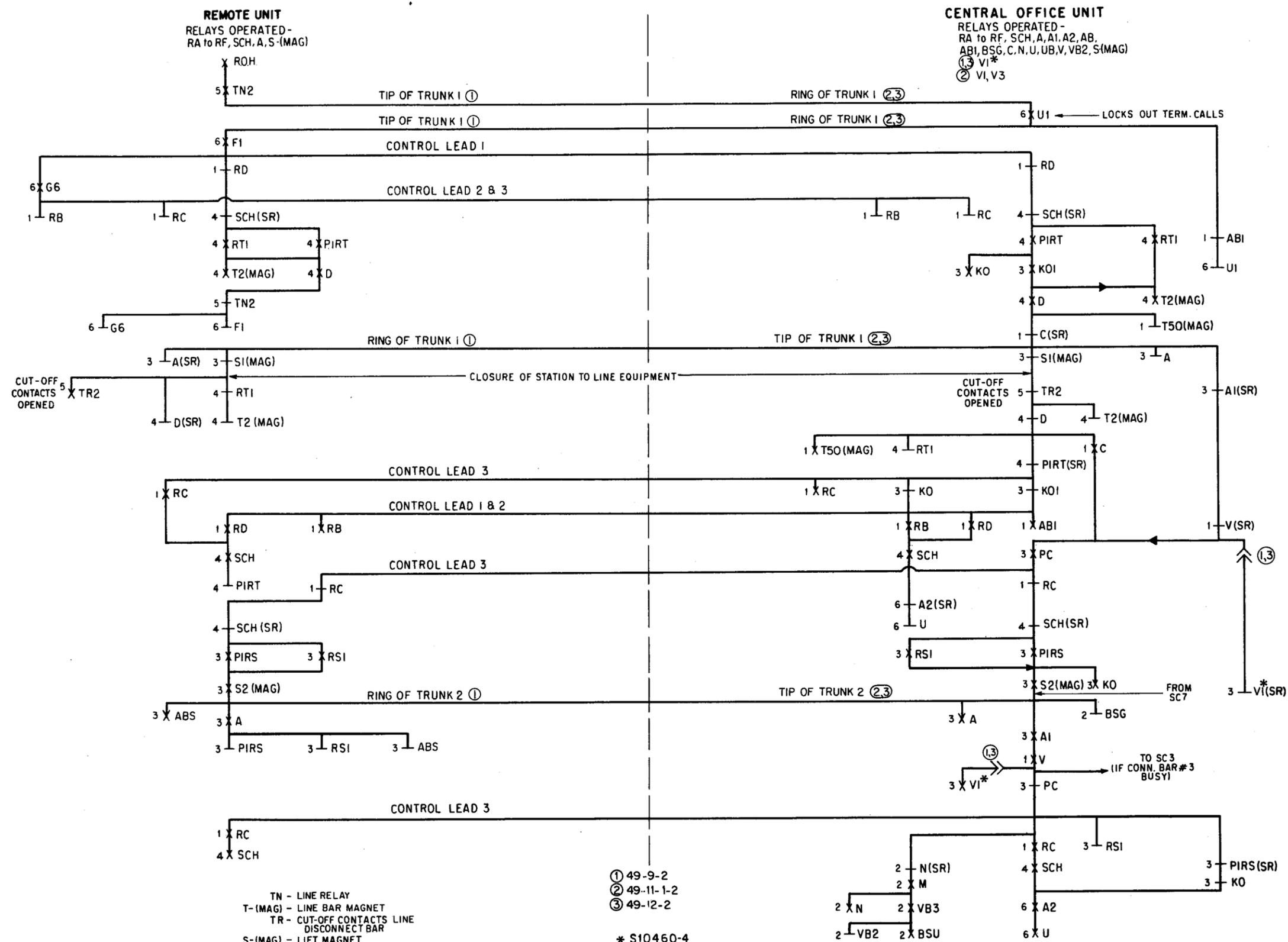


Fig. 5 - Contact Finger and Flag Engagement





INITIAL OPERATION SC1  
(49-11+1-2)



CUT-OFF CONTACTS OPENED

CLOSURE OF STATION TO LINE EQUIPMENT

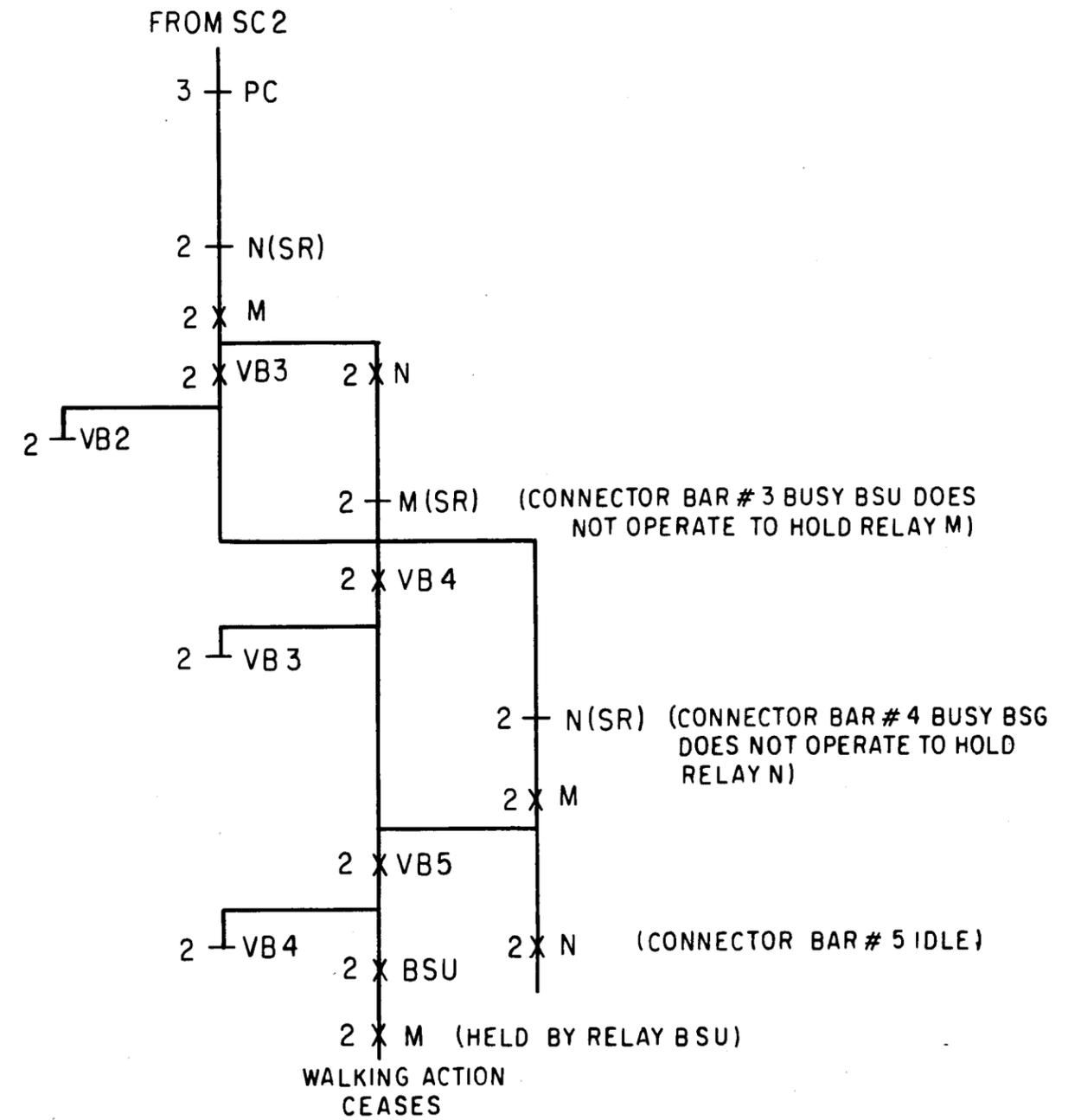
CUT-OFF CONTACTS OPENED

TO SC3 (IF CONN. BAR #3 BUSY)

TN - LINE RELAY  
 T-(MAG) - LINE BAR MAGNET  
 TR - CUT-OFF CONTACTS LINE DISCONNECT BAR  
 S-(MAG) - LIFT MAGNET  
 SR - SLOW RELEASE RELAY  
 NO. ON LEFT - OS DRAWING NUMBERS

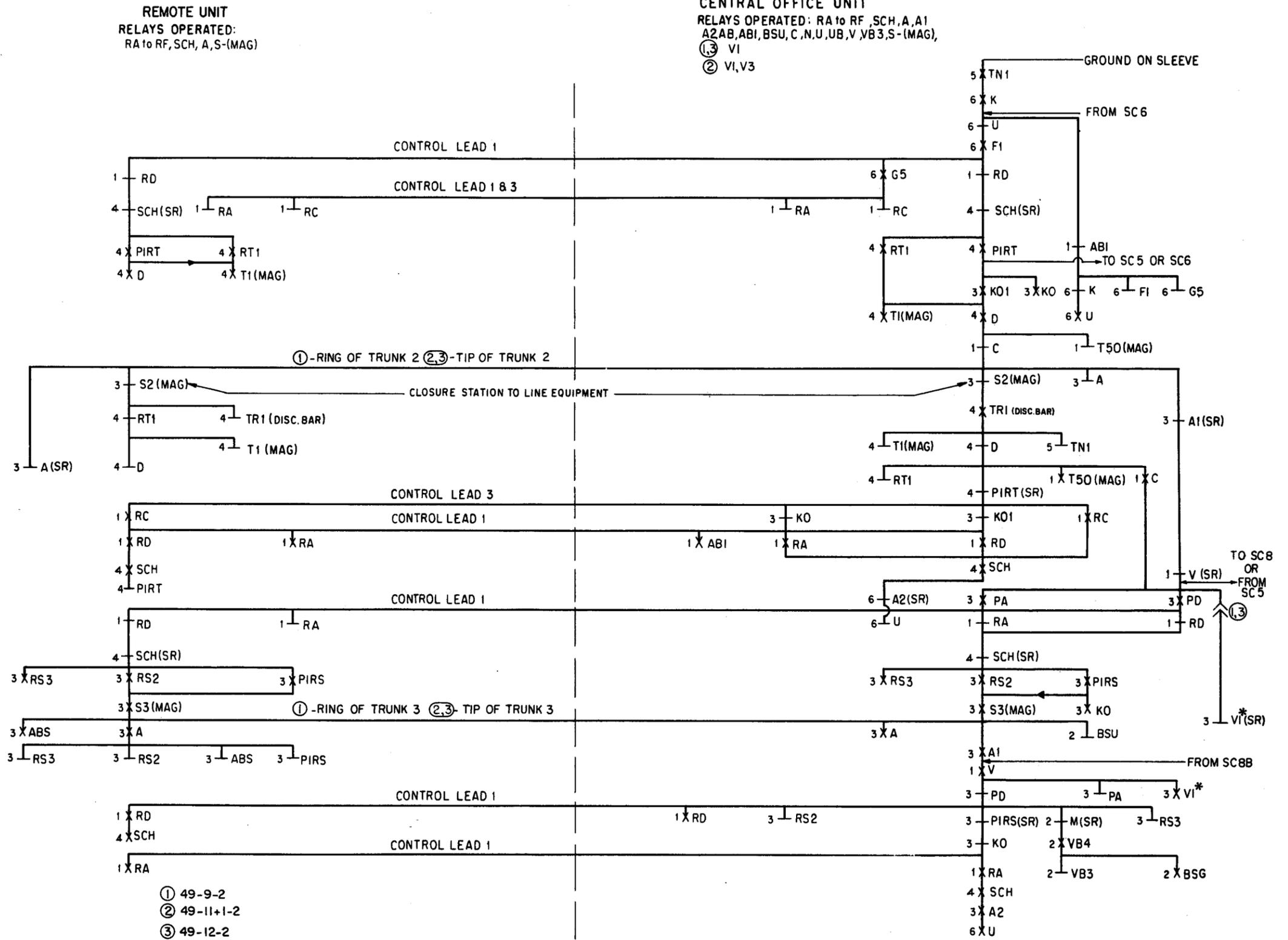
① 49-9-2  
 ② 49-11-1-2  
 ③ 49-12-2  
 \* S10460-4

