LINE CONCENTRATOR NO. 1A
100- AND 50-LINE CAPACITY REMOTE UNITS
GENERAL DESCRIPTIVE INFORMATION

CONTENTS PAGE

1. GENERAL

Scope

1.01 *General:* This section describes the line concentrator No. 1A, 50- and 100-line capacity remote units, discussing the technical characteristics and limitations of its use, the method of operation, the associated traffic measuring facilities provided, and the maintenance facilities provided to minimize out-of-service time and maintenance costs.

Purpose

1.02 This concentrator has been designed to provide a flexible, economical substitute for customer cable plant through use of switching equipment to concentrate a large number of low-usage lines on a few high-usage trunks. The remote units and, to a lesser extent, the central office control units can be moved with relative ease, thereby providing considerable flexibility not present in fixed plants.

Fields of Use

1.03 *Permanent Plant Use*

(a) Concentrators can be used as permanent parts of the outside plant to provide service in residential areas where demands for service exceed the capacity of feeder cable. From an economic standpoint, the areas eligible for concentrator application of this type are those at a distance from the central office where the annual charges on cable required for reinforcement exceeds the annual charges on concentrators required to provide an equivalent number of cable pairs.

(b) Concentrators can be economically used as permanent parts of the outside plant to satisfy new demands for service in areas where reinforcement of moderate lengths of existing cable (such as submarine cable, underground cable requiring duct reinforcement, or cable previously installed over difficult terrain) would be more expensive.

1.04 *Temporary Plant Use*

(a) Concentrators can be used as either temporary or permanent parts of the plant to provide service in areas where deferment of cable reinforcement is desirable or necessary because of slow, unpredictable, or unstable growth, because of seasonal fluctuation in the demand for service, or because large capital expenditures can be economically deferred. The length of time that cable reinforcement may be deferred depends on the relative annual charge rates of cable versus concentrator solutions to a particular problem and the length of time required before cable reinforcement is finally required.

(b) The temporary use of concentrators to defer major cable reinforcements has the marked advantage of permitting the ultimate placing of a permanent plant on a demonstrated rather than on a predicted demand.

1.05 ***Emergency Plant Use:*** Concentrators can be used as temporary installations to provide service directly, or to release feeder pairs to serve areas affected by emergency situations requiring extensive short-term service.

1.06 ***Examples of Use***

(a) Fig. 1A shows possible concentrator installations which can be used to defer a major expenditure for duct and cable reinforcement. Under the circumstances shown, the addition of four concentrators per year will defer reinforcement for three years.

(b) Fig. 1B is an example of the permanent installation of line concentrators to eliminate the need for cable reinforcement. Two 50-line capacity, and one 100-line capacity line concentrators No. 1A installed initially will defer cable reinforcement for two years, and proper concentrator additions thereafter will eliminate the need for cable reinforcement indefinitely.

2. CHARACTERISTICS AND FEATURES

General

2.01 The line concentrator No. 1A consists of two major units, a control unit (CU) mounted in the central office, and a remote unit (RU) usually mounted on a pole in the immediate vicinity of the customer being served. Two remote unit sizes are provided, one having 50-line terminal capacity and the other 100-line terminal capacity. To aid in obtaining high line fill, a concentrator trunk usage recorder (CTUR) is provided. Other accessories are a tent, balcony, and a spare parts and tool kit for use with the remote unit.

2.02 Both the control unit and remote unit use wire-spring relays for control functions, mercury relays for signaling, neutral reed relays for line relays, magnetic latching reed relays for cutoff relays, and magnetic latching crossbar switches as network crosspoints. All switches and relays have noble metal contacts.

2.03 The general system layout is illustrated in Fig. 2. As shown, the control unit is arranged to operate with either one 100-line remote unit or two 50-line remote units. This system is a double-ended, concentrate-deconcentrate arrangement with individual line terminals appearing at each concentrator unit.

Over-All System Characteristics

2.04 ***Applicable Central Offices:*** The line concentrator No. 1A can be used with No. 1 crossbar, No. 5 crossbar, No. 1 and 350 step-by-step, and No. 355A CDO offices with no concentrator modifications.

