GFELLER SUBSCRIBER LINE CONCENTRATOR 49-9-2

DETAILED CIRCUIT OPERATION

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1. GENERAL

1.01 This is one of a group of sections, covering the Gfeller line concentrator, having the base numbers A804.901 and C85.010. This section contains a detailed circuit description, sequence charts, operational sketches and reference material.

1.02 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 nine vertical bars. There are two switches associated with each line concentrator, one in the central office unit and the other in the remote unit.

1.03 The Gfeller line concentrator enables 49 telephone lines, individual or multiparty, to be served by individual central office line equipment over nine cable pairs. This is the maximum capacity of one concentrator, but other combinations less than this can be utilized.

1.04 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.

2. SWITCH FUNCTIONS

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

2.02 Each horizontal bar has nine sets of wire contact fingers which are arranged so that a set is in line with each of the nine 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 nine tips are wired together, as are the rings and sleeves. The subscriber 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.

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. See Fig. 4.

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 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 subscriber relay TN-. At the subscriber unit both pairs of TR- contacts open the path for operating the subscriber TN- relay from the subscriber'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 SO-9 to correspond with their lift magnets SO-9. These contacts remain open until the lift magnets are operated.

2.08 In the central office unit the tips, rings, and sleeves of the 49 horizontal bars, and the tips and rings of the nine vertical bars are wired to a terminal strip within the unit. 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.

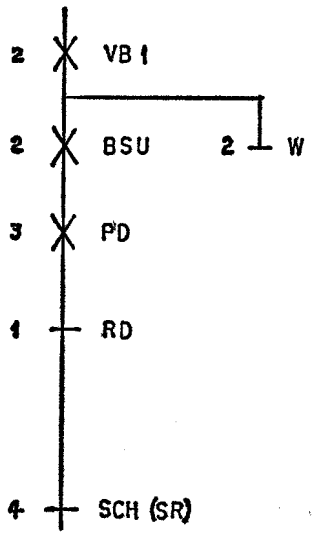
2.09 In the subscriber unit the tips and rings of the 49 horizontal bars and the nine vertical bars are wired to the lugs of a protector mounting within the unit. This provides protection against accidental contact of outside plant with foreign high voltages, lightning or sneak currents that might damage 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 $\times$ 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 below:

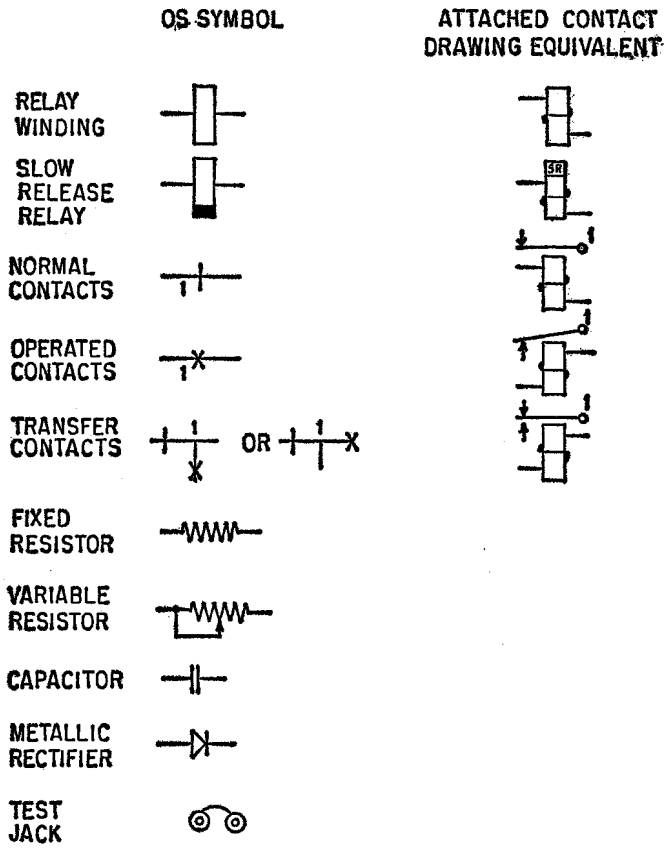


This is interpreted as follows: The VB1 relay operates followed by the release of the W relay and the operation of the BSU relay. The operated BSU relay causes the operation of the PD relay, which in turn causes the release of the RD relay. The released RD relay causes the release of the SCH relay which 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).

TABLE A



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 subscriber 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 A804.901.04, C85.010.04. 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 nine 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 nine vertical bars on horizontal bar 50 manually necessitates holding horizontal bar 50 to the right until each of the nine vertical bars has been, in turn, raised and then dropped. This will provide battery on the sleeves of the nine vertical bars, simulating an idle sleeve indication. This is necessary for the functions of preselecting the vertical bars. After the nine vertical bars have each been used once to serve a call, the sleeve indication will be provided by the connected subscriber 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 70 volts ac 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.

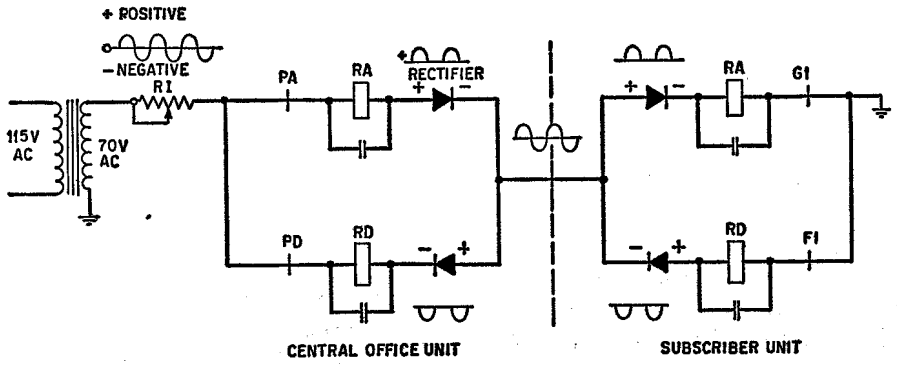


Fig. 1

4.06 The 115-volt alternating current from the commercial power supply is stepped down to 70 volts 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 applied to the circuit can be varied by the adjustment of a variable resistor, RI.

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

TABLE C HORIZONTAL BAR (SUBSCRIBER) 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	x	x	-	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

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 Semiconductor 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 subscriber 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 subscriber 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: AB, AB1, M, SCH, UB, and W. The T50 subscriber coil is energized, operating horizontal bar 50. The operated AB relay operates relay C and closes battery to control pair 4, operating the SCH relay and charging the 3500 MF capacitor in the subscriber 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 sleeve flag contact and horizontal bar 50 sleeve contact finger to 600-ohm battery through the AK key normal. 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.

4.15 The release of relay RD, at the central office end of the marking circuit, releases relay SCH which in turn operates relays 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.

4.16 The release of relay RD, at the subscriber 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 subscriber 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. 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 contacts of lift magnet S1, the S1 magnet 300-ohm winding to ground at 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 is closed through the 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 subscriber unit. The path continues through the No. 2 operated contacts of the S1 lift magnet operated, the S1 magnet 300-ohm winding to ground through the A relay winding, thus operating the A relay in each unit. This also provides a holding path for the S1 magnet in the subscriber unit. The central office lift magnet S1 is provided 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.

4.18 The subscriber 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.

4.19 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. 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 concentrator. It will be covered in detail later under trouble detecting features.

4.20 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 releases 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.

4.21 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 tip side of trunk 1. The subscriber unit is now in a condition to serve an originating call. The operation of the A1 relay in 4.17 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 subscriber connected to horizontal bar 2 and assumes vertical bar (trunk) 1 has been preselected 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 subscriber unit. This closes a circuit from ground on the winding of relay G6 through resistor RTN-2 and both windings in series of relay F1 through normal contacts of all F relays 1 through 7, the operated contacts of the S1 lift magnet over the tip cable pair of trunk 1 to the central office unit. The path continues through the operated contacts of lift magnet S1, the 1-2 winding of relay U1, through variable resistor R12, operated contacts of relays AB1 and A2 and resistor R4 to battery. 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 contacts. This decreases the circuit resistance which increases the current flow in the circuit, allowing relay F1 to operate. The F1 relay short-circuits its 3-4 winding thereby further increasing the current permitting relay G6 to operate.

5.03 The G6 and F1 marking control relays operated in the subscriber 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 GG 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.

5.04 At the subscriber unit magnet T2 is operated through contacts of the operated RA, normal RB and RC relays, operated PIRT relay to battery 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.

5.05 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.

5.06 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.

5.07 Relay C released also opens the circuit for the subscriber 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.

5.08 The subscriber station is now closed through the subscriber 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.

5.09 At the subscriber unit the released vertical bar S1 contacts open the circuit for relay RT1 which in turn releases magnet T2. The S1

contacts opened also open the circuit to slow release relay D.

5.10 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.

5.11 All the marking relays RA to RF operated in both units operate their respective SCH relay. The SCH relay operated in the subscriber 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.

5.12 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.

5.13 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.

5.14 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 subscriber unit through its operated contacts S2, the 300-ohm winding of lift magnet S2 to the winding of the A relay. 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.

5.15 At the subscriber unit relay A releases the PIRS and RS1 relays. At the central office unit relay A operates relay A1 which in turn operates the V relay. Relay V operated releases marking control relay PC which closes the circuit for marking relays RC and they reoperate. 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 tip side of trunk 2. The subscriber unit can now serve the next originating call.

5.16 The connection established on this call will remain closed through the switches after the subscriber 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 subscriber will be connected through to the central office equipment.

5.17 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.

5.18 *Walking Circuit:* The walking circuit as mentioned above consists of relays VB1 to 9, M, N, W, BSU, and BSG. 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 sleeve).

5.19 M and N are slow release relays that function together to alternately operate the odd and even VB- relays. One of the even VB- relays will be operated with relay M operated and one of the odd 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 established connection (see 5.16) 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. 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 the 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. If all trunks are busy the circuit will continue to walk until a trunk becomes idle (BSU or BSG operated).

5.20 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.

5.21 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 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.

5.22 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.

5.23 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 subscriber 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 subscriber 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 winding of relay F1, operated TN1 relay contacts, windings 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 through contacts of magnet S2.

6.04 Relay U1 normally operates to ground at the subscriber 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 subscriber 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.

6.05 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.

6.06 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.

6.07 In the subscriber 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.

6.08 At the central office unit relay PIRT operated, operates relays KO1 and KO. Relays KO1, RA to RC, and RT1 operate magnet T1 and relay D in series. Relay D operated releases relay C and horizontal bar 50. Relay KO1 operated releases relay AB1 which in turn releases relays K, F1, and G5. Relay K released reoperates relay U. Relay C released, releases relay A1 which in turn starts the release of relay V.

6.09 Released relay C, in the same manner as in 5.06, 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 subscriber unit removes relay TN1 and ground from the ring and tip to the subscriber loop. The released S2 magnet contacts in each unit, also releases relays RT1, D, and magnet T.

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

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

6.12 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.