ORIGINATING CALL LINE #2 TO TRUNK #1 SC2



(SR) - SLOW RELEASE

WALKING CIRCUIT SC3-



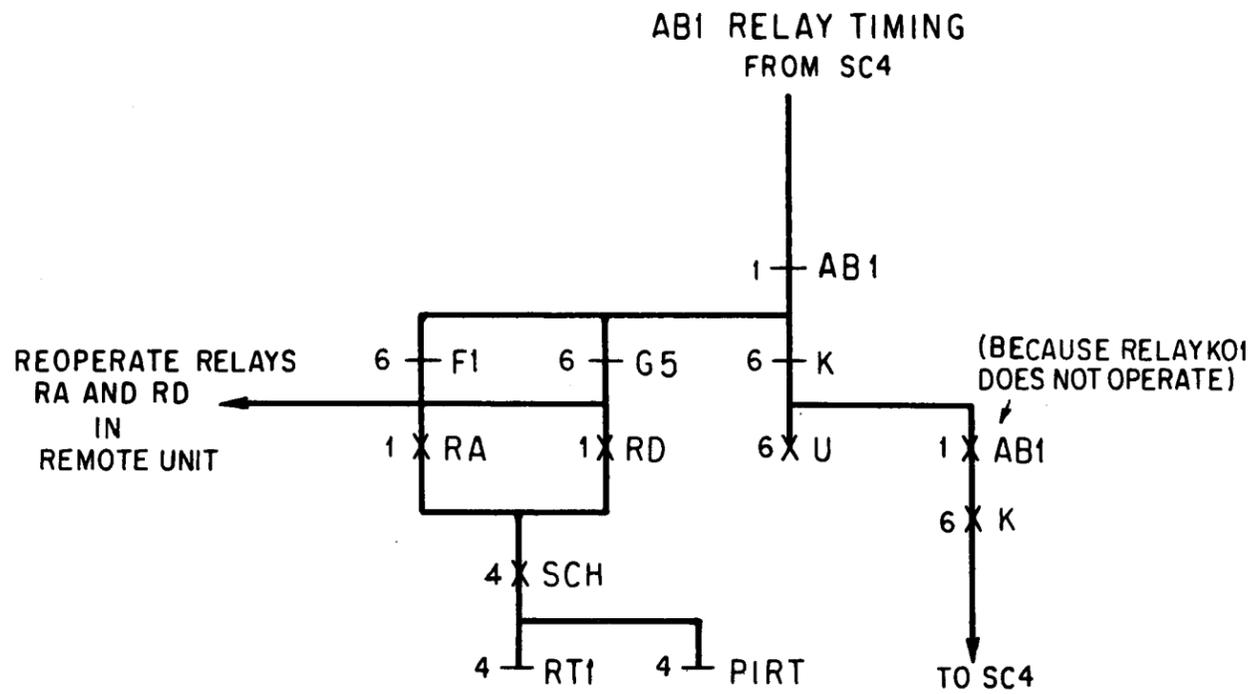
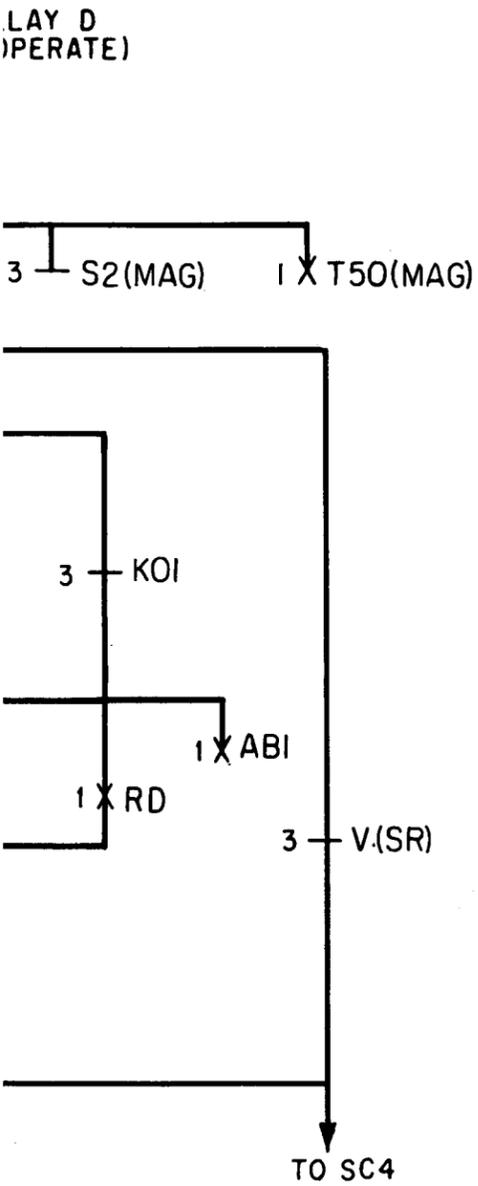
REMOTE UNIT  
RELAYS OPERATED:  
RA to RF, SCH, A, S-(MAG)

CENTRAL OFFICE UNIT  
RELAYS OPERATED: RA to RF, SCH, A, A1,  
A2, AB, ABI, BSU, C, N, U, UB, V, VB3, S-(MAG),  
①③ VI  
② VI, V3

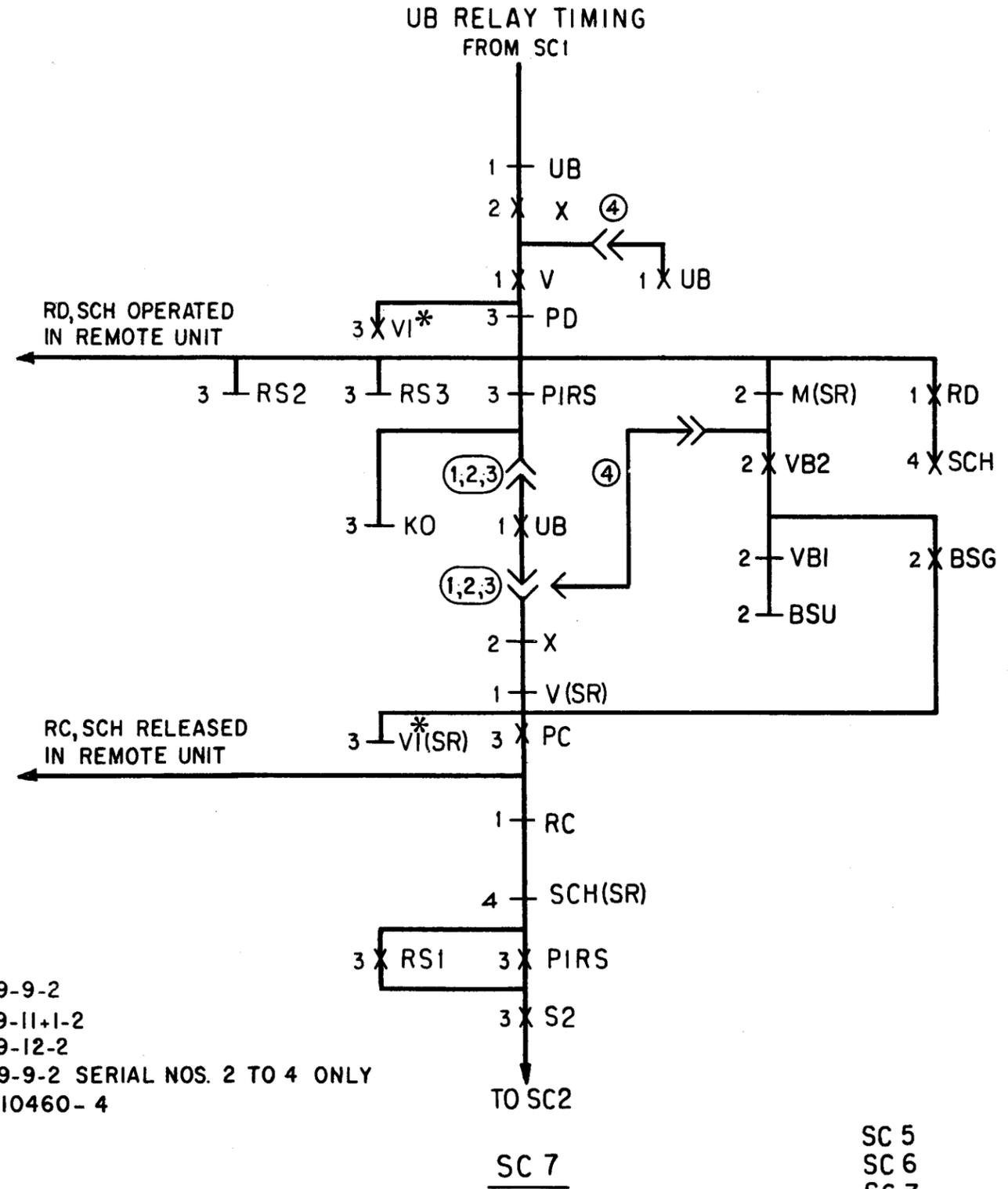
- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2