2.05 ***Types of Lines Served:*** The line concentrator No. 1A can serve individual, 2-party, 4-party, and multiparty flat or message rate, residence and business and loop start coin lines in any combination. Generally, individual and 2-party residential lines are the best candidates for concentration.

2.06 ***Line and Trunk Terminal Capacity***

(a) ***Control Unit:*** The control unit is capable of operating with up to 20 trunks and 100 lines; therefore, it can operate with either one 100-line 20-trunk or two 50-line 10-trunk capacity remote units. When operating with a 100-line remote unit, two control trunks are required. When operating with two 50-line remote units, four control trunks are required (two control trunks for each remote unit). The control unit can also operate with one 50-line 10-trunk group on each of two 100-line remote units (each 100-line remote unit being used as a 50-line unit). This arrangement may be useful where 100-line remote units are available and where future growth will require 100 lines at each location. Under this condition, the carrying charges of the second control unit may be deferred. Operation with either 100- or 50-line remote units is possible with less than the full complement of concentrator trunks by making unused trunk positions test busy to the trunk selection circuit but idle to the CTUR.

(b) ***100-Line Capacity Remote Unit:*** The 100-line capacity remote unit can concentrate a maximum of 100 lines to 20 trunks in two groups of 50 lines to ten trunks each. In addition, there are two control trunks for signaling. One line terminal in each 50-line group will usually be reserved for test purposes.

(c) ***50-Line Capacity Remote Unit:*** The 50-line capacity remote unit can concentrate a maximum of 50 lines to ten trunks, and uses two pair as control or signaling trunks. One line terminal is reserved for test purposes.

2.07 ***Resistance Range Limits***

(a) ***General:*** The concentrator has no effect on transmission limits. Maximum concentrator range is determined by both dc control and supervision signaling limitations, and by normal central office range limits. Concentrator system resistance range is determined by the following three parameters: CU to RU range, RU to customer subset range, and customer subset to central office equipment range.

(b) ***CU to RU Resistance Range:*** The normal CU to RU signaling circuit external cable resistance range is 0- to 1600-ohm loop resistance (0 to 800 ohms per individual signaling wire) with a maximum of 10-volt peak ac and dc interference. By means of internal strapping, the individual signaling leads are padded out to a minimum of 700 ohms at installation.

(c) ***RU to Customer Subset Resistance Range:*** The normal RU to customer subset external cable loop resistance range is 0 to 800 ohms (0 to 1200 ohms including subset).

(d) ***Central Office to Customer Subset Resistance Range:*** The maximum range from the central office to a customer subset served by a concentrator can be no greater than the normal maximum central office resistance range. When calculating the customer subset to central office range of a line served by a concentrator, the following factors must be considered.

(1) The concentrator trunk and signaling pair loop resistance from the CU to the RU.

(2) The loop resistance from the RU to the customer subset.

(e) ***Operation With Long Line Circuits:*** Long line circuits may be used on the line side of either concentrator unit on a one-per-line basis in the conventional manner or may be used on the concentrator trunks. In the latter case, all the trunks in the trunk group or groups involved must be equipped with the same type of set and minor rearrangements of the CU or RU power arrangements are required to allow supplying RU power over idle talking trunks. Long line sets may not be used to extend the concentrator control pair range (normally 800 ohms per wire, 1600 ohms per pair loop). However, with zero ac and dc earth potential, the standard signaling circuit will operate to a 1000 ohms per wire, 2000-ohm loop range.

2.08 ***Delayed Disconnect Feature:*** The delayed disconnect feature insures that a minimum of four lines in each 50-line group is always connected through the concentrator to central office line terminals. These four lines are either in use on a service call or are on-hook, but still have a concentrator trunk attached and cut-through to the central office equipment. This feature helps to minimize the effect of low insulation resistance lines and to insure that, in case of an emergency, some concentrated lines will always have service.

2.09 ***Temperature Limits***

(a) ***Control Unit:*** The control unit is capable of operating within the normal central office equipment temperature limits.

(b) ***Remote Units:*** The remote units are capable of operating in ambient outside air temperatures from −39 F to +140 F, and with relative humidity up to 100 per cent.

2.10 ***Trunk and Line Protection:*** Carbon block protectors are provided for all lines and trunks at the remote unit.