6.13 The lift magnets operated, operate the check relays A in both units. The A relay operated in the subscriber unit releases relays PIRS, RS2, and RS3. The A relay operated in the central office unit operates relay A1 which in turn operates relay V. Relay V operated releases relays PA and PD. Relay PR released reoperates marking relays 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 subscriber 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.

6.14 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 release opens the battery supply to the magnets and relays in the subscriber unit. This causes the T- magnet and any relays that are operated to release. Relay AB released also releases relay C in the central office unit. Relay C released, releases the preselected S- magnet in each unit. At the subscriber unit, no switch connection will be established when the vertical bar drops. At the central office unit, however, a sleeve connection will be established to bar 50. The S- magnets releasing, release both A relays and relay A1 which in turn releases relay PIRT. Relay PIRT released, operates relay AB which recloses the battery supply to the subscriber unit over control lead 4. Relay PIRT also releases relays KO and KO1 which in turn reoperate the released marking relays. Released relay PIRT releases relay AB1 which in turn releases relay K and marking control relays F1 and G5. Relay SCH reoperates through operated relays RA to RF in each unit.

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 relays V and UB. Relay V operated releases marking control relay PD which in turn releases relays PIRS, RD, RS2, and RS3 in each unit and relay M in the central office unit. Relay PIRS released, releases relay KO. Relay M released, releases relay X and operates relay VB2. 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.

7.12 Relay X released, releases relay V which in turn operates relay PC. 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.

7.13 *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.

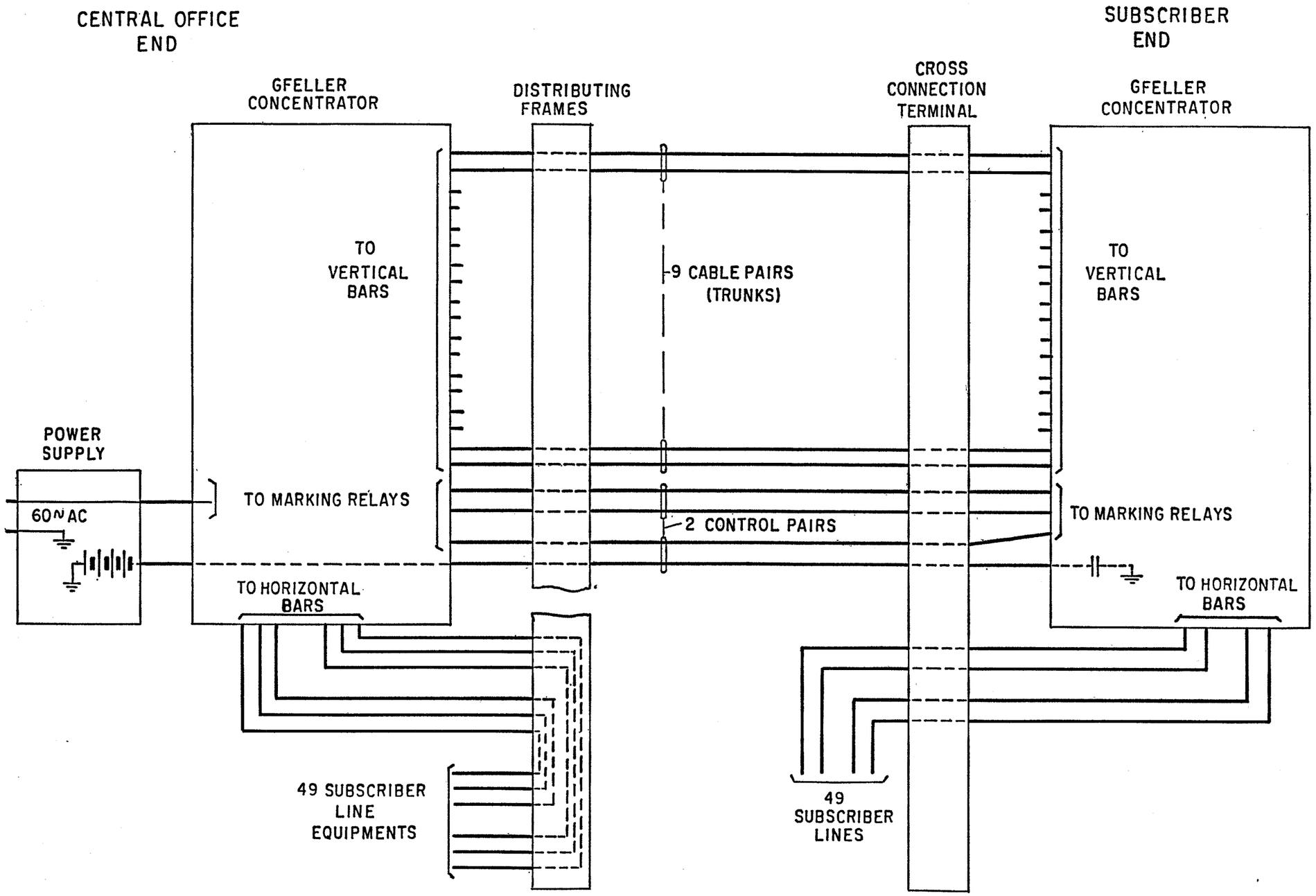
7.14 Holding key AK operated in the central office unit will close through a path to operate relays K, G6, and F7 in the same manner as on a terminating call. The relay functions are similar to a terminating call except relay D does not operate. This allows magnet T50 to remain operated until the vertical 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.

7.15 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.

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

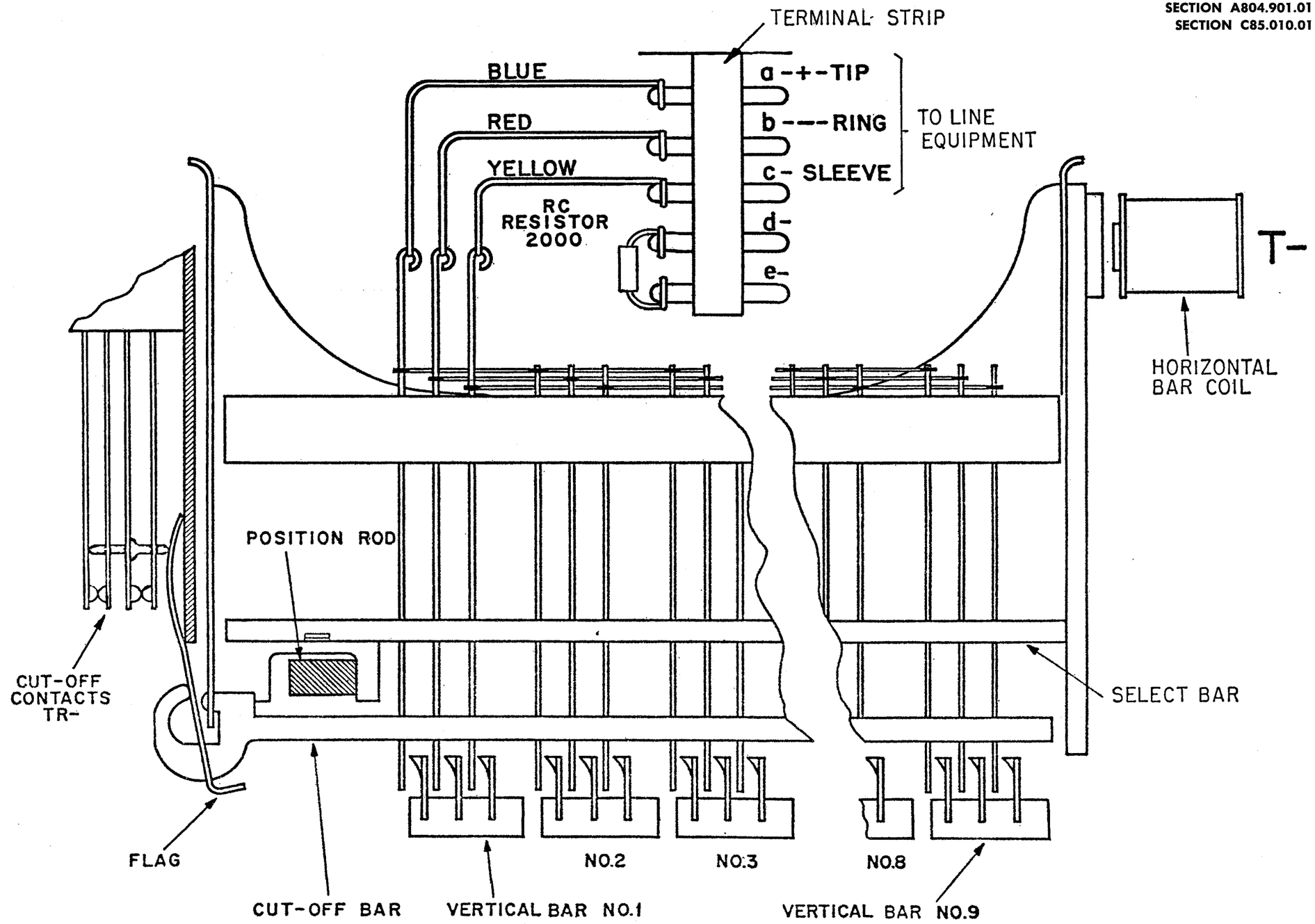
7.17 Holding key AK operated in the subscriber unit will close through a path to operate the associated G6 and F7 relays over the tip side of a trunk through the winding of relay U1 in the same manner as on an originating call. The relay functions are similar to an originating call except that no horizontal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

7.18 The operation of either of the AK keys will affect service calls because of their position in the F- and G- relay chains.