\*S10460-4

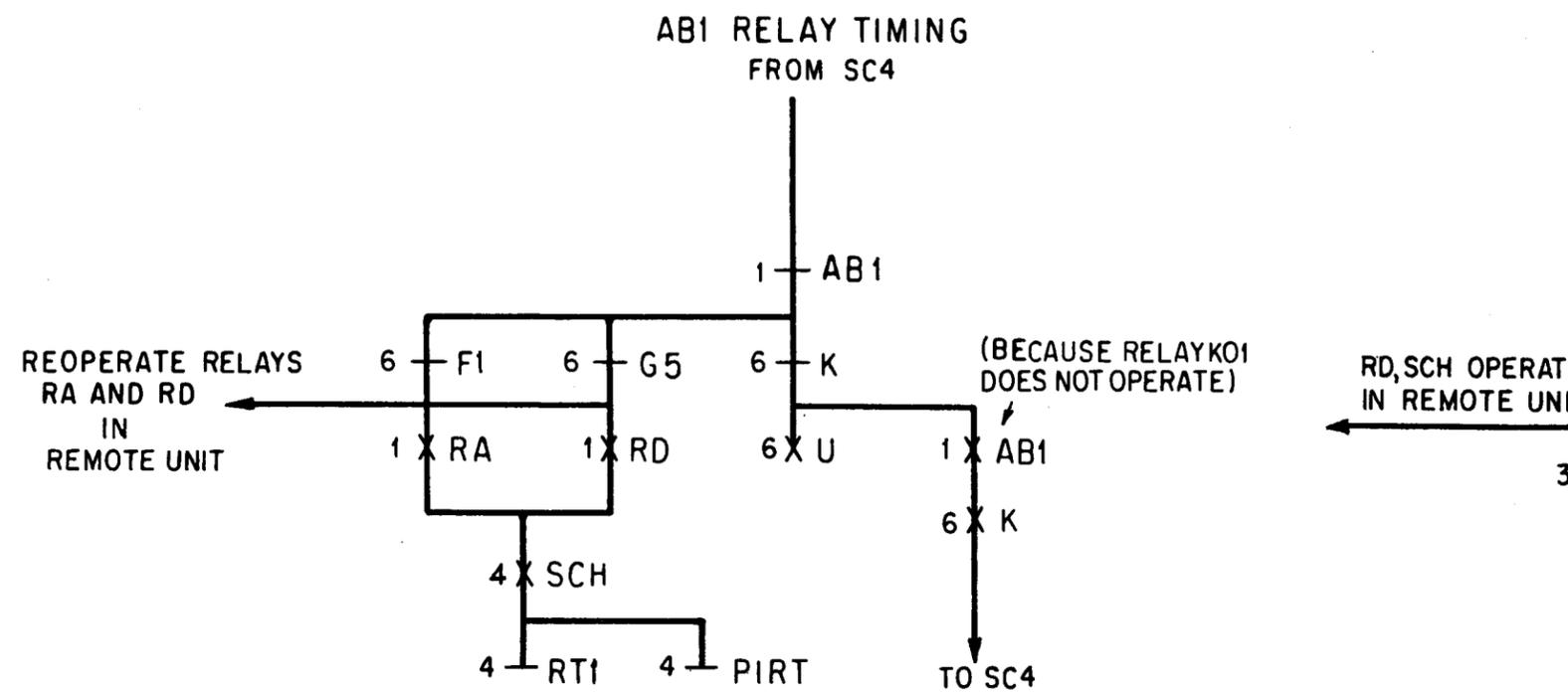
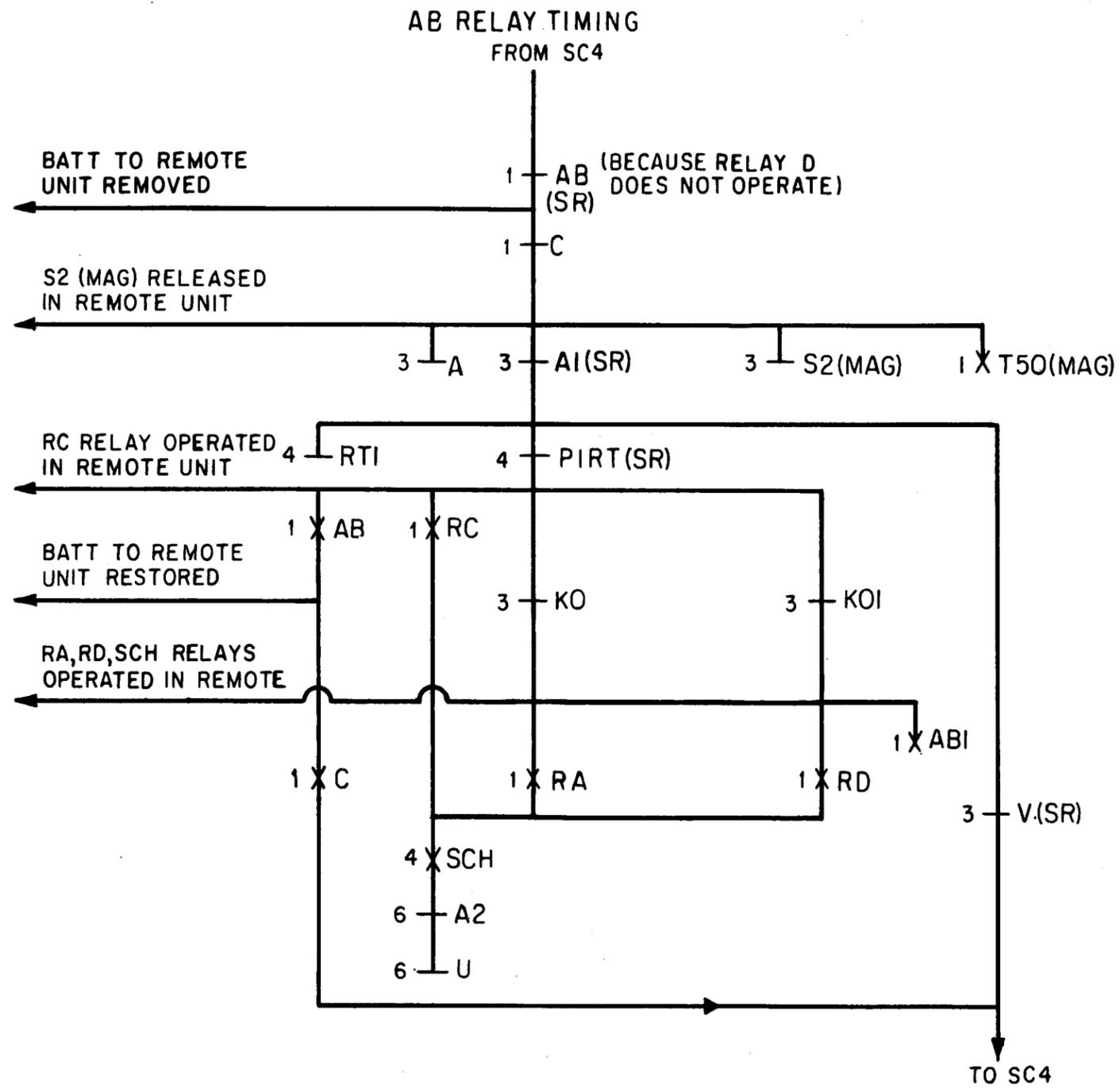
TERMINATING CALL  
LINE #1 TO TRUNK #2 SC4



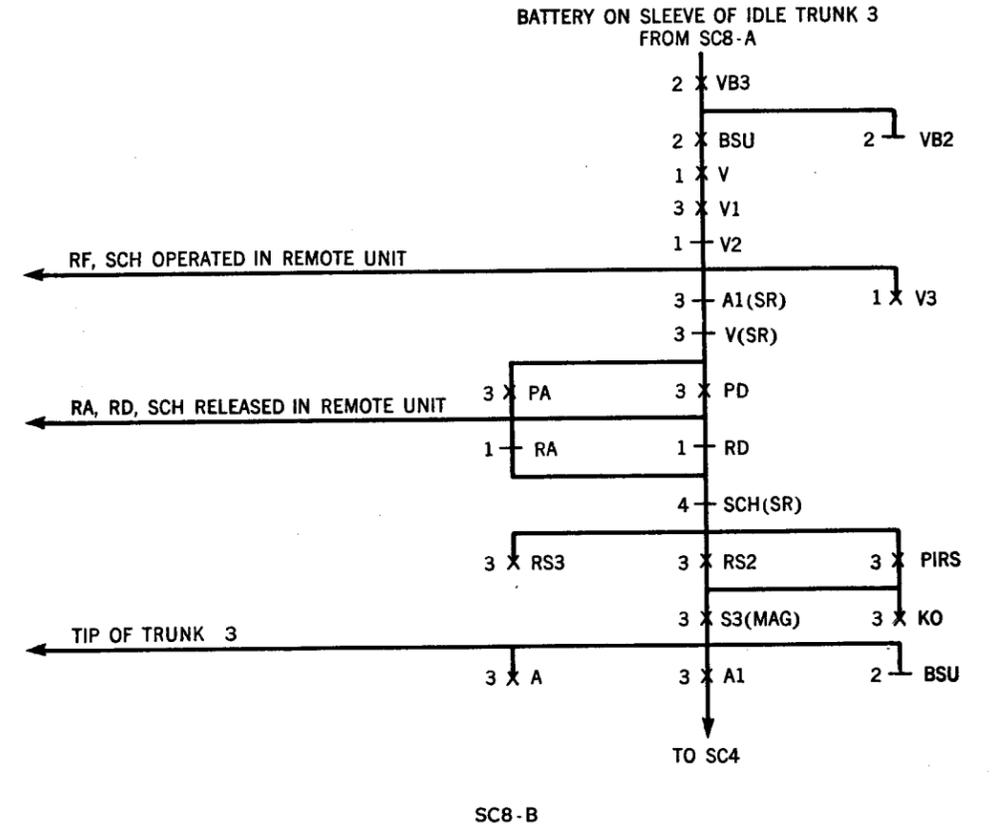
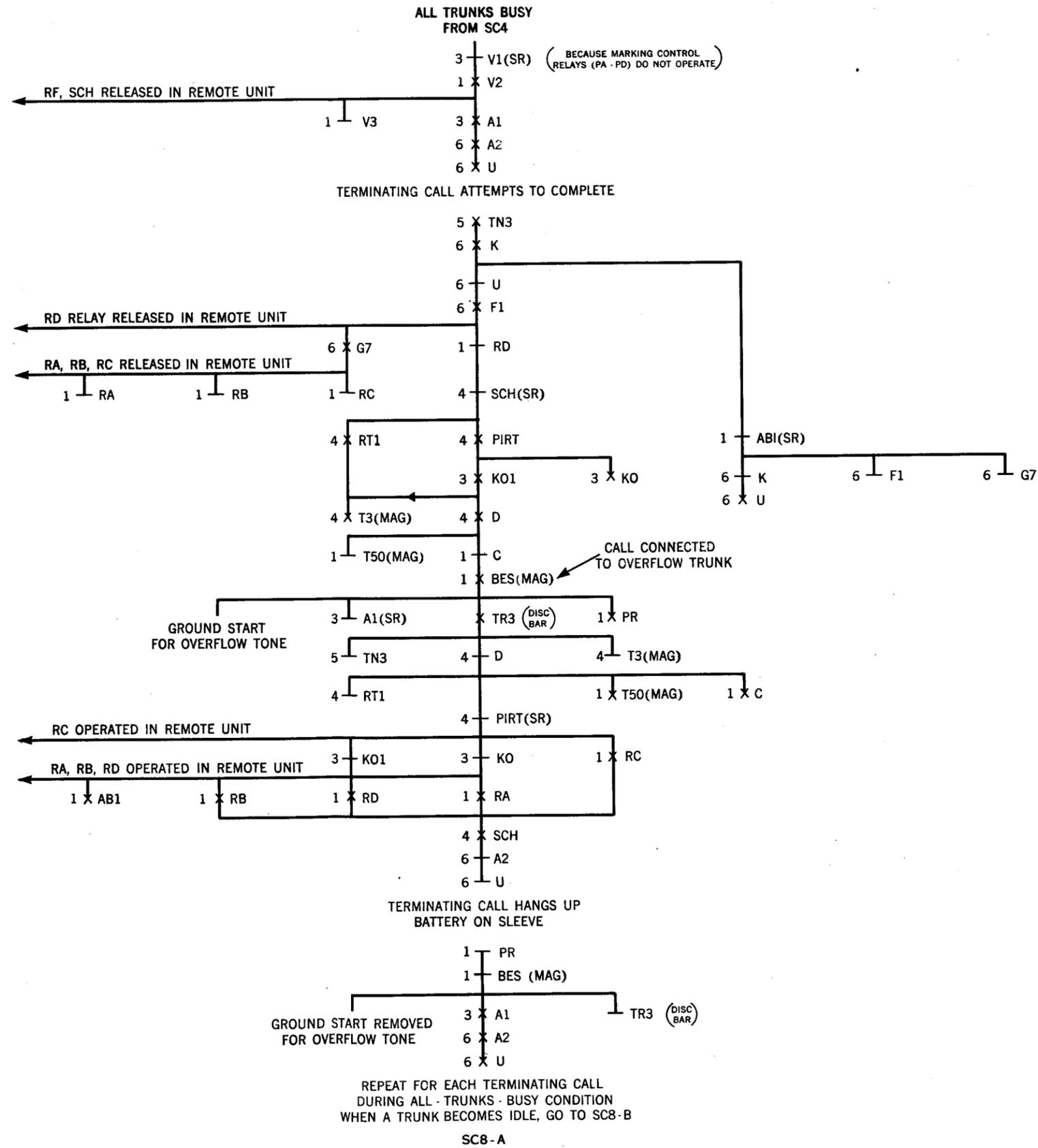
SC 6