Power Arrangements

2.11 ***Control Unit:*** All power for the control unit comes from the 48-volt central office supply.

2.12 *Remote Unit:* The power in the remote unit is supplied by a 24-volt sealed, nickel-cadmium storage battery which is charged from the central office 48-volt battery over idle talking trunks. Under normal operating conditions, the battery has sufficient capacity to sustain concentrator operation for extended periods without any charging from the central office.

Traffic Features and Characteristics

2.13 *Engineered Capacity:* Each 10-trunk group has an engineered traffic capacity of about 145 ccs (hundred call seconds). The 100-line capacity remote unit has twice the capacity, or 290 ccs. This system has been designed to provide the proper balance between minimum switching and cable cost and maximum average line terminal fill to result in minimum cost per net line gained. The ten trunks, with 145 ccs capacity per 50-line group used in conjunction with a traffic measuring device, are expected to allow operation at full line fill in most applications.

2.14 *Concentrator Trunk Usage Recorder:* In order to fulfill the requirements in 2.13, a concentrator trunk usage recorder (CTUR), which measures trunk usage in ccs, has been developed. The CTUR can measure usage on as many as five concentrator systems simultaneously (five 100-line or ten 50-line remote units). Measurement intervals can be controlled from a TUR timer, from a traffic register camera timer, or from a timer which has been made available for this purpose.

2.15 *Dial Tone Speed:* Arrangements are provided for measuring concentrator dial tone speed by the standard dial tone speed measuring circuit. One arc of the dial tone speed measuring circuit must be assigned exclusively to this use. Each arc has a terminal capacity for 20 test leads.

2.16 *Overflow Tone:* An incoming call received during a period when all trunks in a group are busy will be connected to a tone supply. Overflow tone will usually be supplied, but in offices where overflow tone is not available, busy tone may be substituted.

Maintenance Features

2.17 *Alarm Arrangements:* In general, equipment that is common to more than one line is alarmed. The alarm arrangements provide for localizing and individually indicating trouble conditions in the control unit, the remote unit, or the signaling circuit.

2.18 *Customer Loop Testing:* Cutoff relays are provided in both the control and remote units; therefore, the concentrator connection provides a clean tip and ring. This allows normal customer loop testing procedures to be used.

2.19 *Automatic Line Insulation Test:* A minor modification of the standard automatic line insulation test (ALIT) circuit provides for testing all loops connected to this concentrator. The modification causes the ALIT to increase its dwell time on concentrated lines in order to give the concentrator time to set up the connection before tests are applied.

2.20 *Test Equipment and Tool Kit:* This concentrator is composed largely of standard electromechanical switching apparatus. Therefore, standard testing equipment and tools may be used. A spare parts and tool kit is provided for the use of outside craftsmen when maintaining the remote unit.

2.21 *Ground Return Path:* The working limits for the concentrator signaling circuits are ±10 volts for dc interference, 5 volts rms for ac interference, and 10 volts peak for any combination of ac and dc interference. This interference should be measured across a 3000-ohm resistor. To allow limited operation with interference conditions in excess of these limits, terminals have been provided in the concentrator units for operating the signaling circuits on a metallic loop basis (not ground return). This mode of operation requires a number of extra signaling pairs, the exact number depending on resistance range involved. With neither ac nor dc interference, the working limits of the signaling circuit may be extended.

3. MAJOR EQUIPMENT ELEMENTS

New Types of Apparatus

3.01 *Magnetic Latching Relays* (Fig. 3): The *cutoff* relays in both the CU and RU of the line concentrator No. 1A system are of the magnetic latching dry reed type. The relay consists of 50 coils, each coil having two reed switches. These coil and contact subassemblies are replaceable. In the RU, the upper 25 subassemblies are magnetic latching and the lower 25 are nonlatching. This combination has been coded the 302A relay. In the CU, all 50 of the subassemblies are magnetic latching and the composite structure has been coded the 302B relay. The *line* relays in the RU are the nonlatching type. In the magnetic latching subassemblies, each pair of reed switches has a corresponding permanent magnet. This magnet is too weak to operate the contacts, but once the contacts have operated, the magnet is strong enough to keep the contacts closed with adequate contact pressure to assure a good contact under vibration and shock conditions. These magnetic latching relays require no current to hold them operated, but after a pulse of current has initially operated them, the permanent magnets will hold them operated until they are released by a pulse of current opposite in direction to the operate current.