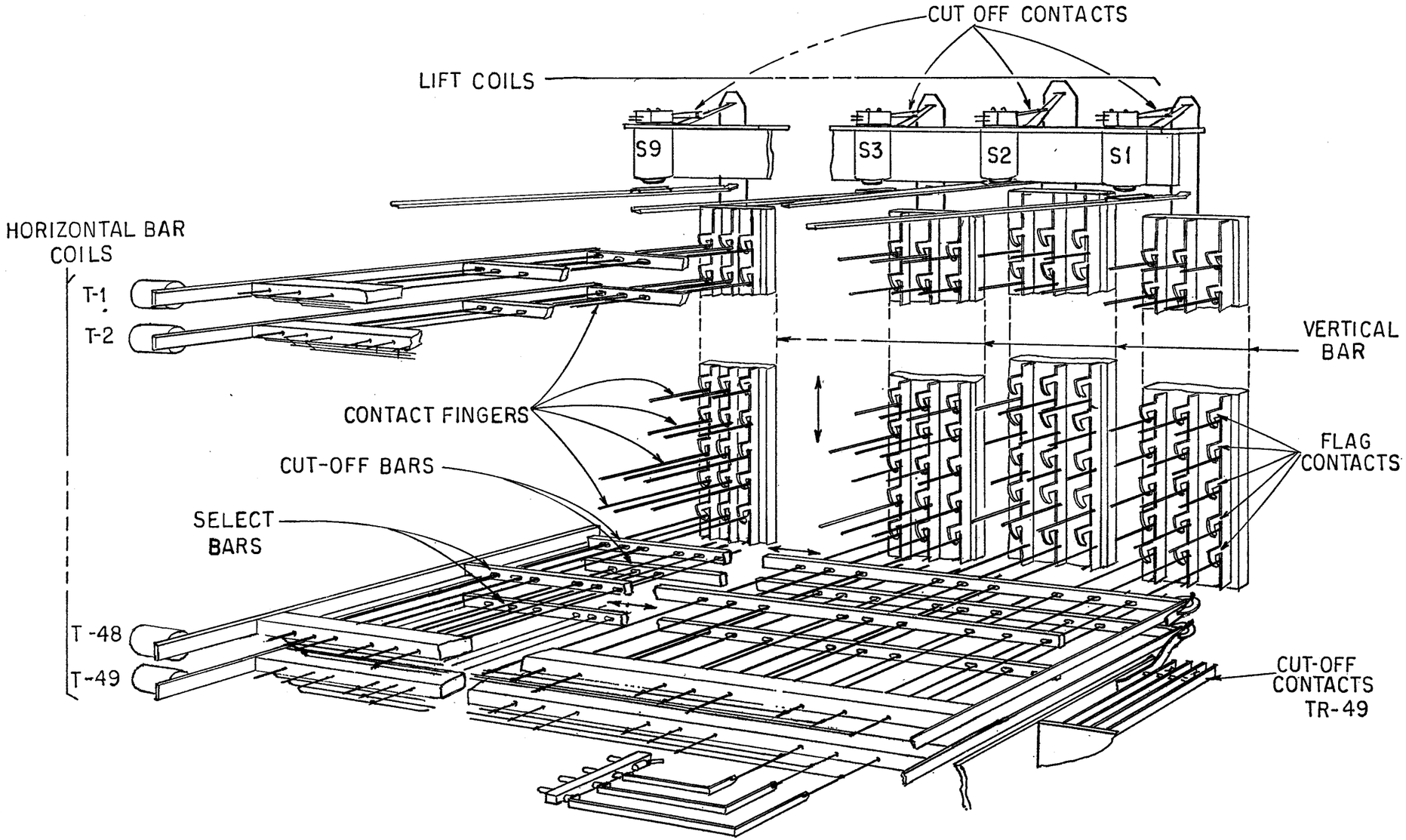
BLOCK DIAGRAM OF TYPICAL LAYOUT

FIG. 2

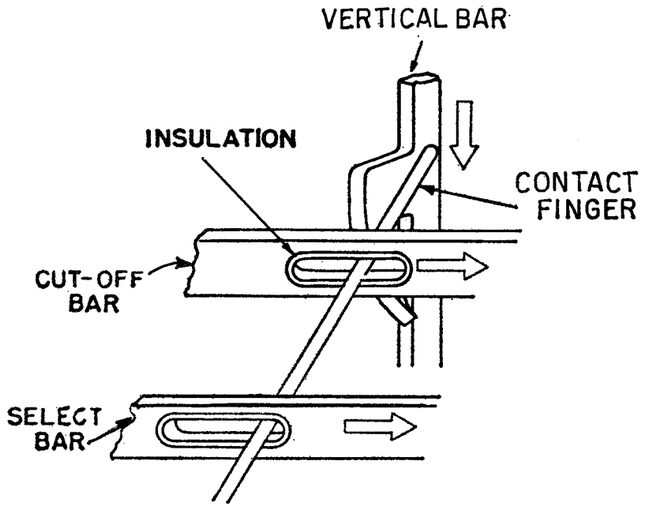


HORIZONTAL BAR MULTIPLE WIRING

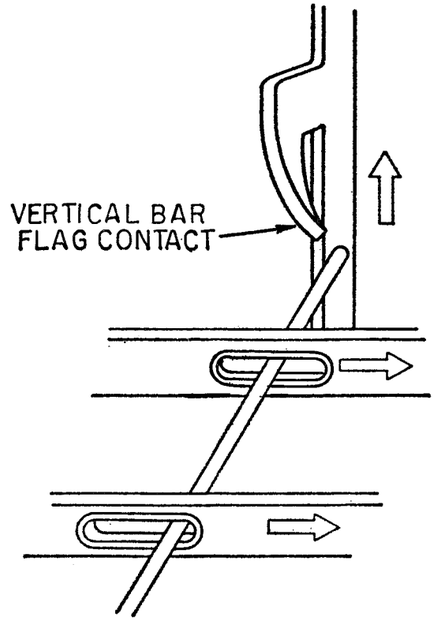
FIG.3



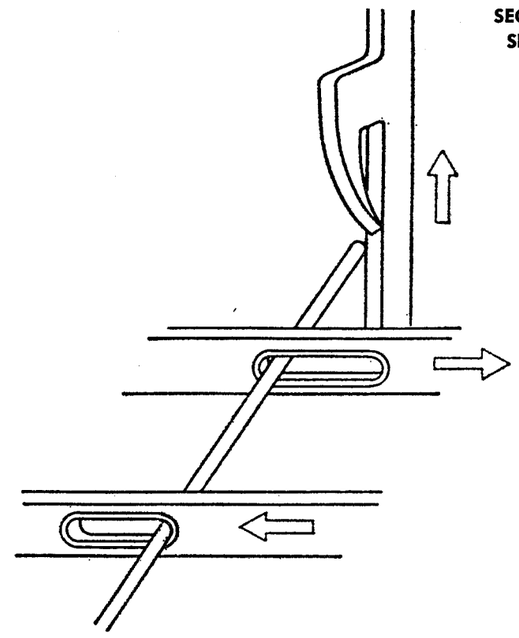
SWITCH
REAR VIEW
FIG. 4



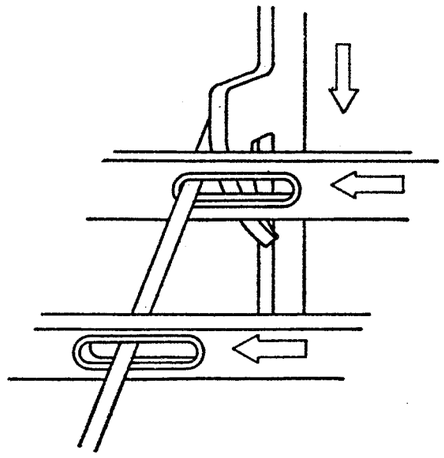
1 NORMAL SELECT AND CUT-OFF BARS
NON-LOADED VERTICAL BAR



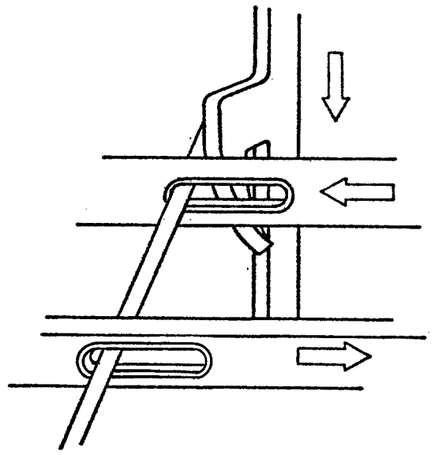
2 NORMAL SELECT AND CUT-OFF BARS