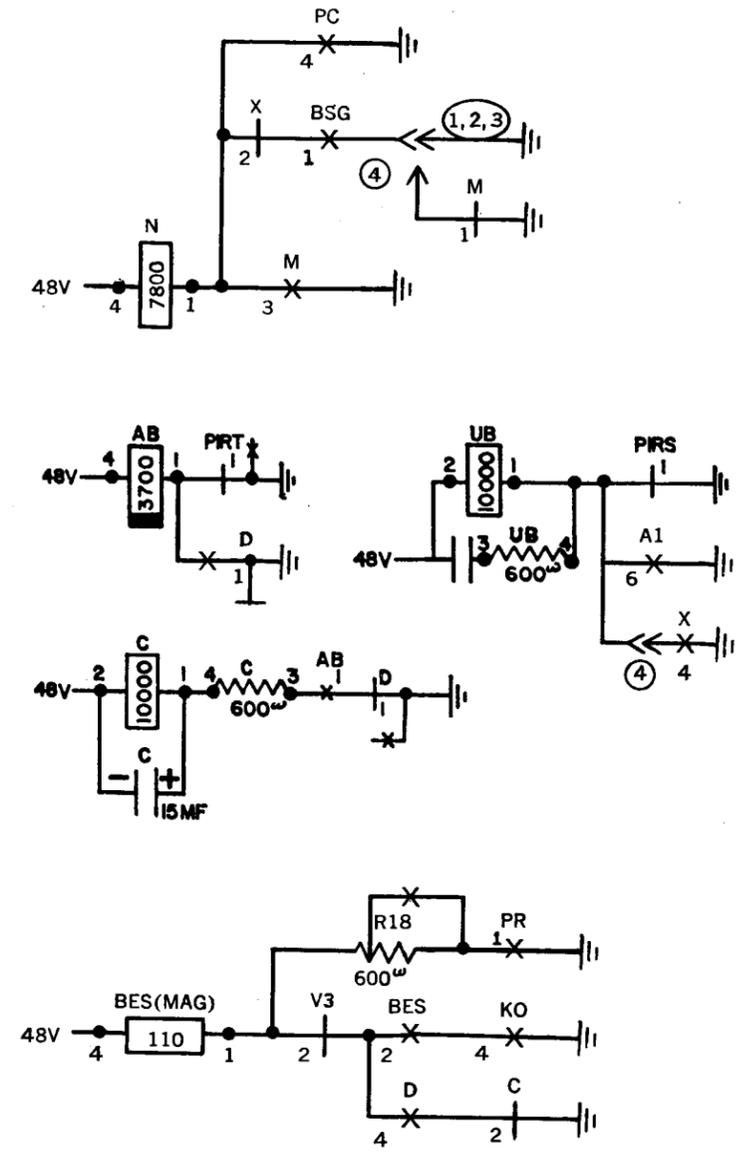
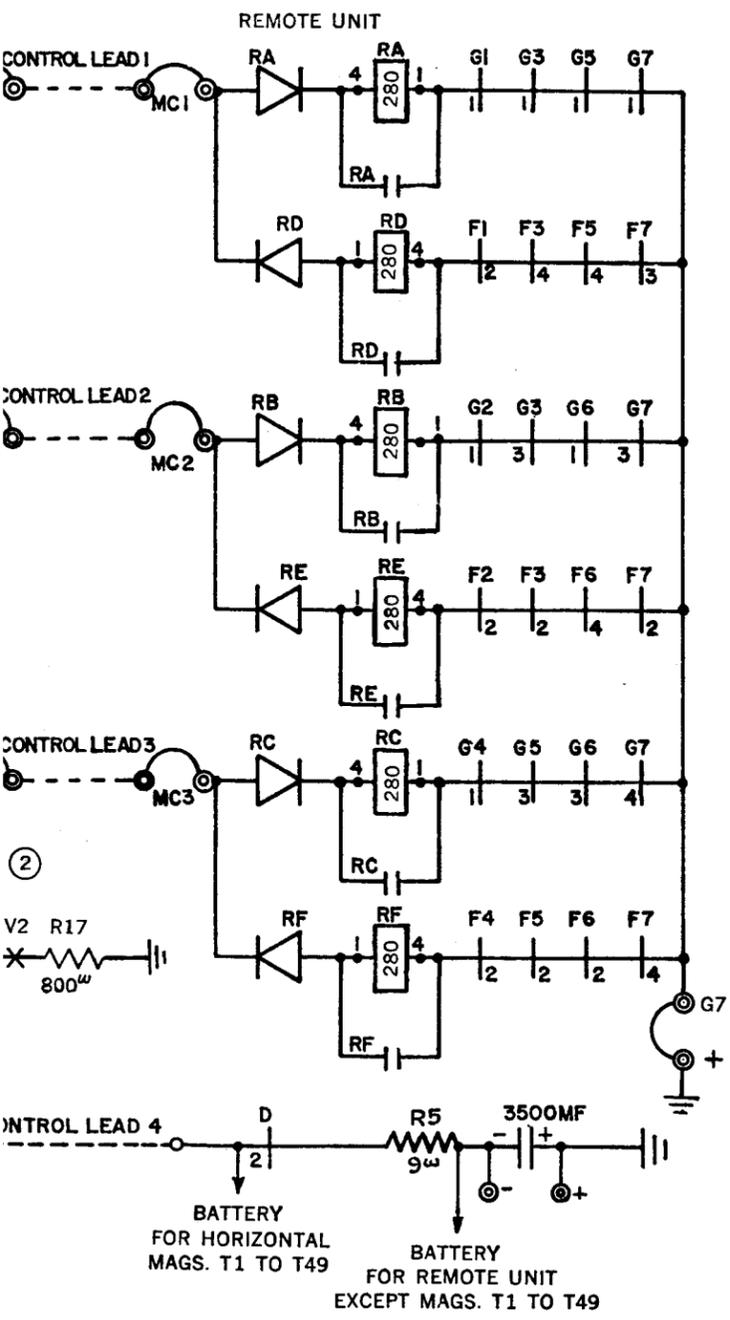


- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2
- ④ 49-9-2 SERIAL NOS. 2 TO 4 ONLY
- \* S10460-4

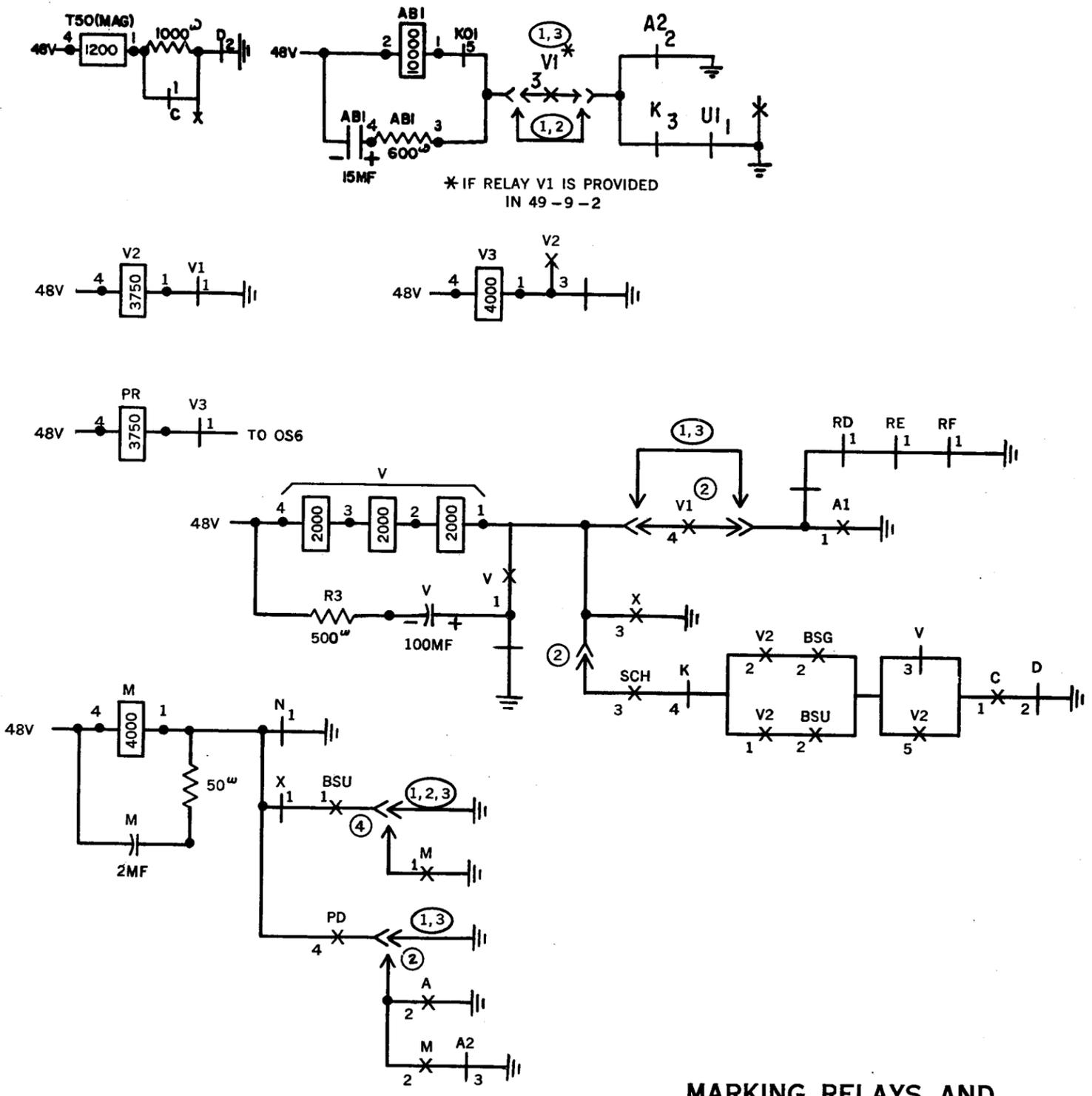


- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2
- ④ 49-9-2 SERIAL NOS
- \* S10460-4



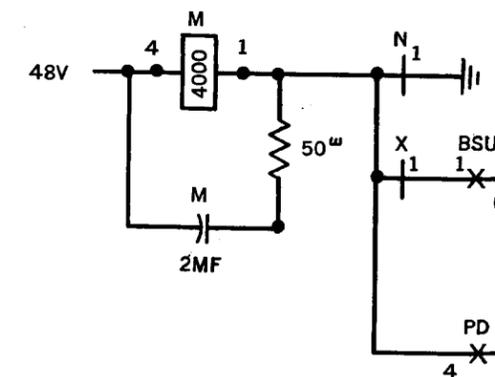
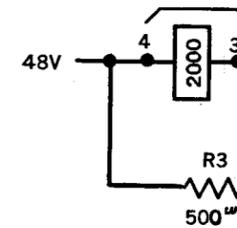
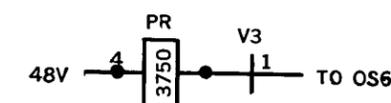
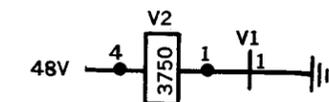
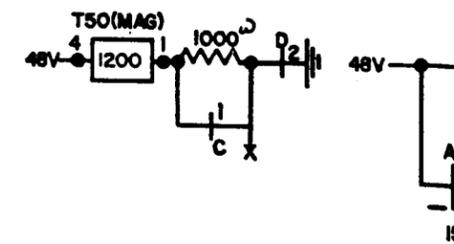
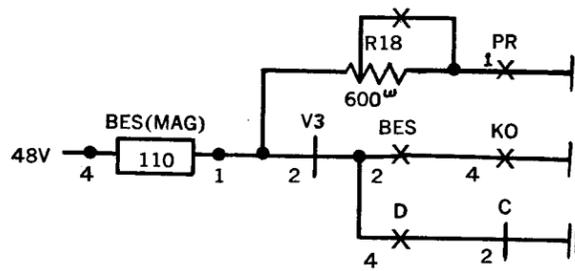
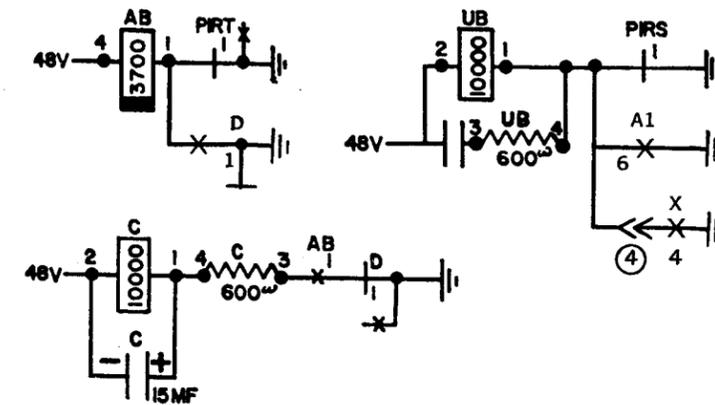
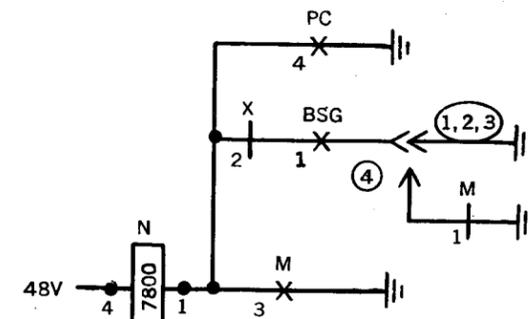
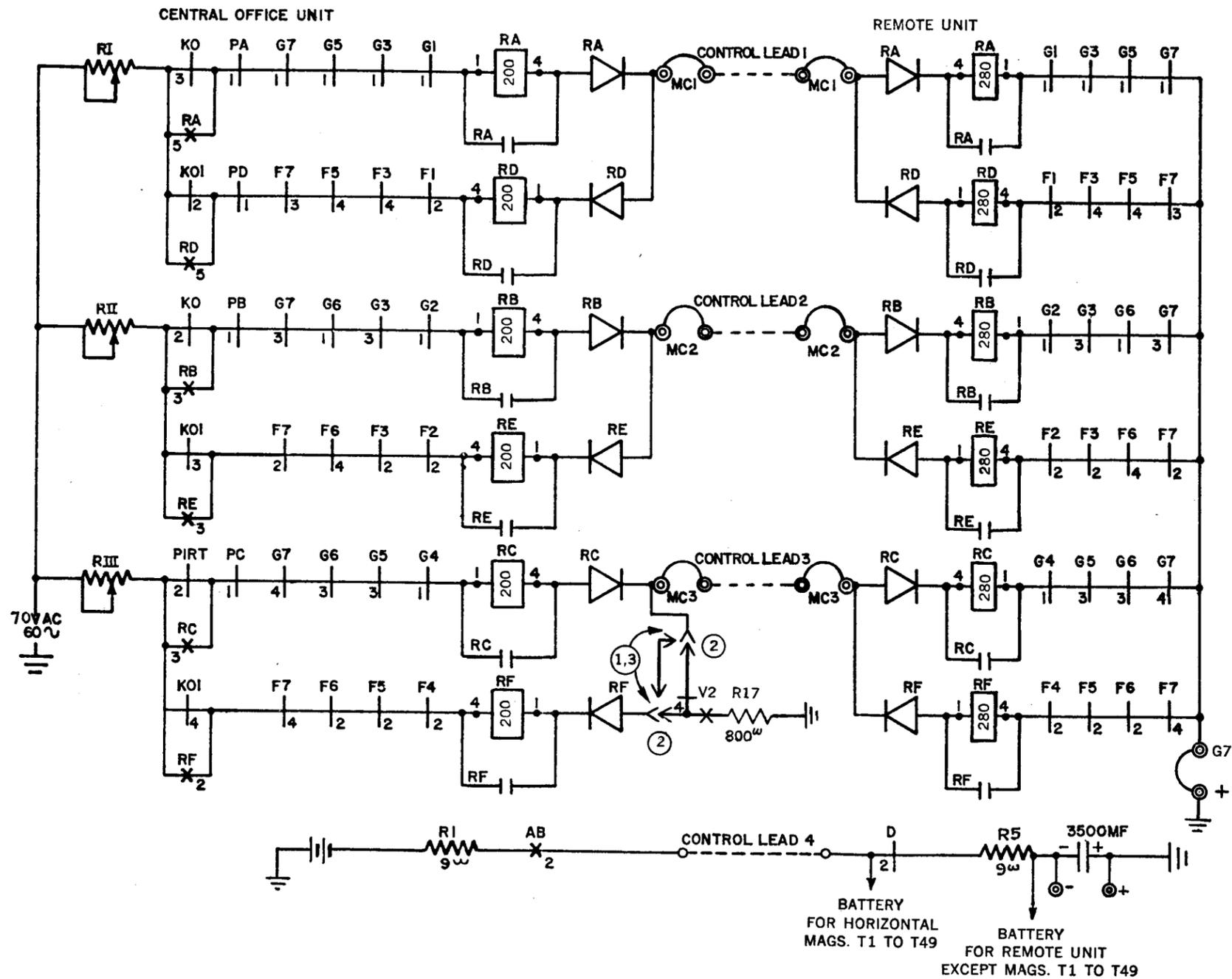


- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2
- ④ 49-9-2 SERIAL NOS. 2 TO 4 ONLY

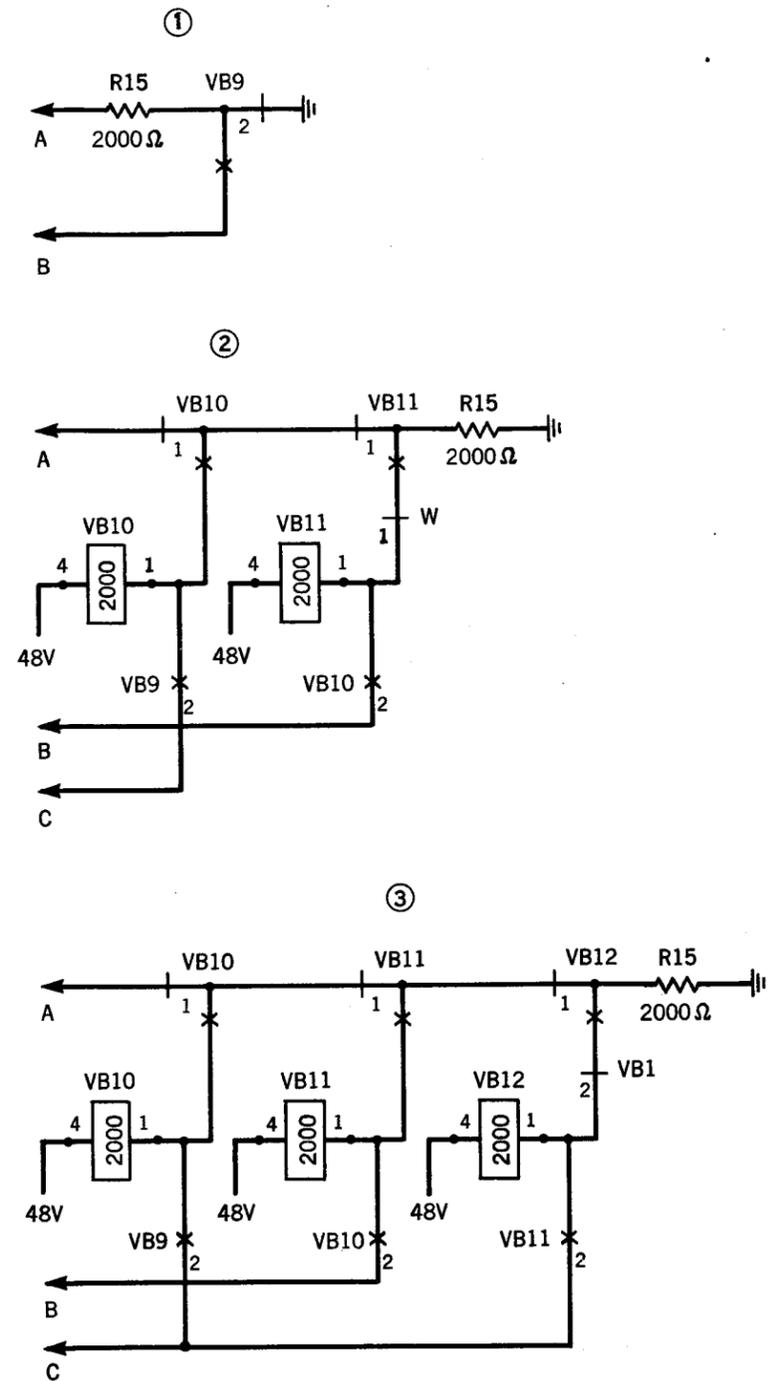
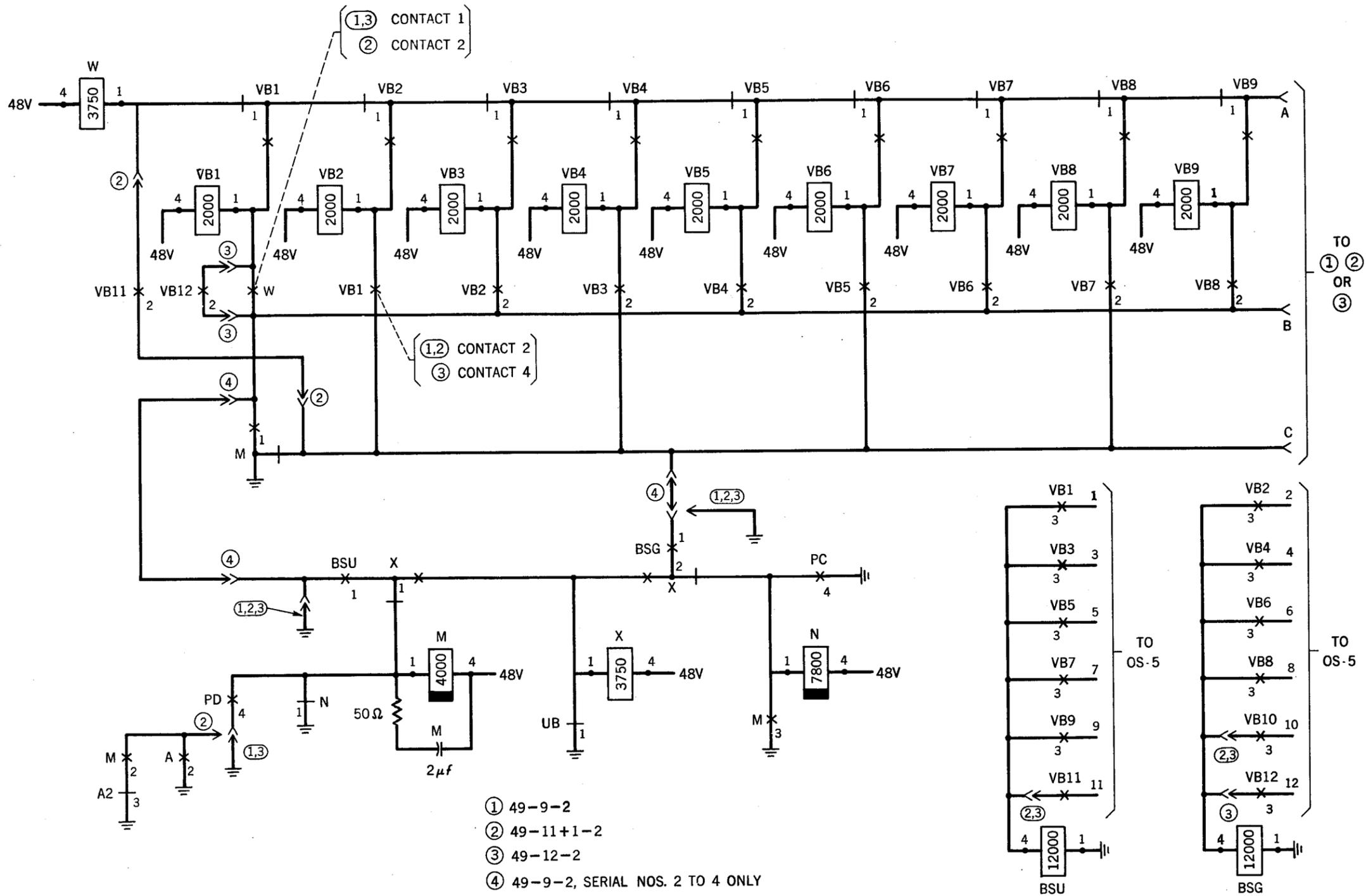