3.02 ***Magnetic Latching Crossbar Switch:*** The crossbar switches used in both units are magnetic latching, 6-wire crossbar switches. In the CU, 10 by 20 crossbar switches are used; in the RU, 10 by 10 crossbar switches are used. The major difference between this latching switch and a conventional switch is the use of a hold magnet core material which retains a high degree of residual magnetism. To operate the hold magnet, a pulse of current is sent through the hold magnet coil. The residual magnetism in the core is great enough to hold the switch operated until a pulse of current in the opposite direction to that of the operate pulse is sent through the coil.

3.03 ***Remote Unit Power Supply:*** The power supply in the remote unit consists of a 19-cell, 24-volt, nickel-cadmium storage battery with a capacity of 2.5 to 4.0 ampere-hours. Each cell is a sealed unit and will not be damaged or emit gases even with a moderately heavy overcharge. The battery is charged from the 48-volt central office supply over idle concentrator trunks. Battery current drain is very low because magnetic latching relays and switches are used in all places where a connection must be maintained between calls.

3.04 ***Mercury Relays:*** All signaling is done by means of a new code of mercury relays which are 1-7/8 inches high when mounted.

Central Office

3.05 ***General*** (Fig. 4): The three major units of the central office control unit are a single-bay frame, a control unit mounted on an equipment frame, and a concentrator trunk usage recorder.

3.06 ***Frame*** (Fig. 4): The frame is 38-1/2 inches wide and either 11 feet, 6 inches or 9 feet, 0 inches high, depending on the ceiling height of the office in which it is to be installed. Since there are no protrusions from the side of the frame, two frames can be mounted side by side. A fuse panel is mounted near the top of the frame and a terminal strip is located directly above the terminal strip on the control unit. All power is connected through the fuse panel to the terminal block.

3.07 ***Control Unit*** (Fig. 5): The control unit is 38-1/4 inches wide and 85 inches high, and weighs approximately 500 pounds. The control unit includes all of the concentrator central office equipment and comes prewired from the factory. All electrical connections on the control unit terminate at the terminal block mounted near the top of the unit. At the time of installation, cross-connections are run between corresponding terminals of this terminal block and the adjacent frame terminal block.

3.08 ***Central Office Equipment Installation Flexibility:*** The control unit was designed as a self-contained subframe to facilitate short installation and service intervals. This may be achieved through advance planning of installation of frames for expected needs during a normal engineering interval. With a frame previously installed in the central office, the local plant forces can mount the control units as needed, making the necessary cross-connections between the adjacent terminal blocks when the control unit is installed.

3.09 ***Concentrator Trunk Usage Recorder*** (Fig. 6): The CTUR consists of stepping switches, a 100-second timer, and associated relays, all of which are mounted on a mounting plate 8 inches high and 23 inches wide. The CTUR can be mounted above the control unit equipment frame on the 11-foot, 6-inch frame by means of adapters, or on a standard 23-inch relay rack. The CTUR can be controlled from a TUR, a traffic camera control circuit, or a seven-day program timer which has been made available for that purpose. The CTUR can measure the traffic usage of 100 trunks in ten groups of ten trunks each. This will accommodate five 100-line or ten 50-line capacity line concentrators No. 1A or various combinations thereof.

Remote Unit — 100-Line Capacity

3.10 *General* (Fig. 7): The remote unit consists of a frame, a housing, two gates, and a connecting block.

3.11 *Frame:* All of the equipment in the remote unit is mounted on an angle iron framework which also supplies the necessary bracing and support for the housing.

3.12 *Housing:* The housing is approximately 51 inches high, 26 inches wide, and 16 inches deep. It is both weatherproof and insectproof, and has filtered vents to allow air to circulate within the unit. The housing door is diagonal across the top and bottom to permit easy access to all concentrator equipment. Provisions are included to allow the stub cable to enter through either the top or bottom of the housing depending upon the type of installation used. The housing is equipped with hangers which are bolted to both the housing and the frame to provide support. In addition, the housing is provided with facilities for locking the door, with hoisting straps, and with means for mounting a tent. The method and hardware for mounting a concentrator is similar to that for mounting a cross-connection terminal (BD) box. A concentrator can be mounted on a pole or on a wall. A typical installation is shown in Fig. 8.