LIFTED VERTICAL BAR



3 OPERATED SELECT BAR
NORMAL CUT-OFF BAR
LIFTED VERTICAL BAR

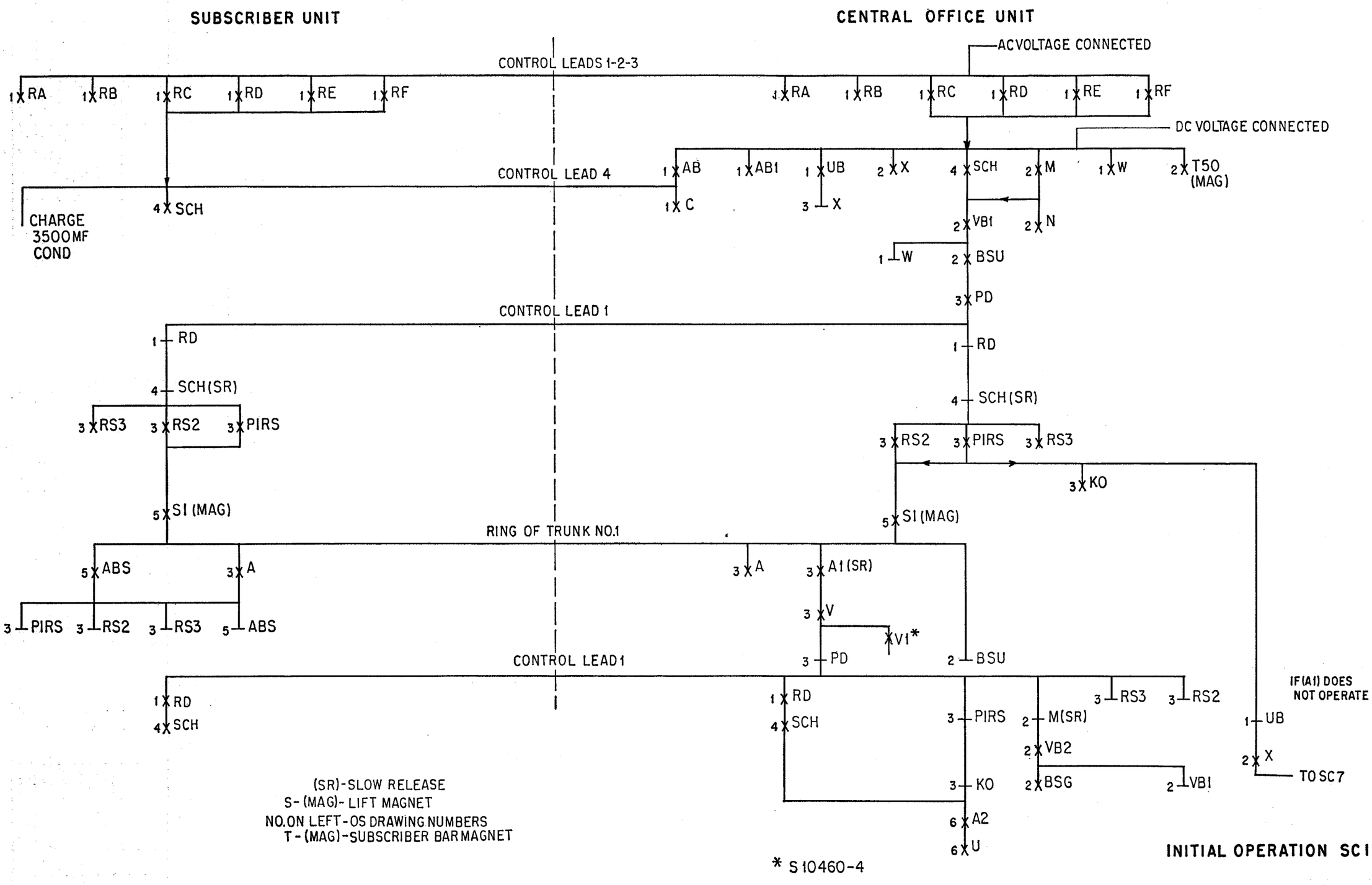


4 OPERATED SELECT AND CUT-OFF BARS
VERTICAL BAR LOADED ON HORIZONTAL BAR

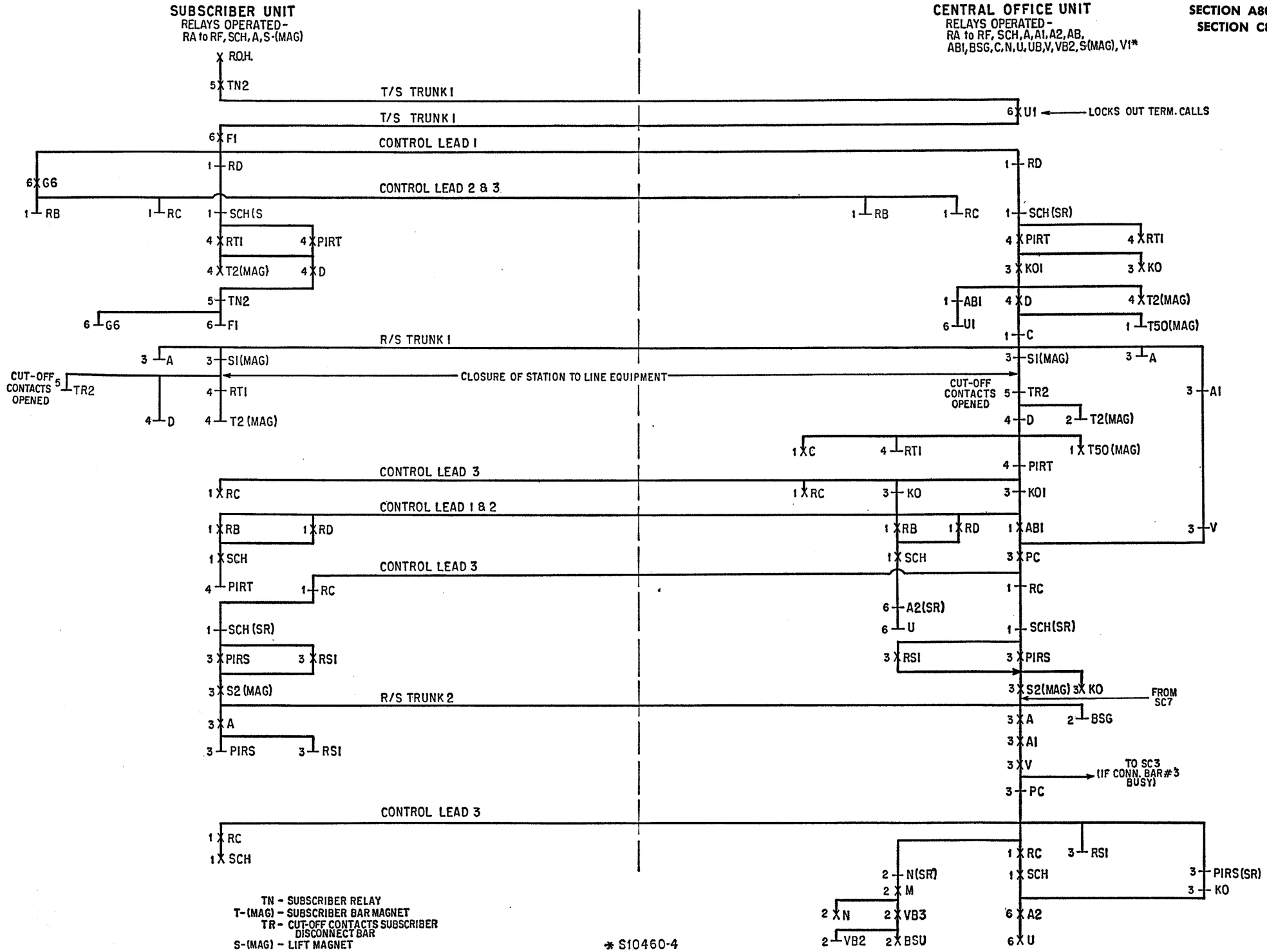


5 NORMAL SELECT BAR
OPERATED CUT-OFF BAR
VERTICAL BAR LOADED ON HORIZONTAL BAR

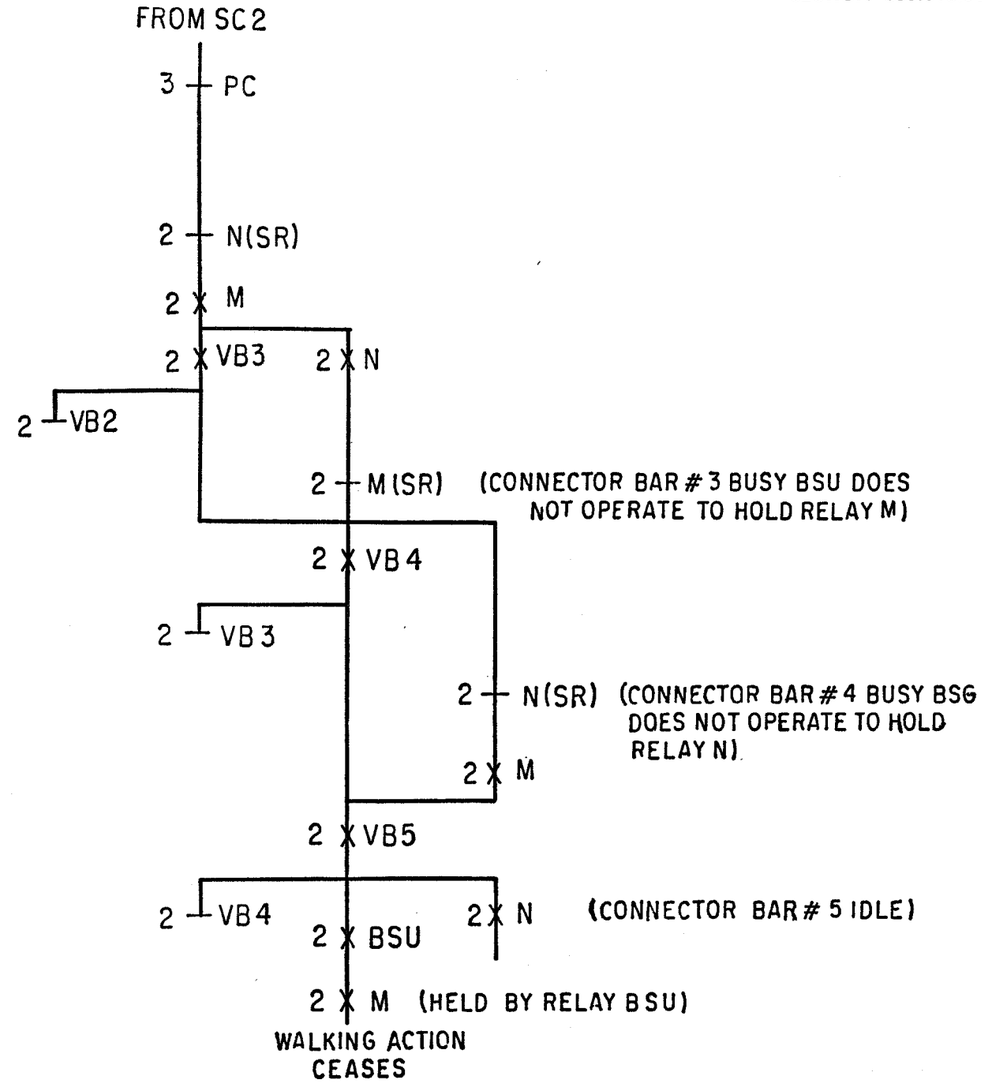
FIG. 5
CONTACT FINGER AND FLAG ENGAGEMENT



INITIAL OPERATION SC1



ORIGINATING CALL LINE #2 TO TRUNK #1 SC2