MARKING RELAYS AND INITIAL RELAY OPERATION

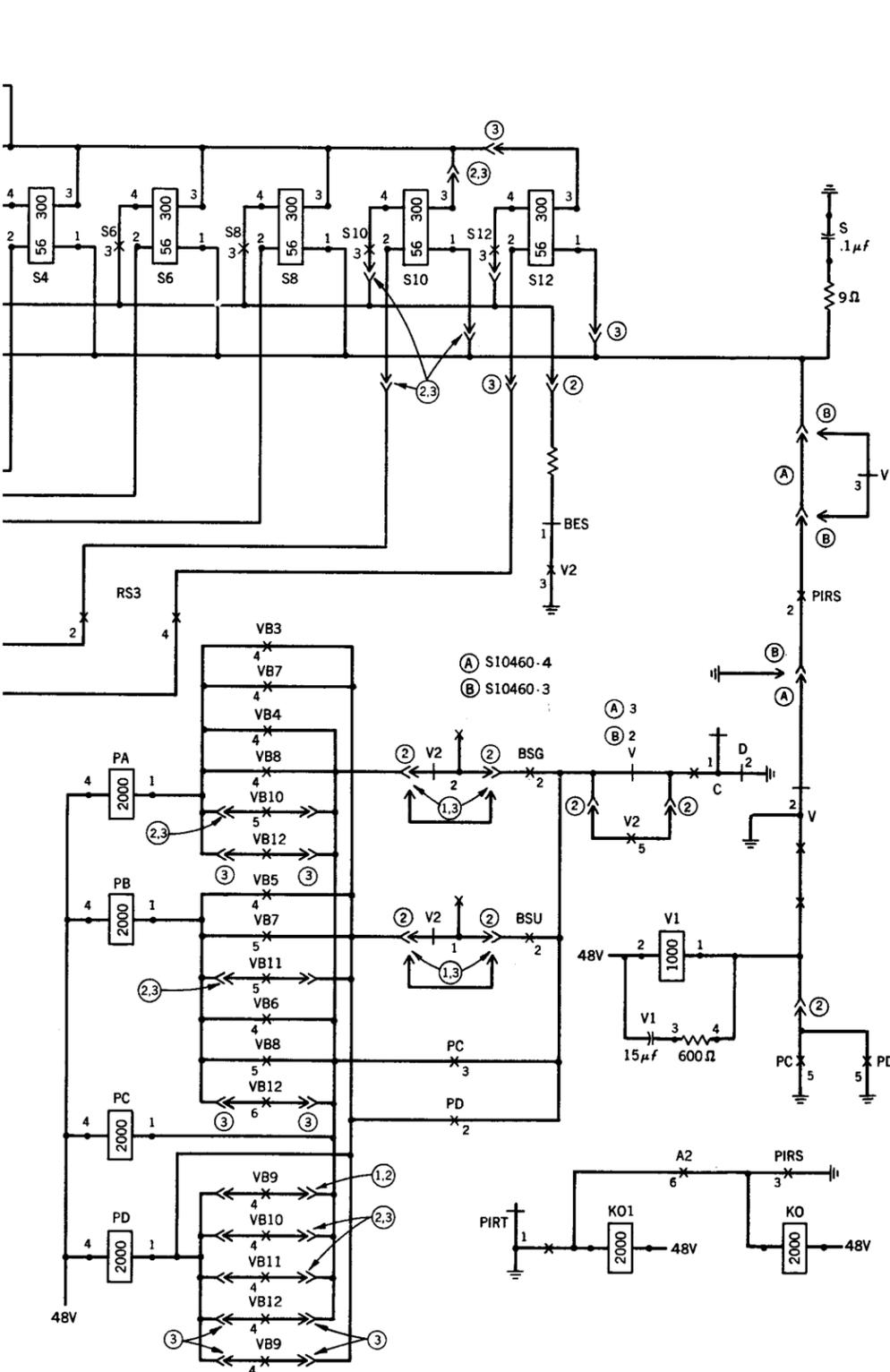
OS1



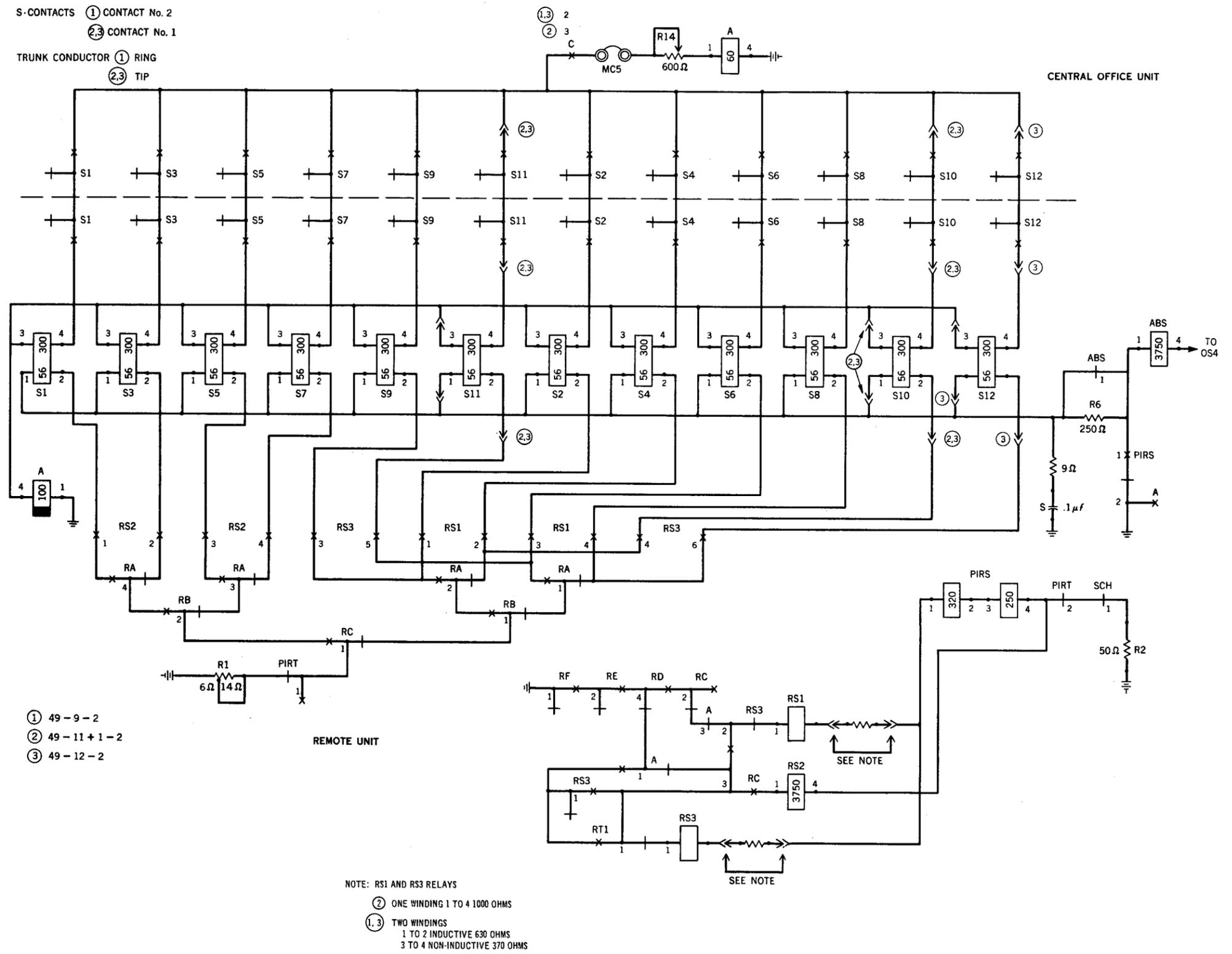
- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2
- ④ 49-9-2 SERIAL NOS. 2 TO 4 ONLY



WALKING CIRCUIT FOR CONNECTOR BAR PRESELECTION OS2



S-CONTACTS ① CONTACT No. 2  
 ②,③ CONTACT No. 1  
 TRUNK CONDUCTOR ① RING  
 ②,③ TIP

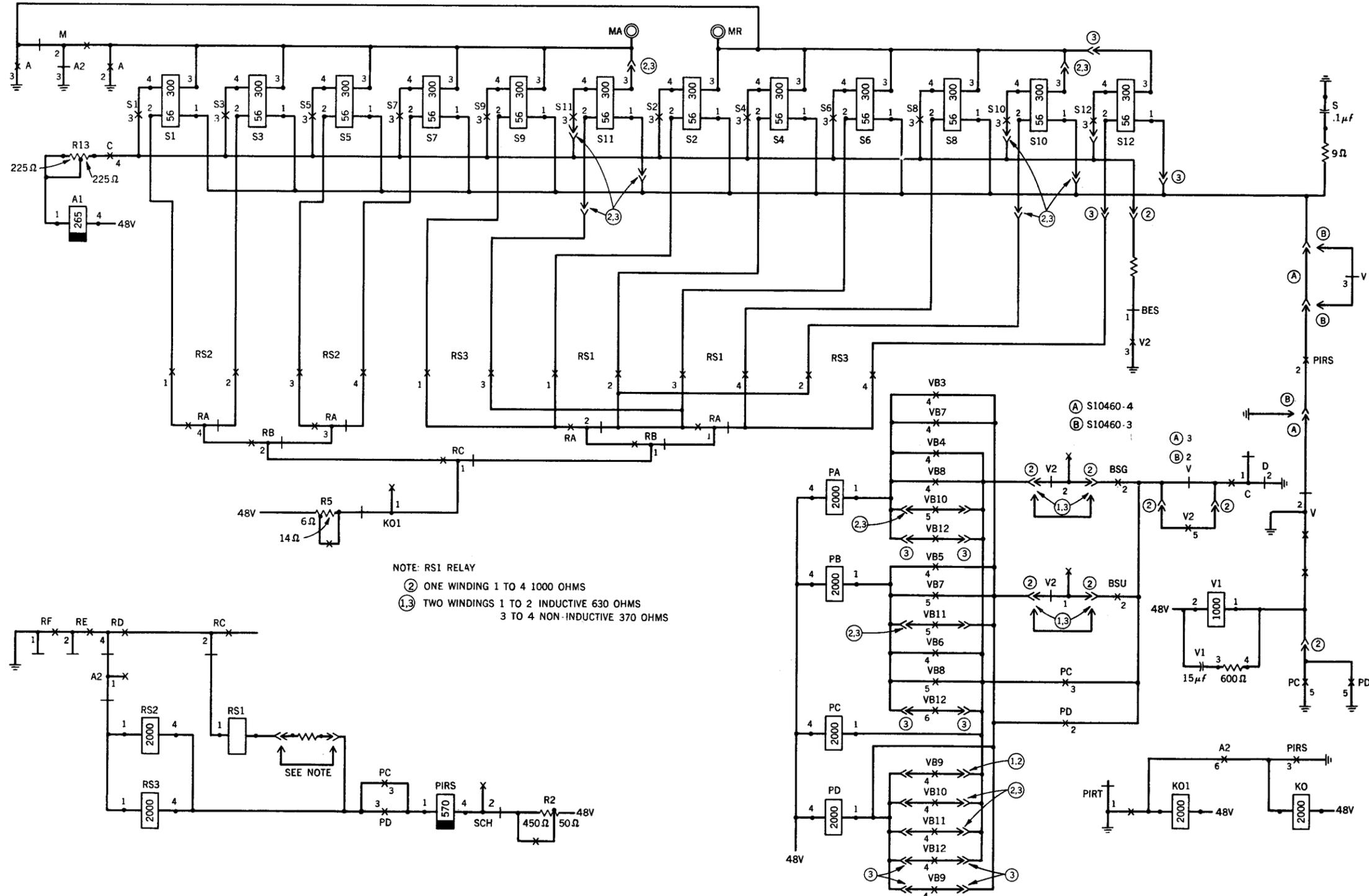


- ① 49-9-2
- ② 49-11+1-2
- ③ 49-12-2

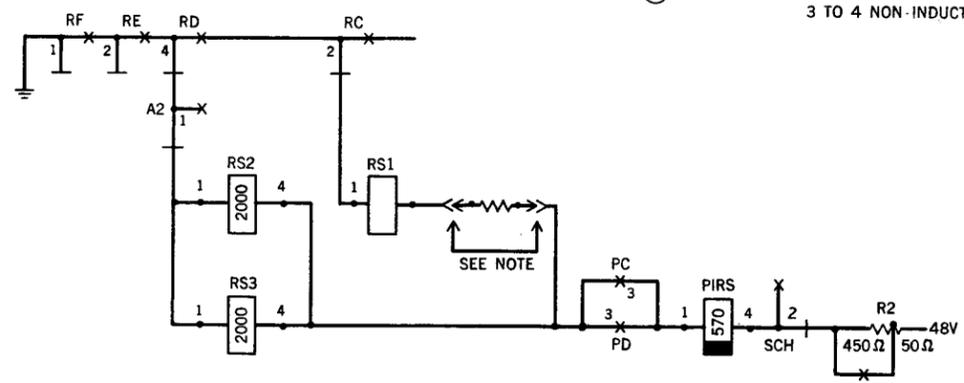
NOTE: RS1 AND RS3 RELAYS  
 ② ONE WINDING 1 TO 4 1000 OHMS  
 ①,③ TWO WINDINGS  
 1 TO 2 INDUCTIVE 630 OHMS  
 3 TO 4 NON-INDUCTIVE 370 OHMS