3.13 *Front Gate* (Fig. 7B): Factory wired and mounted on the front gate are the signaling circuit, line and cutoff relays, protectors, power supply, and other components. The front gate is pivoted to open away from the housing door. When this gate is open, the wiring side of the front gate and the equipment side of the rear gate are accessible.

3.14 *Rear Gate* (Fig. 7C): The only equipment mounted on the rear gate is the factory wired crossbar switches. When open, this gate is partially in the housing door. The wiring side of the crossbar switches and the rear of the connecting block are accessible with the gate in this position.

3.15 *Connecting Block:* The connecting block is permanently mounted at the bottom of the frame below the equipment gates. The stub cable pairs terminate on the front of this block under screw terminals. The concentrator equipment is factory connected to terminals at the rear of this block. When both gates of the concentrator are open, the rear connections are accessible for maintenance.

Remote Unit — 50-Line Capacity

3.16 The 50-line capacity remote unit is a 2-gate, aluminum housing unit very similar to the 100-line unit, but has a height of only 35 inches.

4. METHOD OF OPERATION

Circuit Description

4.01 *Block Diagram:* The block diagram in Fig. 9 shows the major functional blocks for both the remote and control units of the No. 1A line concentrator. Because some of the circuits in both the remote and control units are very similar, they will be discussed together. All other circuits will be discussed separately.

4.02 *Switching Network:* The switching network at the 100-line capacity remote unit consists of four magnetic latching 10 by 10, 6-wire crossbar switches, with three lines per crosspoint (tip and ring). The 50-line capacity remote unit requires only two crossbar switches. The network at the control unit consists of three magnetic latching, 10 by 20, 6-wire crossbar switches with two lines per crosspoint (tip, ring, and sleeve). Fig. 10 illustrates the remote unit crosspoint wiring per group. Three customer lines appear at each crosspoint on each horizontal level and all but three levels are used for customer lines. The other three levels are used for steering (one out of three selections). One trunk is assigned to each vertical and it is multipled to each of the three steering levels. When a line is to be connected to a trunk, the following select magnets operate.

(a) The select magnet which corresponds to the horizontal level of the line requesting service.

(b) The select magnet of the steering level which corresponds to the line in (a).

After both select magnets have operated, the hold magnets corresponding to the vertical on which the selected trunk appears operate. (Like-numbered hold magnets on switches A and B always operate together.) For example, to connect line 29 to trunk 00, the select magnets for level nine of switch A and level seven of switch B must be operated, followed by operation of the hold magnets for trunk 00. The crossbar switches in the central office are wired in a similar manner except that there are only two steering levels since only two lines appear on each switch level.

4.03 ***Line Circuit:*** The line circuit in the remote unit consists of a dry reed type line relay bridged to the ring lead through contacts of the cutoff relay. This line relay operates only on an originating service request. The line circuit in the control unit consists of a wire spring type sleeve lead relay, which operates on terminating calls. This sleeve lead relay also operates on disconnect to provide line identity of the line from which a trunk is to be disconnected.

4.04 ***Lockout and Identification:*** As shown in Fig. 11, the lockout and identification circuit for the 50-line capacity remote unit consists of a two-dimensional relay matrix. Since the 100-line capacity remote unit and the control unit each require facilities for 100 lines, there are two of the above circuits in each of these units. The matrix for each group of 50 lines consists of five subdivisions of nine lines and one subdivision of five lines for a total of 50 lines. The operation of one or more line or sleeve relays results in lockout of all but the highest preference request, and in identification of the line selected in terms of one LA and one LB relay operated. In cases of simultaneous or overlapping requests for service, the concentrated line with the lowest terminal number receives the highest preference.