(SR)- SLOW RELEASE

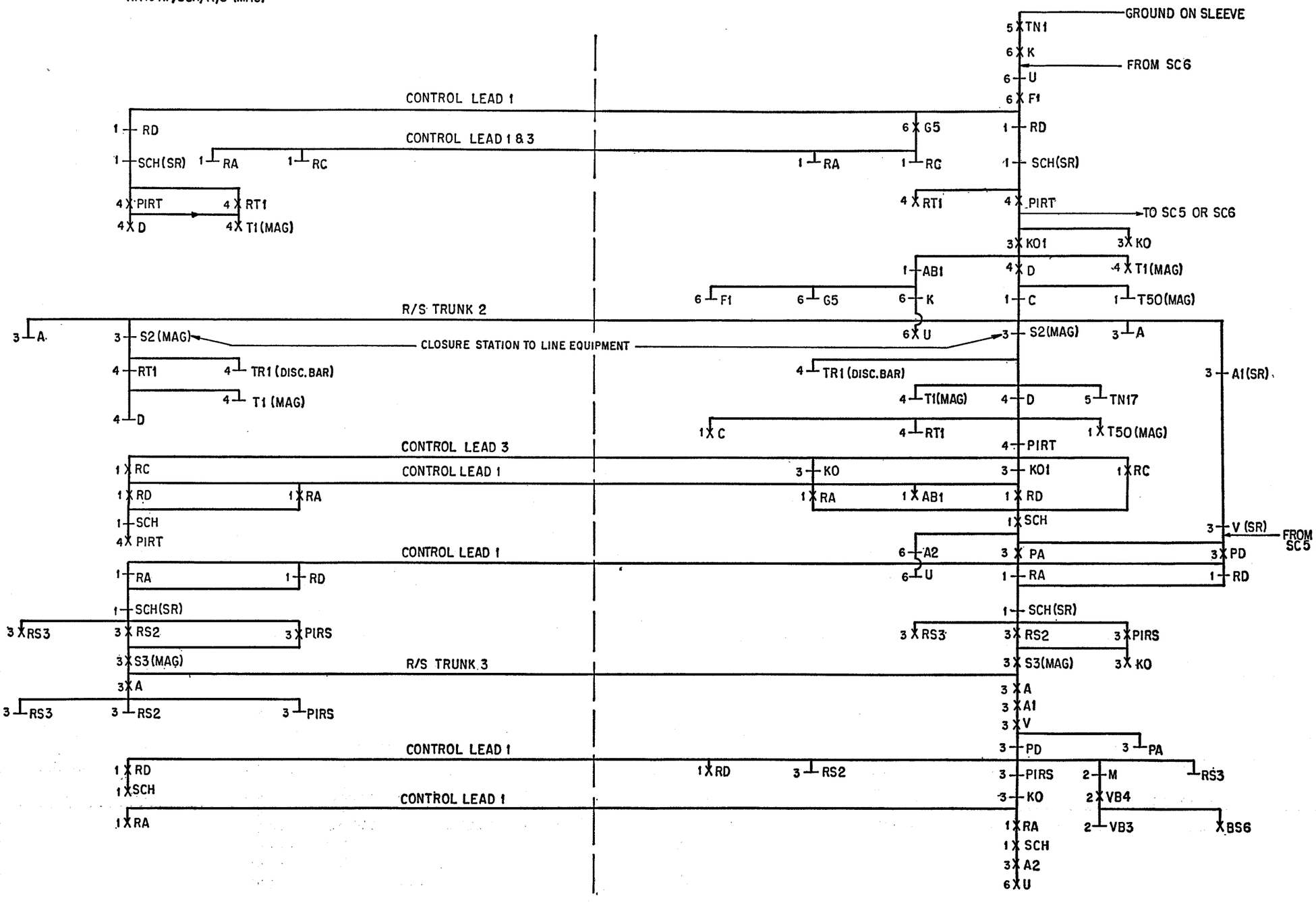
WALKING CIRCUIT SC3-

SUBSCRIBER UNIT

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

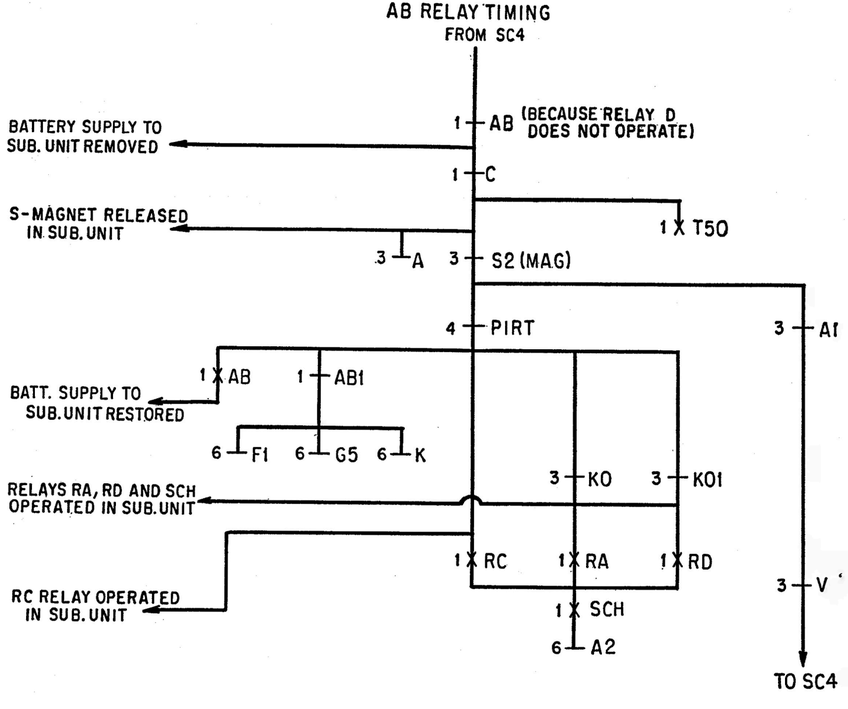
CENTRAL OFFICE UNIT

RELAYS OPERATED: RA to RF, SCH, A, A1
A2, AB, AB1, BSU, C, N, U, UB, V, VB3, S-(MAG), V1 *

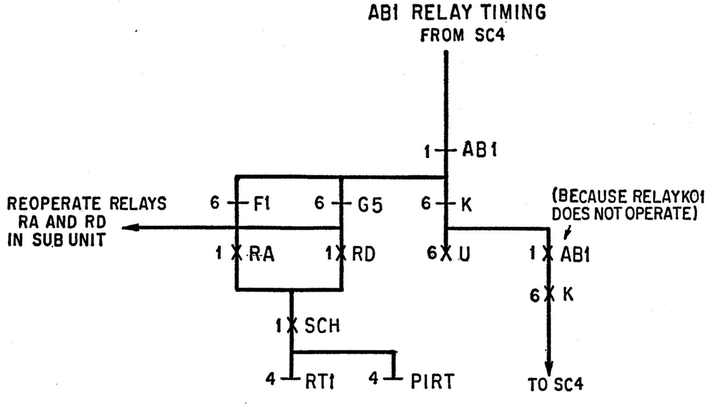


* S10460-4

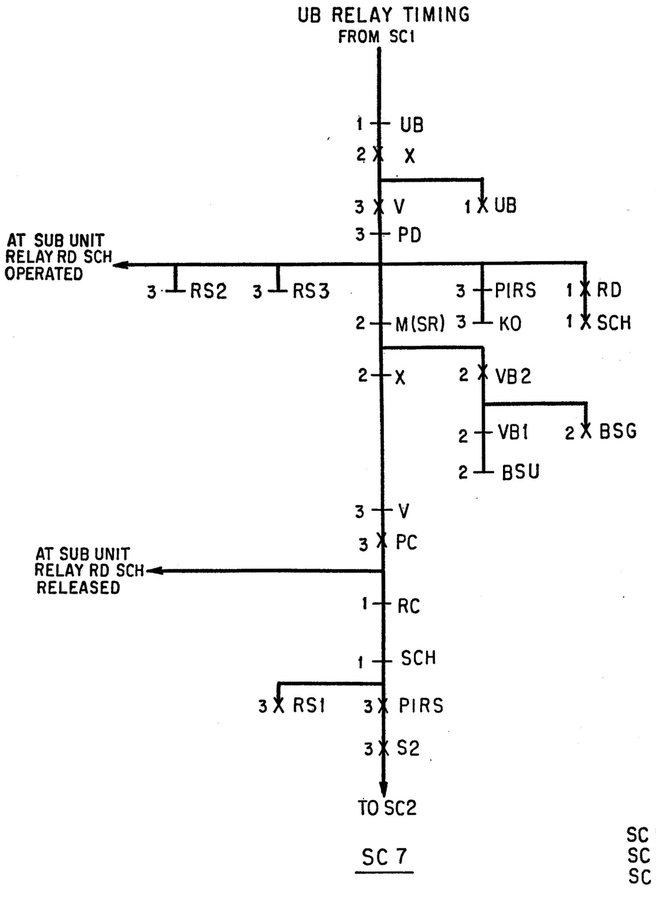
TERMINATING CALL
LINE #1 TO TRUNK # 2 SC4