Lift Magnet Cut-in and Control Relays OS3

CENTRAL OFFICE UNIT

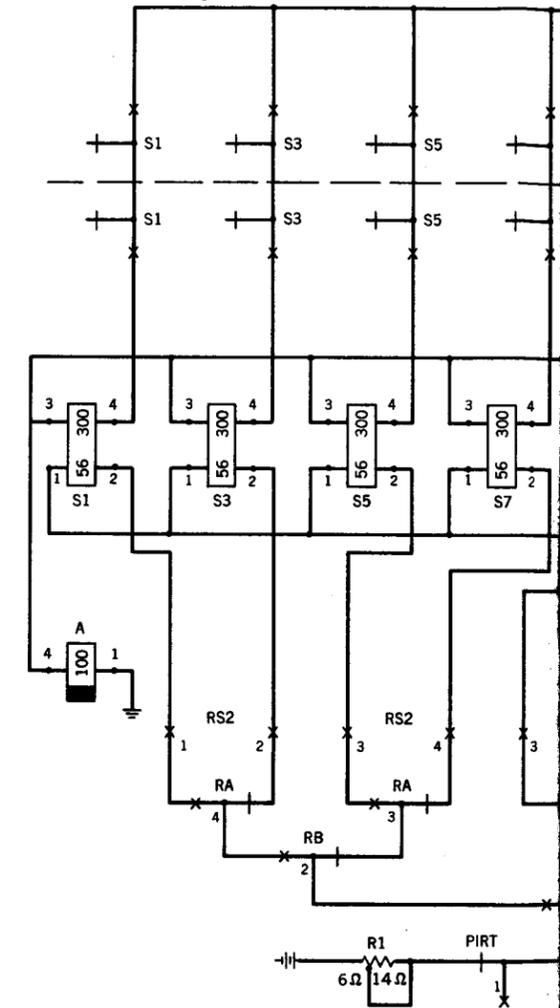


NOTE: RS1 RELAY  
 (2) ONE WINDING 1 TO 4 1000 OHMS  
 (1,3) TWO WINDINGS 1 TO 2 INDUCTIVE 630 OHMS  
 3 TO 4 NON-INDUCTIVE 370 OHMS



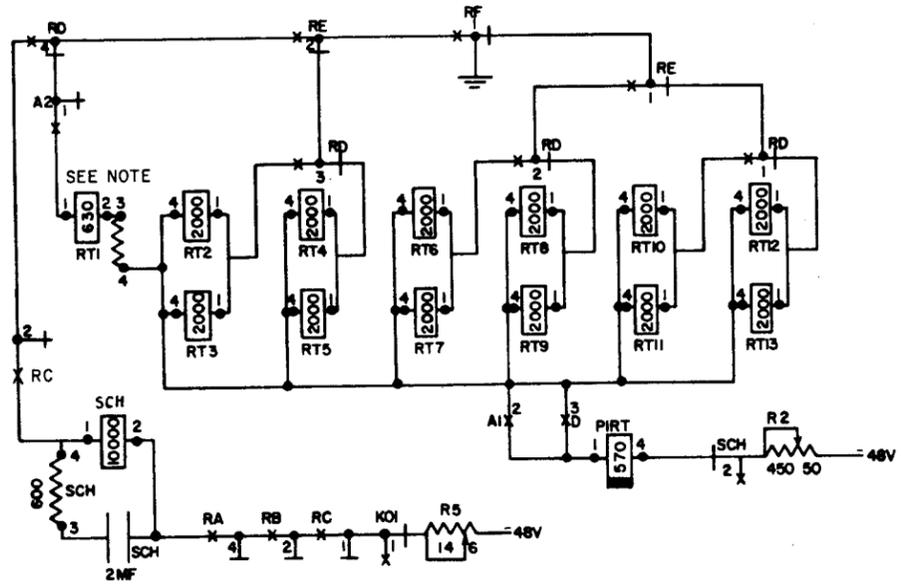
S-CONTACTS (1) CONTACT No. 2  
 (2,3) CONTACT No. 1

TRUNK CONDUCTOR (1) RING  
 (2,3) TIP



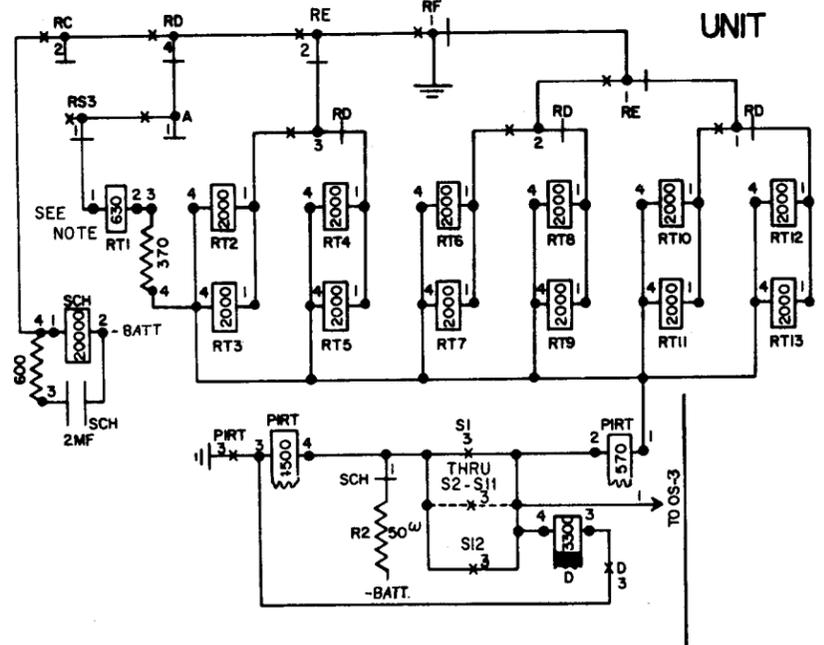
(1) 49-9-2  
 (2) 49-11+1-2  
 (3) 49-12-2

CENTRAL OFFICE UNIT

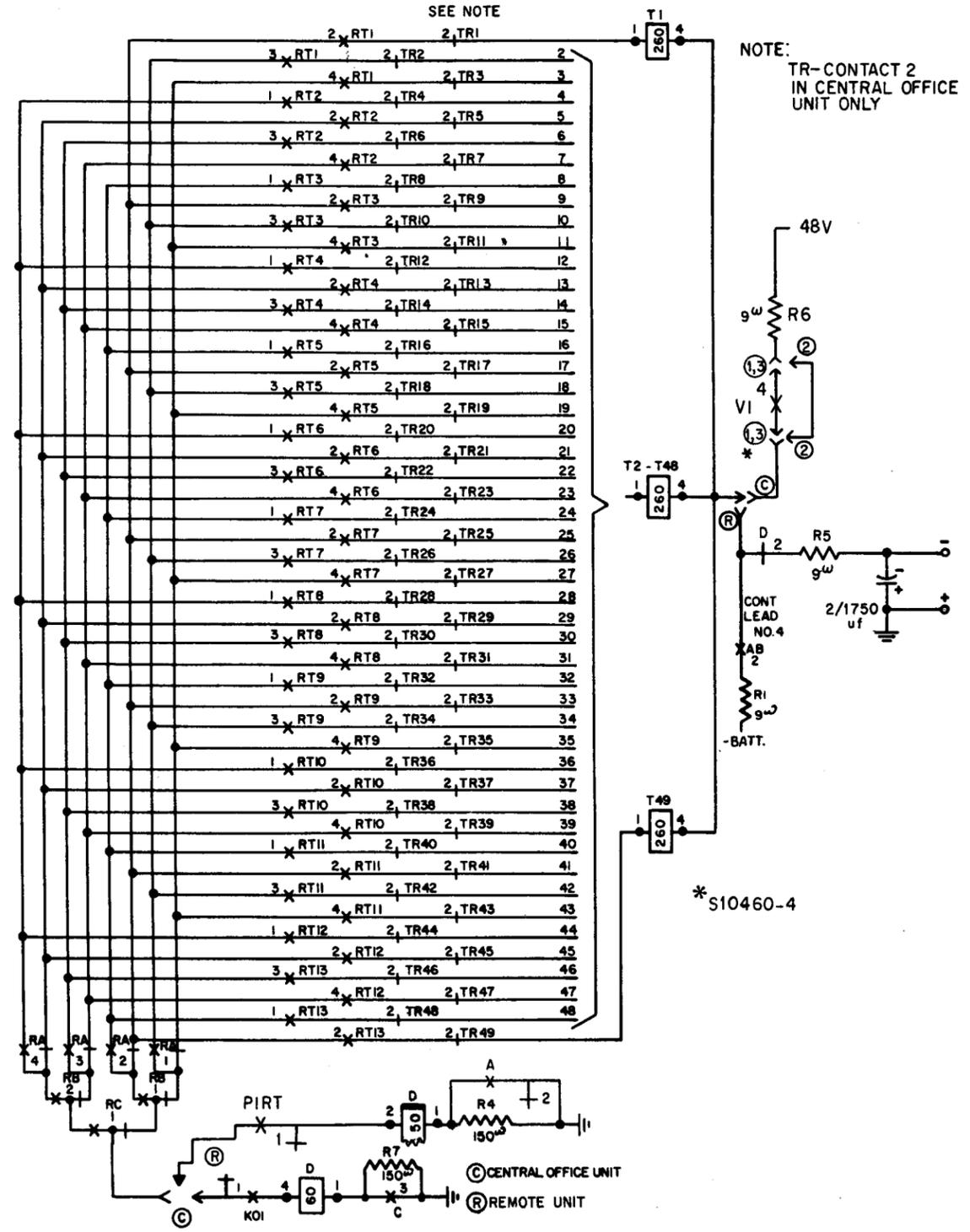


NOTE: RT1 RELAY  
 (2) ONE WINDING 1000Ω  
 (1,3) TWO WINDINGS  
 ONE INDUCTIVE 1 TO 2 630Ω  
 TWO NON-INDUCTIVE 3 TO 4 370Ω

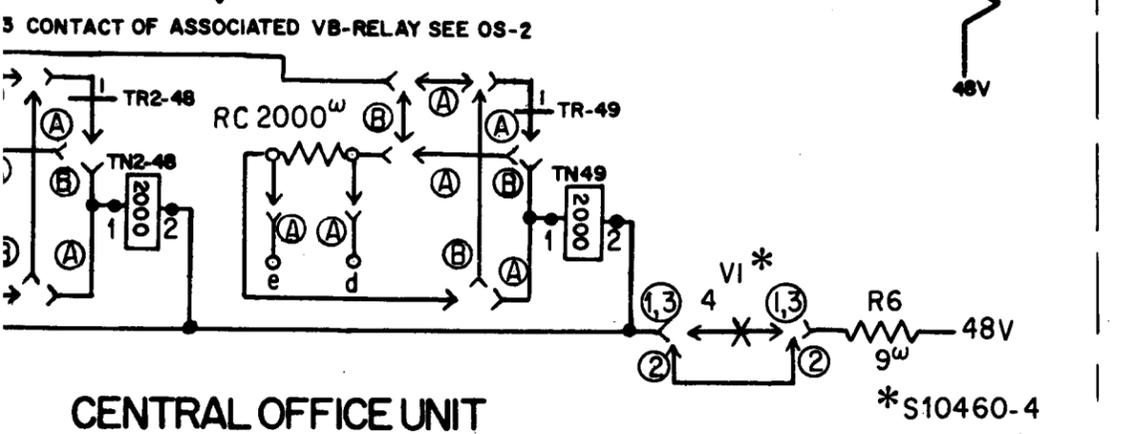
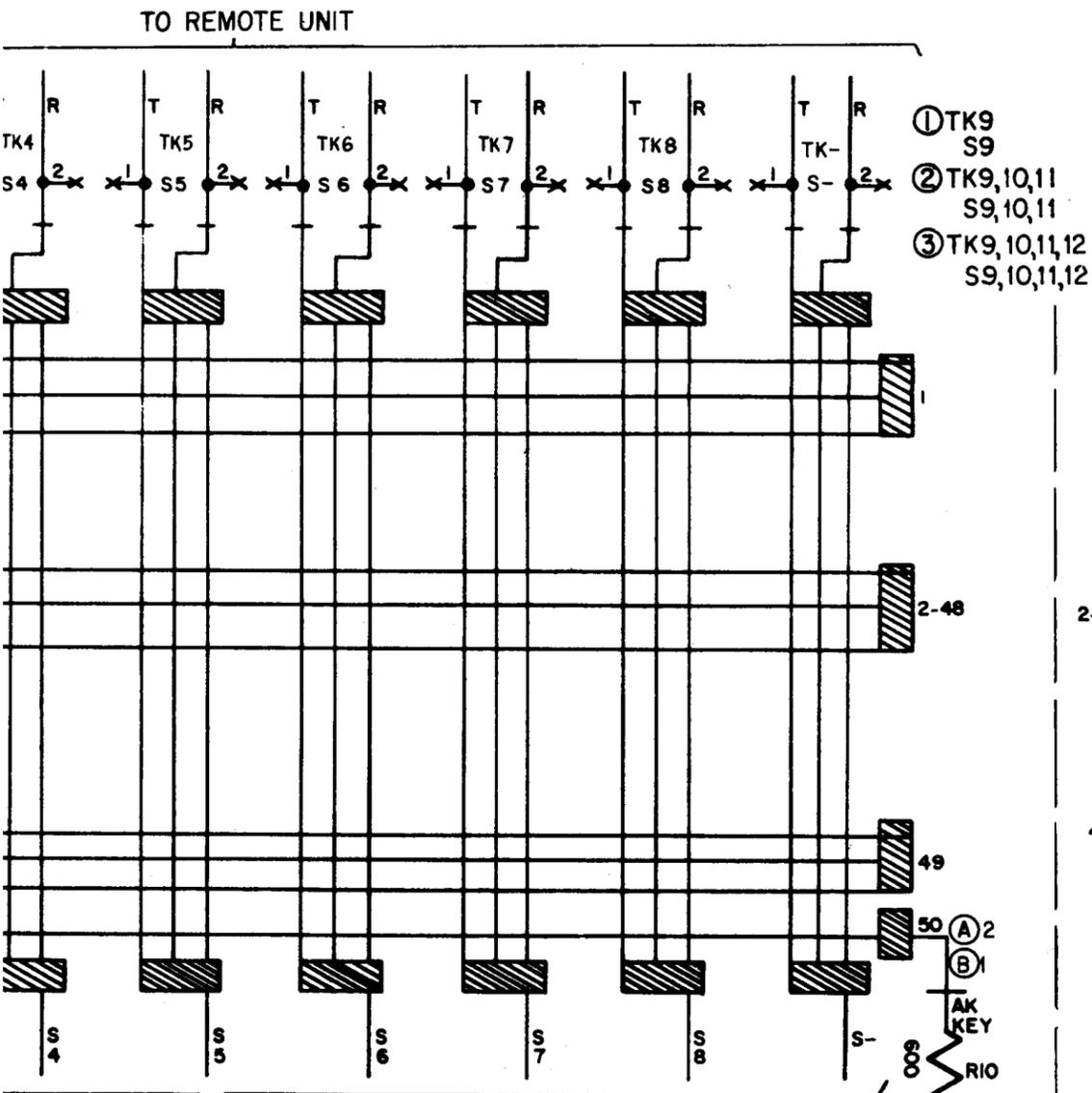
REMOTE UNIT