4.05 ***Signaling Circuit:*** The signaling circuit consists of two cable pairs (control trunks) and their associated circuitry. Control trunk 0 (TS0, RS0) is used for the transmission of line, group and type of call, and trunk identity information. Control trunk 1 (TS1, RS1) is used for transmitting marking, checking, releasing, and trunk steering information. Fig. 12 shows a simplified schematic of the TS0 wire of control pair 0, which is used to transmit part of the line and trunk identity information. This circuit consists of one sensitive and one marginal relay at each end of the signaling path. These relays can produce a total of three signaling conditions which appear simultaneously at both ends of the wire and, because of the bi-directional characteristic of the circuit, may be initiated from either end of the signaling path. The three signaling conditions are also specified in Fig. 12. The circuit of the second wire (RS0) of control trunk 0 is identical with that of the first wire (TS0). Used together, the wires of control trunk 0 send a total of nine signaling combinations for complete line and trunk identity information. The line and trunk identity information is sent in four parts. The method of sending this information is shown in Fig. 12 and discussed below.

(1) Line group identification (one out of two combinations) to identify both the group of 50 lines, or remote unit, in which the line requesting service appears, and the type of request being made.

(2) "B" line information (one out of nine combinations) to identify the subgroup of six lines in which the line requesting service appears.

(3) "A" line information (one out of six combinations) to identify the line requesting service.

(4) Trunk information (one out of nine combinations) to identify the trunk to which the line requesting service is to be connected. (A tenth combination for trunk selection is available and discussed below.)

Control trunk 1 (TS1, RS1) has different circuits on each wire. TS1 has no relays at the central office end, and two oppositely polarized polar relays at the remote end. The information sent over this path includes marking and release signals. RS1 has one standard relay at the control office end and one polar relay at the remote unit. The information sent over this wire includes checking and steering information. The steering information on this lead is used together with the information sent on control trunk 0 to select the tenth trunk available to each group of 50 lines.

4.06 ***Register Circuit:*** The register circuit in the control unit consists of three sets of register relays which record group and B and A line information. In addition to three sets of register relays identical with those in the control unit, the remote unit register circuit contains a fourth set of register relays which records trunk information. This latter set of register relays is not required in the control unit since trunk selection and registration occur in the control unit trunk selection circuit.

4.07 ***Sequence Circuit:*** Identical W-Z type sequence circuits, including four W and three Z relays, are used in both units of the concentrator system. Sequencing for all types of calls is similar and includes combinations of corresponding W and Z relays operated, and W relays operated with corresponding Z relays unoperated.

4.08 ***Select and Hold Magnets:*** The hold magnets are of the magnetic latching type and require a pulse of current in one direction to operate and a pulse in the reverse direction to release. The hold and select magnets operated for a particular line are determined by the line requesting service and by the trunk selected to serve the line. The magnets are operated through contacts on the relays in the register circuit.

4.09 ***Cutoff and Cutoff Check Circuit:*** The contacts on the cutoff relays are of the magnetic latching type. A pulse of current in one direction will cause the contacts to close. These contacts will remain closed until a pulse of current in the reverse direction releases them. When a customer line is connected to a trunk, the cutoff relays are in a nonoperated position (contacts open). When a line is to be disconnected from a trunk, a pulse of current passes through the coil of the relay, thereby closing the contacts which then remain closed due to magnetic latching. The cutoff relay to be pulsed (operated) is selected by contacts on the register relays. A mercury cutoff check relay, which is in a common point in both the operate and release paths for all cutoff relays, will operate each time a cutoff relay is pulsed thereby checking the operation of the cutoff relay.

4.10 ***Checking Circuits:*** Checking circuits in both units check the operation of hold magnets, group selection relays, both A and B line selection relays, trunk selection relays, and cutoff relays. If any of these checking relays does not operate, the concentrator system will time out and an alarm will be generated.

4.11 ***Power Supply and Alarm Circuit:*** The power for the control unit is obtained directly from the 48-volt central office supply. In the remote unit, a 24-volt, nickel-cadmium storage battery is provided. This battery is charged over idle talking trunks directly from the 48-volt central office supply. The battery acts as a "flywheel" in that it supplies the high-current, short-duration pulses which are required during actual call handling operations while it is continuously being charged at a lower current rate. The capacity of the battery is such that it will allow normal operation for many hours even though it receives no charging from the central office. The charging path is protected by an indicating fuse which, when open, operates a charging alarm.