SC 5

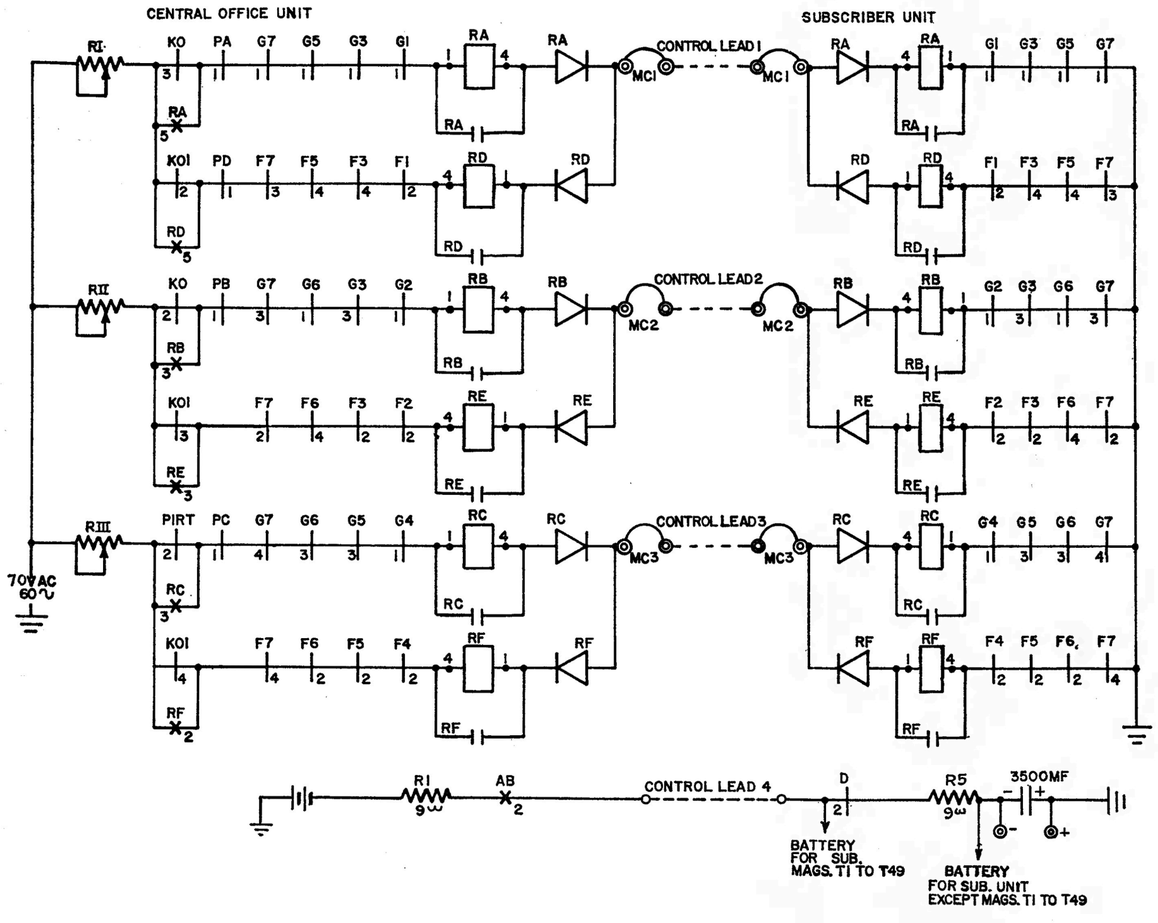


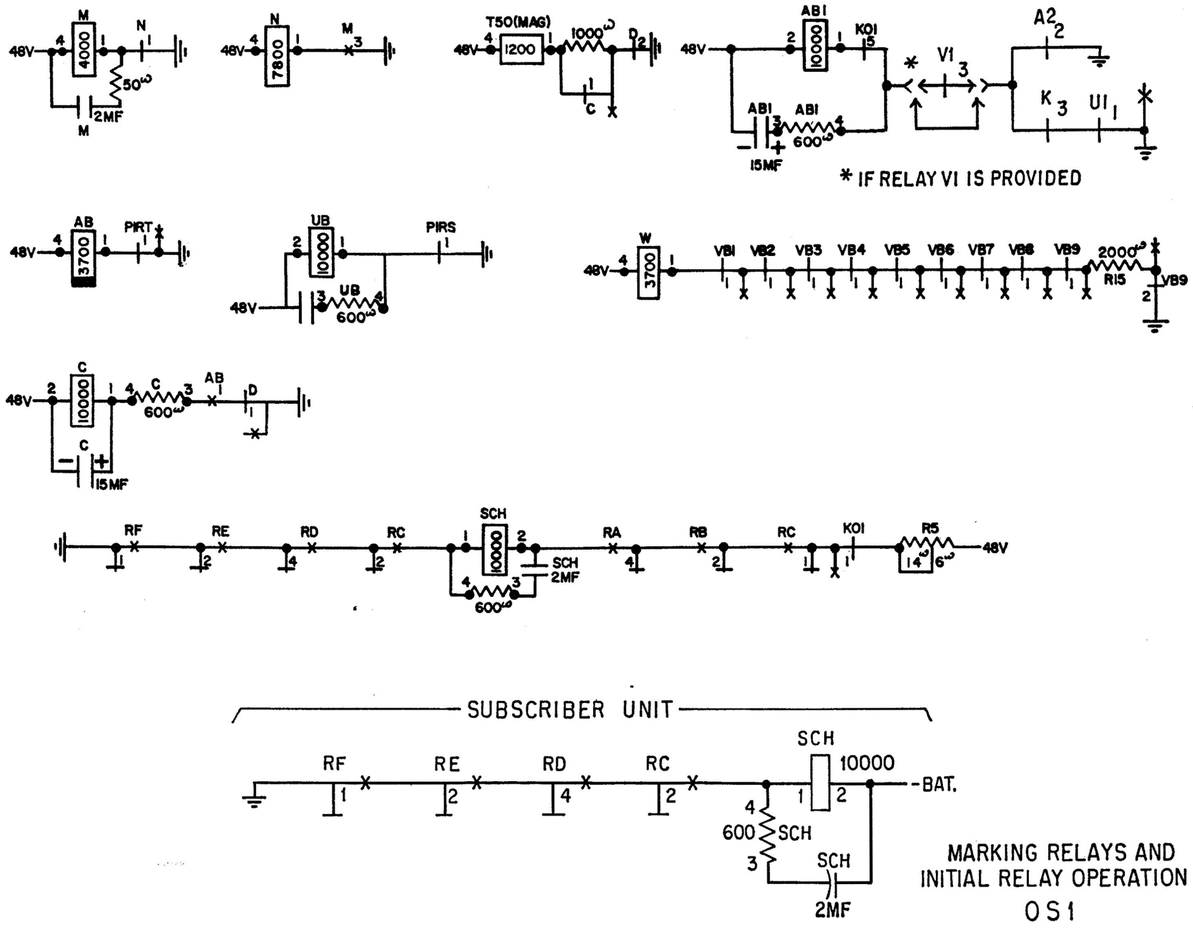
SC 6

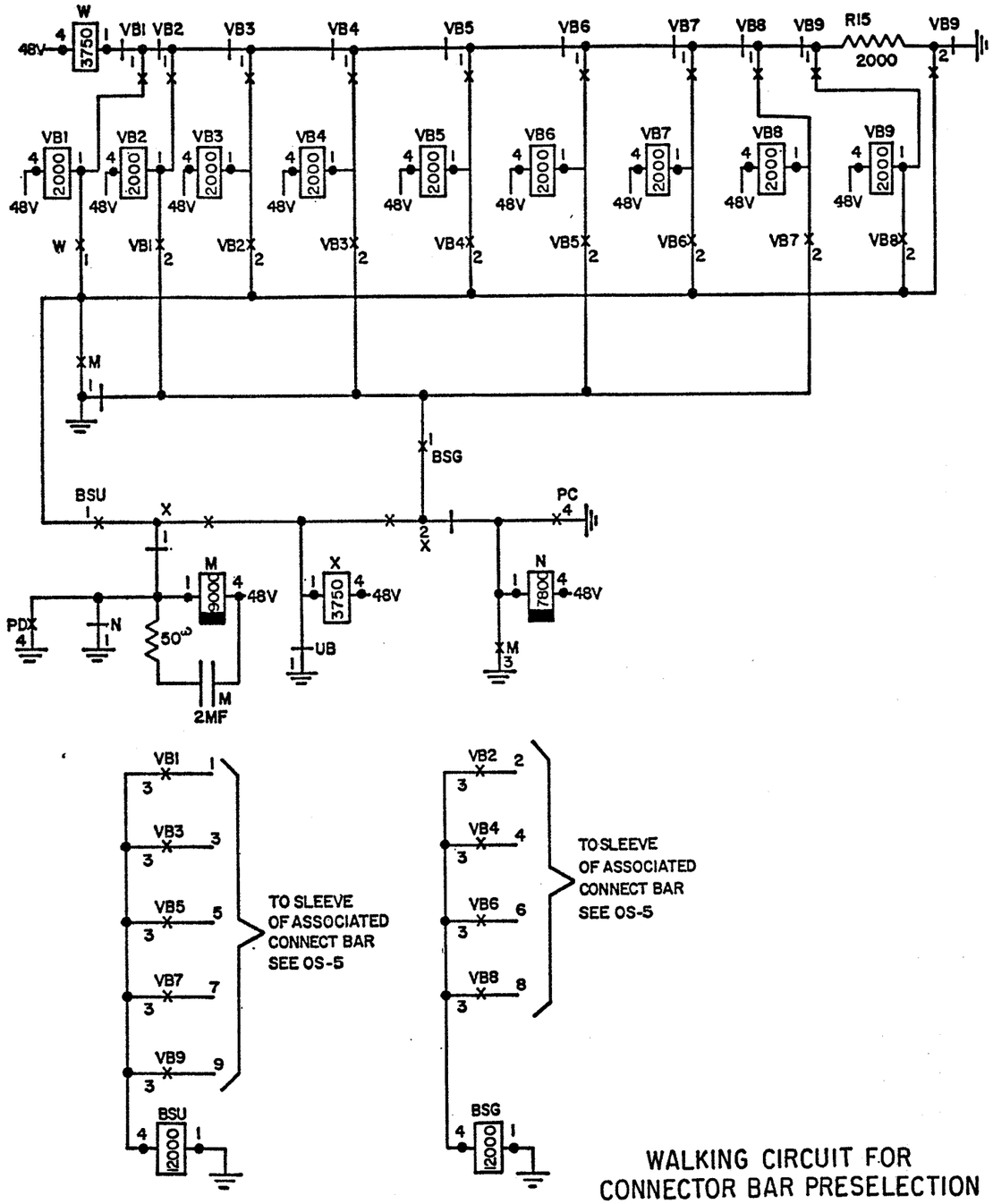


SC 7

SC 5
SC 6
SC 7

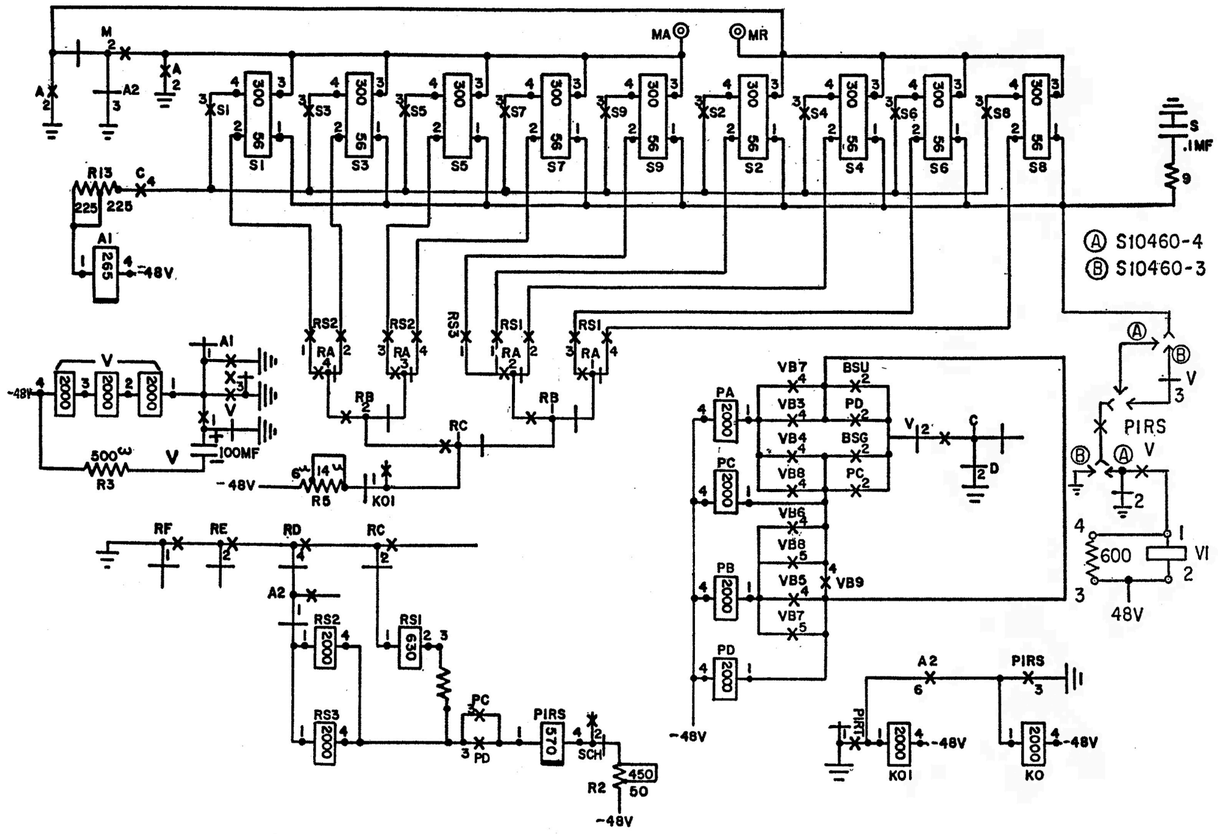

CENTRAL OFFICE UNIT
SUBSCRIBER UNIT
CONTROL LEAD 1
CONTROL LEAD 2
CONTROL LEAD 3
CONTROL LEAD 4
MC1
MC2
MC3
RI
RII
RIII
70V AC 60~
3500MF
BATTERY FOR SUB. MAGS. T1 TO T49
BATTERY FOR SUB. UNIT EXCEPT MAGS. T1 TO T49


48V
T50(MAG)
1000ω
1200
7800
4000
3700
10000
600ω
50ω
2MF
15MF
* IF RELAY VI IS PROVIDED
SUBSCRIBER UNIT
SCH
BAT.
MARKING RELAYS AND INITIAL RELAY OPERATION
OS1