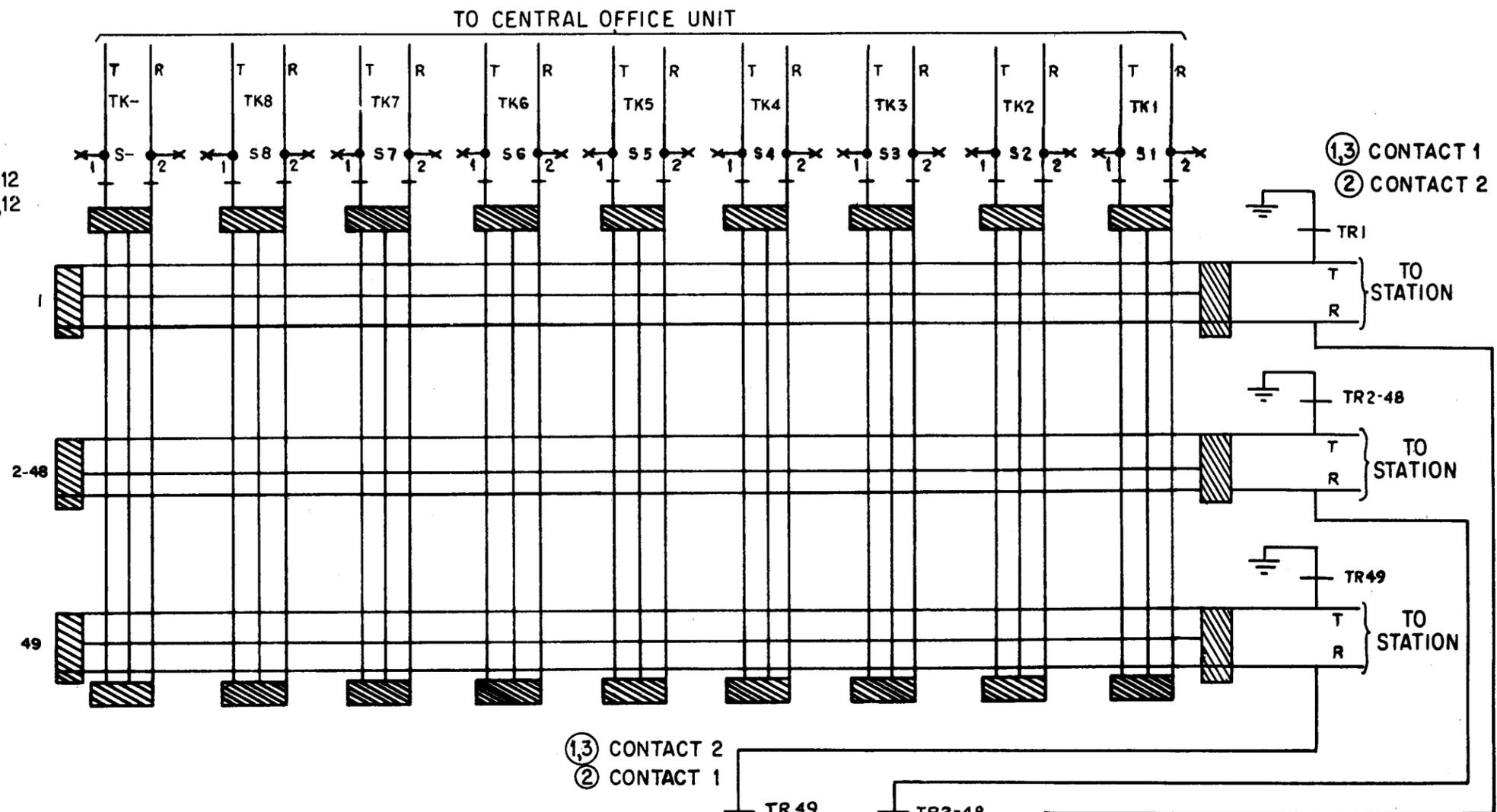
- ① 49-9-2
- ② 49-11-1-2
- ③ 49-12-2



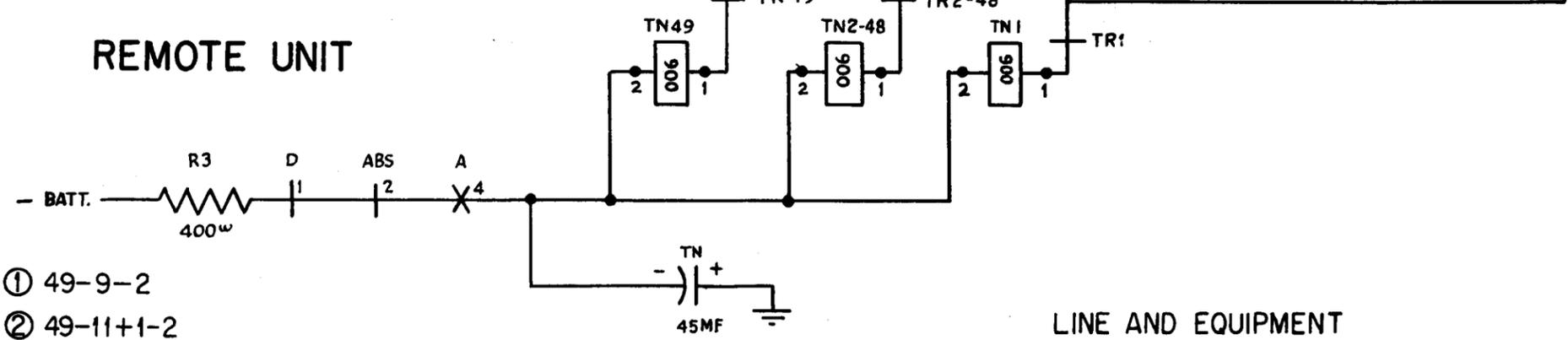
MAGNET CUT-IN RELAYS AND HORIZONTAL BAR MAGNET OPERATION OS4



CENTRAL OFFICE UNIT



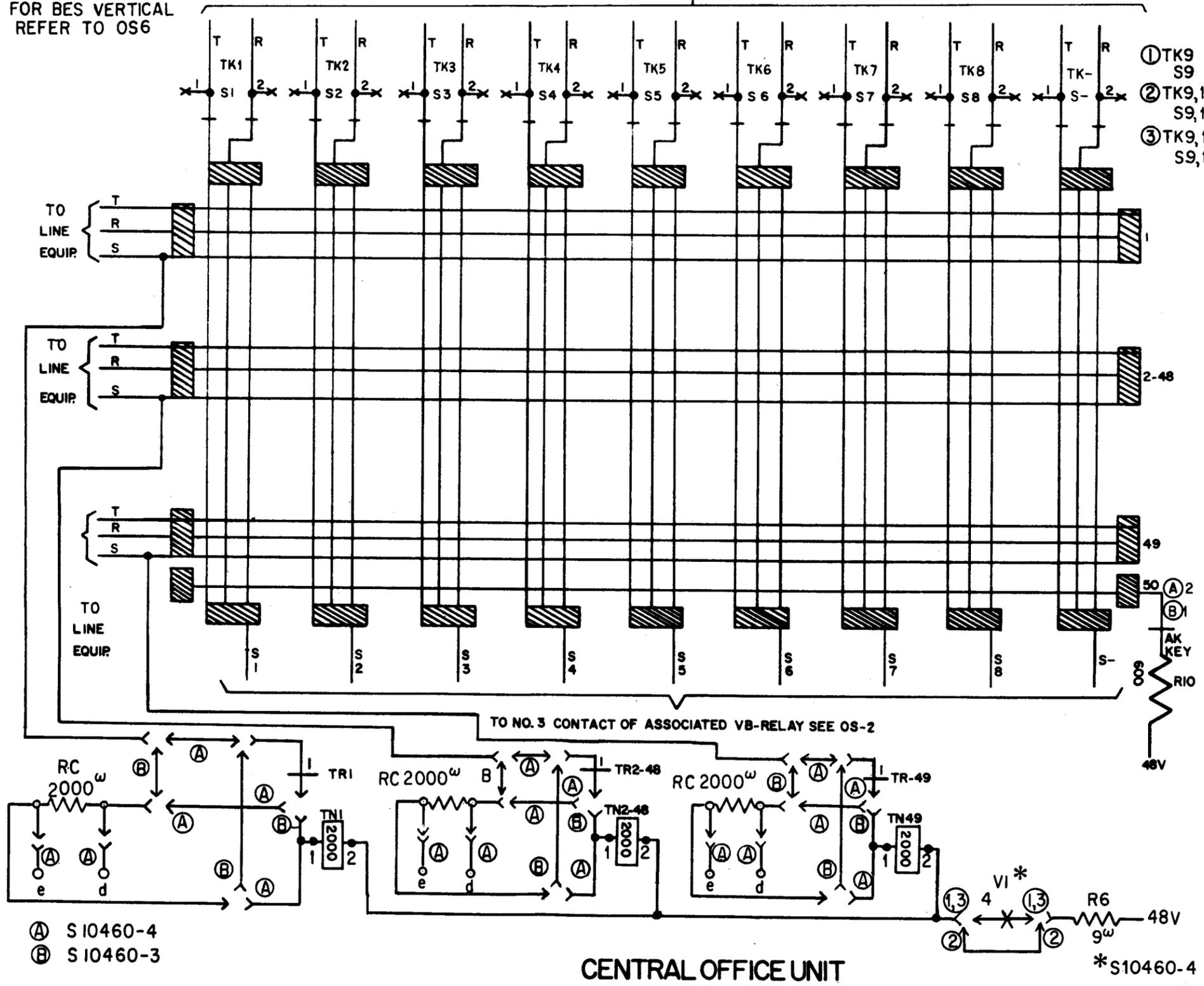
REMOTE UNIT



LINE AND EQUIPMENT  
RELAYS AND SWITCHES  
OS 5

FOR BES VERTICAL REFER TO OS6

TO REMOTE UNIT



TO CENTRAL OFFICE UNIT