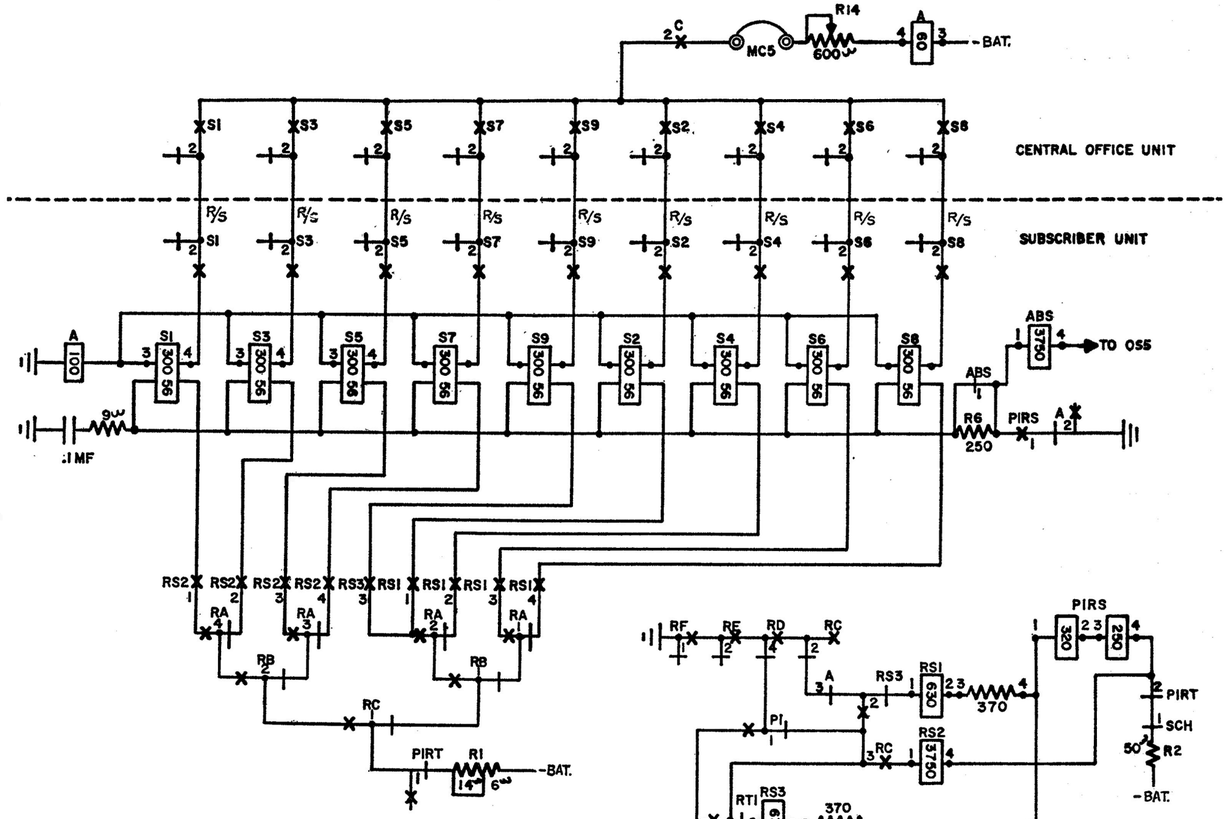


WALKING CIRCUIT FOR
CONNECTOR BAR PRESELECTION

OS 2



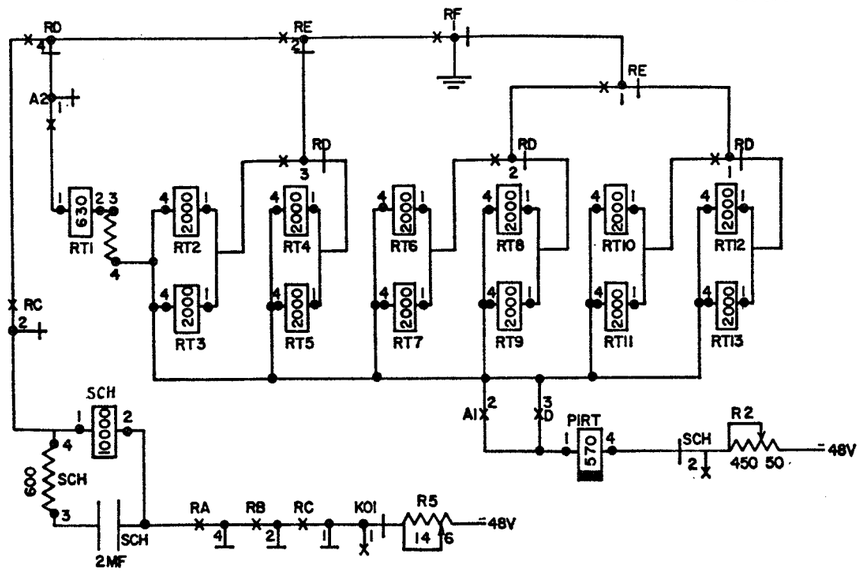
CENTRAL OFFICE UNIT



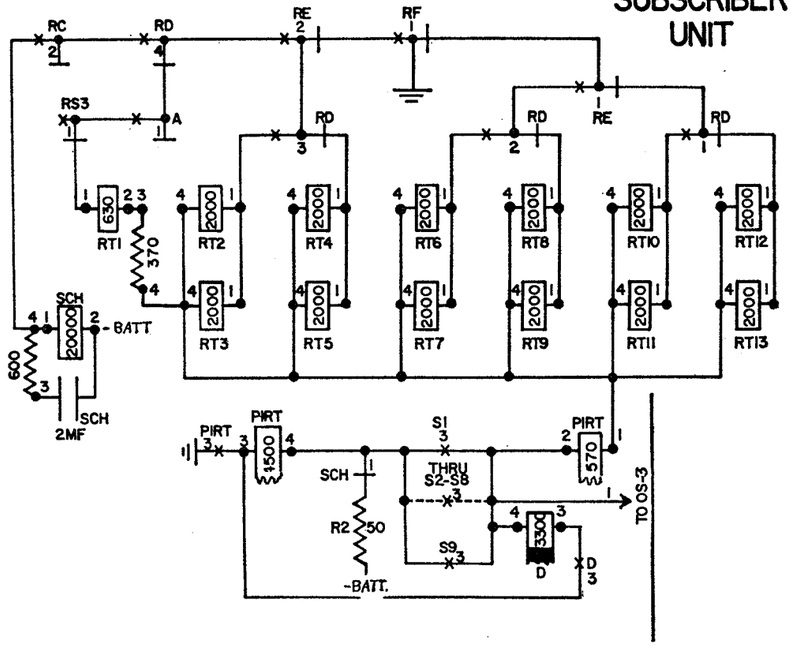
SUBSCRIBER UNIT

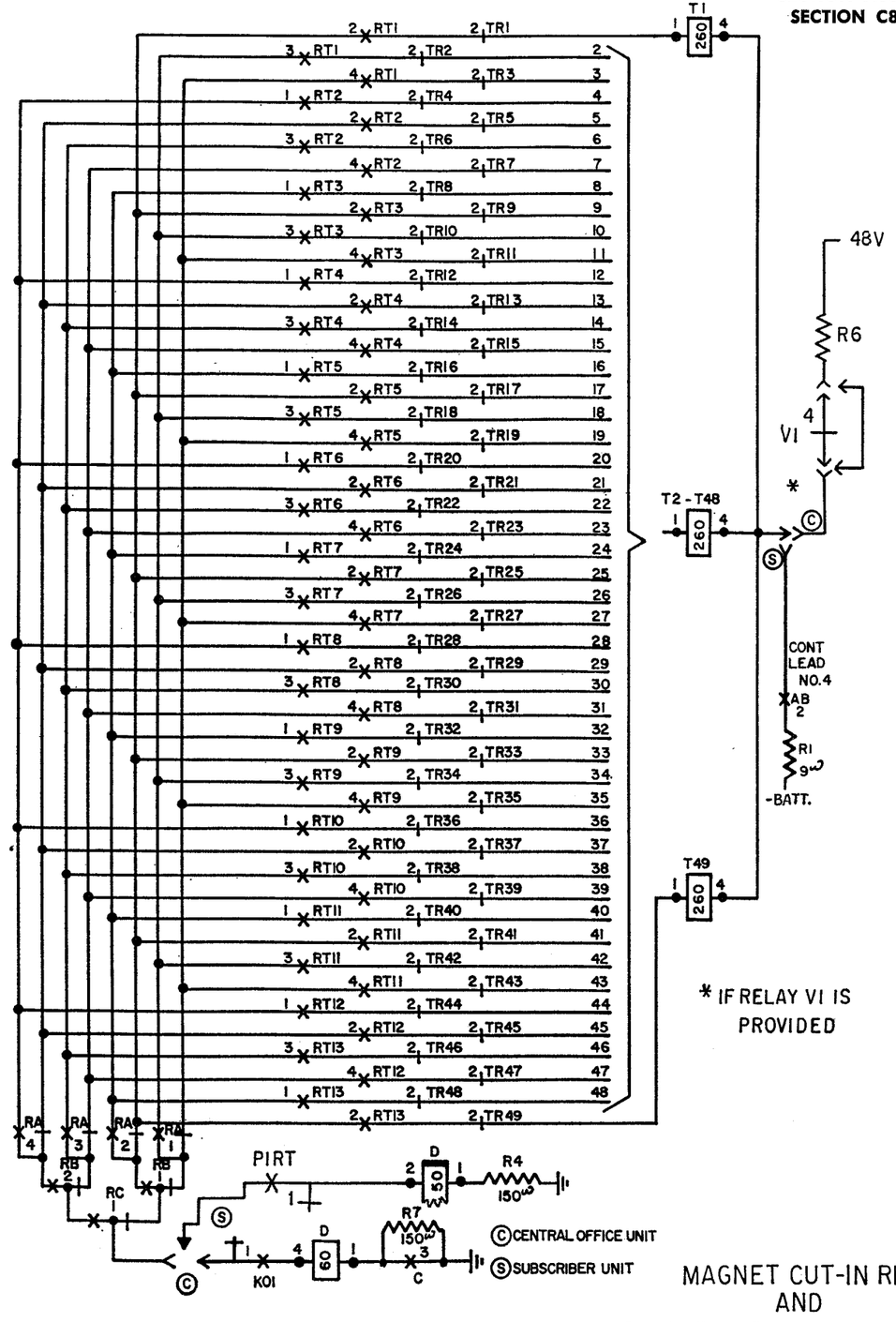
LIFT MAGNET CUT-IN AND
CONTROL RELAYS AND OPERATION
OS 3

CENTRAL OFFICE UNIT



SUBSCRIBER UNIT

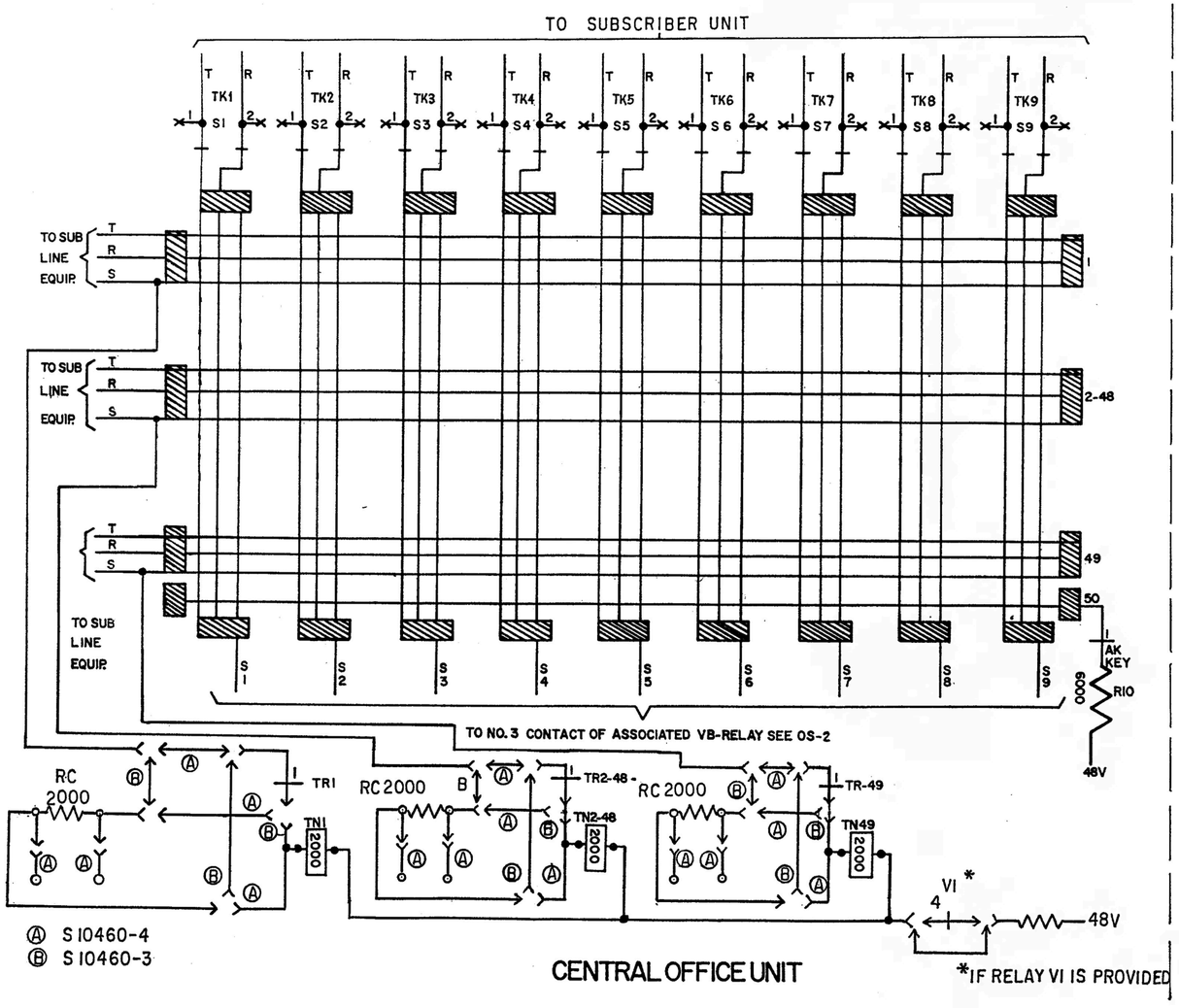


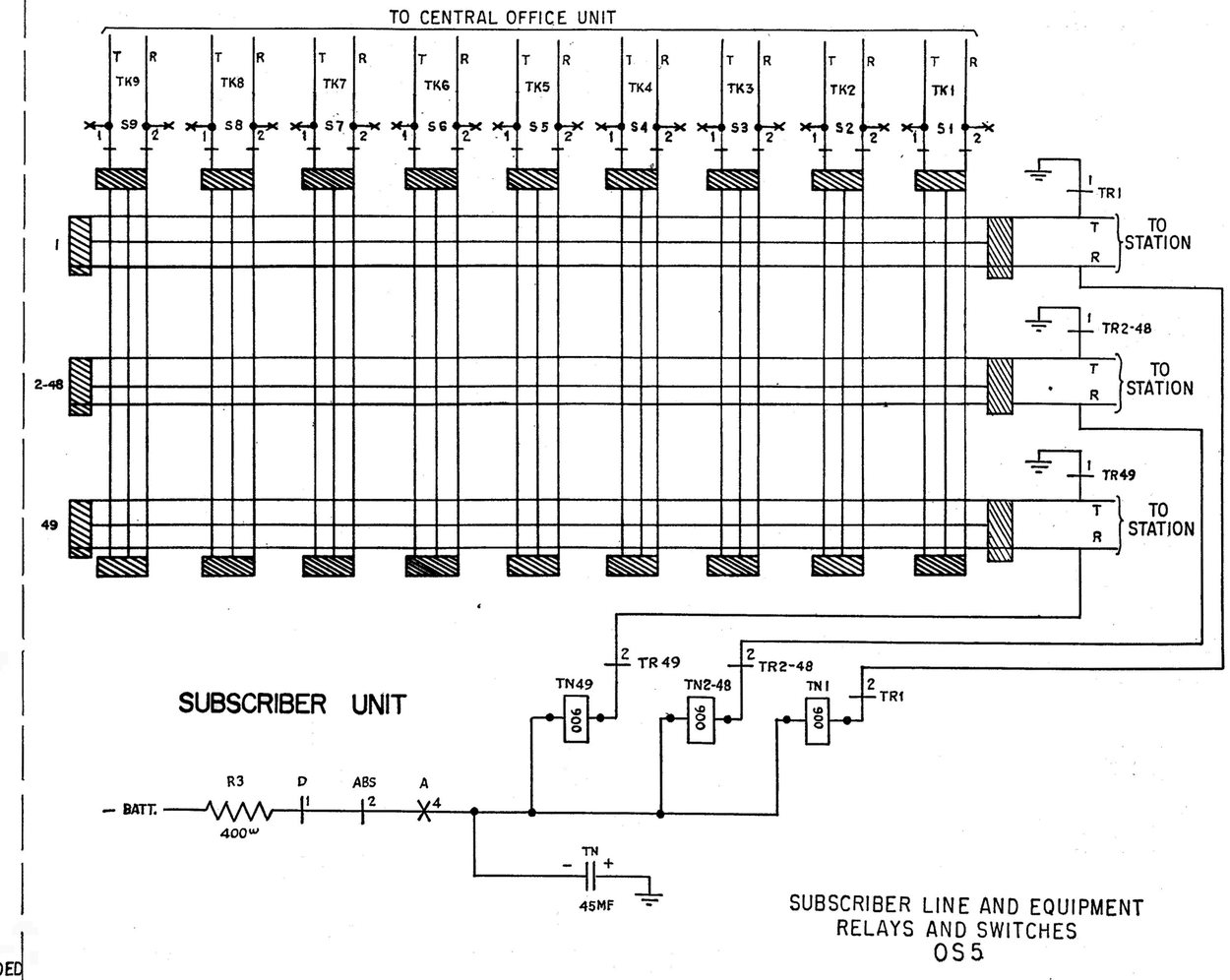


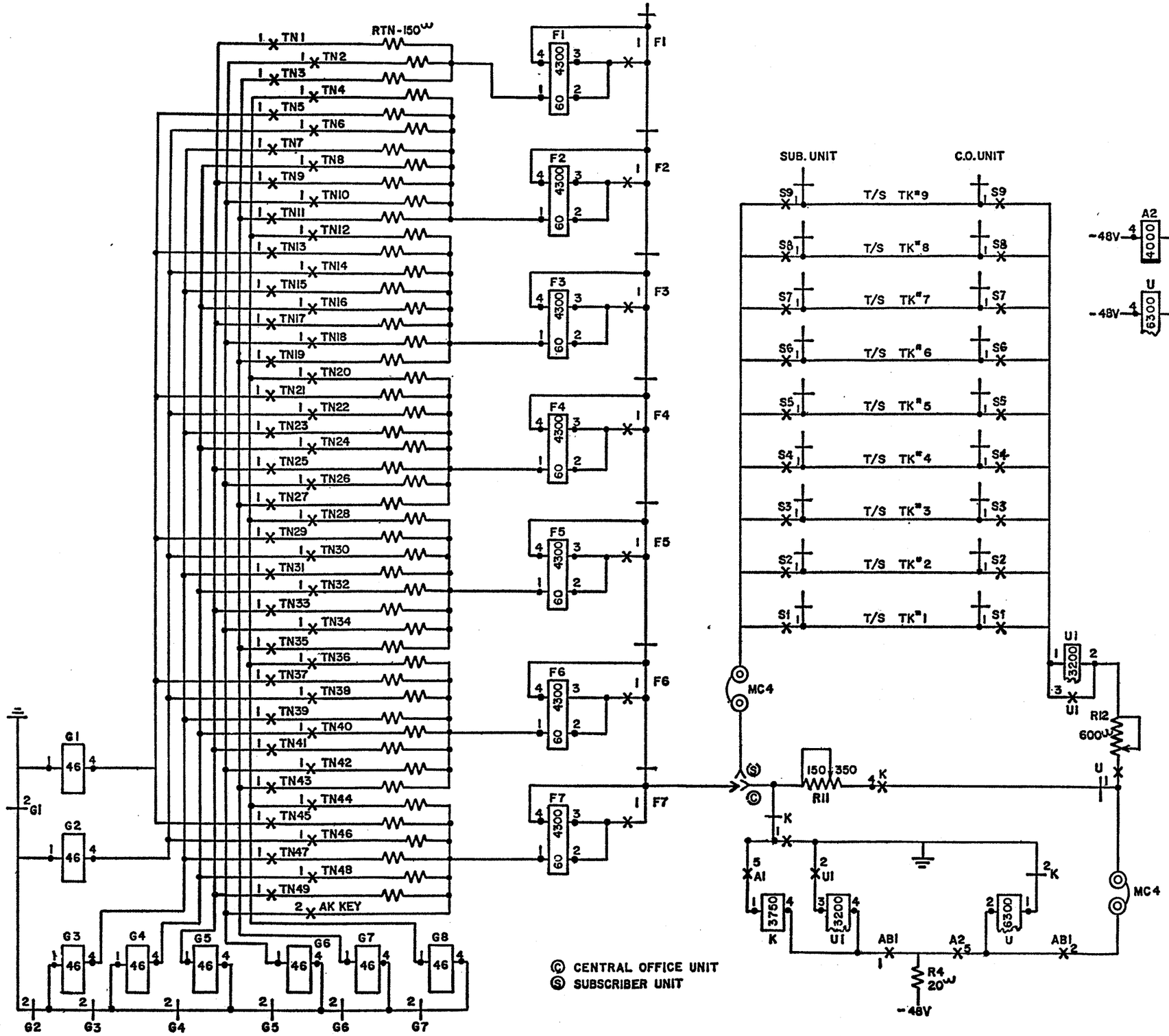
* IF RELAY VI IS PROVIDED

MAGNET CUT-IN RELAYS
AND
SUBSCRIBER BAR MAGNET
OPERATION

OS 4


TO SUBSCRIBER UNIT
TK1
TK2
TK3
TK4
TK5
TK6
TK7
TK8
TK9
S1
S2
S3
S4
S5
S6
S7
S8
S9
TO SUB LINE EQUIP
T
R
S
1
2-48
49
50
AK KEY
RIO
6000
48V
TO NO. 3 CONTACT OF ASSOCIATED VB-RELAY SEE OS-2
RC 2000
TR1
TR2-48
TR-49
TN1
TN2-48
TN49
2000
VI *
48V
Ⓐ S 10460-4
Ⓑ S 10460-3
CENTRAL OFFICE UNIT
*IF RELAY VI IS PROVIDED


TO CENTRAL OFFICE UNIT
TK9
TK8
TK7
TK6
TK5
TK4
TK3
TK2
TK1
S9
S8
S7
S6
S5
S4
S3
S2
S1
1
2-48
49
TR1
TR2-48
TR49
TO STATION
SUBSCRIBER UNIT
TN49
TN2-48
TN1
900
TR 49
TR2-48
TR1
BATT.
R3
400ω
D
ABS
A
TN
45MF
SUBSCRIBER LINE AND EQUIPMENT
RELAYS AND SWITCHES
OS5



MARKING CONTROL RELAYS FOR SUBSCRIBER BAR SELECTION

OS 6