Circuits Appearing Only in Control Unit

4.12 ***Preference Control and Trunk Selection Circuit:*** In cases of simultaneous or overlapping requests, the preference control circuit determines the order in which requests will be served. While a request is being served, the preference control locks out all other requests. Terminating calls, disconnect requests, and originating service requests will usually be served in that order unless a group-trunk-busy condition occurs, in which case a disconnect request will receive preference. The trunk selection circuit selects the trunk which is to be used to complete a connection or which is to be disconnected. If a trunk is needed to complete a connection, one of the trunks on charging will be selected. If a trunk is to be disconnected, a trunk from delayed disconnect (a trunk not being used for talking but still connected to a line) will be chosen. In either case, the highest preference trunk will be chosen (preference goes from trunk 00 through trunk 09 in that order).

4.13 ***Signal Control Circuit:*** After receipt of all checks for a given part of the signaling cycle, the relays in the signal control circuit operate. This causes the signal circuit to transmit the next bits of information.

4.14 ***Trunk Load Control:*** Operation of the trunk load control relay indicates that a total of five or more trunks are being used for talking and/or for delayed disconnect. Operation of this relay initiates a disconnect request in the preference control circuit to replenish the number of trunks disconnected, on charging, and available to the trunk selection circuit for use on calls.

4.15 ***Release Control:*** The release control initiates the cycle which releases all of the remote and central office control relays after a connection has been set up for a service request, after a connection has been released by a disconnect request, or after the concentrator time-out and alarm circuit has operated.

4.16 ***Miscellaneous Circuits:*** Five miscellaneous circuits are shown as a group on the block diagram. These circuits will be discussed below.

(1) ***Dial Tone Speed Register Circuit:*** Facilities are incorporated which allow the standard dial tone speed register circuit to measure dial tone delay caused by the concentrator for each 10-trunk 50-line group. In order to make this measurement with the dial tone speed register circuits, the concentrator must be treated as a separate class of service by assigning concentrators to a separate arc. Each arc provides facilities for twenty 10-trunk groups.

(2) ***Line Insulation Test Control Circuit:*** To insure that the ALIT does not complete its test cycle and release the concentrator line terminal under test before the concentrator has completed the connection to the customer loop, the concentrator signals the ALIT to extend its line terminal dwell time whenever a concentrated line not already cut through is under test. This feature assures that all lines which are not busy when tested will be fully tested. During the test of all lines, the probability is very high that all trunks will be utilized and tested.

(3) ***Charge Failure Alarm Circuit:*** The operation of the charging lead power fuse in the remote unit causes a power alarm relay to operate. This alarm is sent to the central office via the tip side of trunk 00.

(4) ***Alarm Circuit:*** The alarm circuit consists of four subcircuits: a timing circuit, a release circuit, an alarm relay circuit, and a circuit which provides alarm indications to connecting circuits. The major unit in the alarm circuit is the timing circuit which controls all of the other units. In timing out, the timing circuit operates an alarm relay and releases the concentrator so that it may serve another call. The operation of the alarm relay activates the connecting circuit which indicates that there is a trouble by operating a central office alarm or by tranferring the information to an alarm sending circuit. By noting which alarm relay has operated, the trouble can be localized to the central unit, the remote unit, or the signaling circuit.

(5) ***Trunk Overflow Indication Circuit:*** When all trunks in a 10-trunk 50-line group are busy, terminating calls will receive an overflow indication. Under this same all-trunks-busy condition, originating call attempts are subject to dial tone delay until a trunk becomes available.

Establishing a Connection

4.17 ***General:*** In the following section, a description of system operation for typical calls is presented in terms of the block diagram of Fig. 9, the signaling diagram of Fig. 12, and the functional sequence charts of Fig. 13, 14, and 15. The description will follow the sequences shown in these charts, but there will be no direct references made to them in the text.

4.18 ***Originating Call***

(a) A customer originates a service request by taking the subset off hook. The RU ***line circuit*** then operates, which in turn operates the ***lockout and identification circuit.*** The ***signal circuits*** in both the RU and CU, which are controlled by contacts on the RU ***lockout and identification circuit*** relays for the transmission of line and group information, simultaneously reflect the signaling relay combination for the group number (Fig. 12). Contacts on these signaling relays which appear in the CU ***preference control circuit*** indicate that an originating service request desires to establish preference and seize the control circuit. If all trunks in the customer group are busy, the ***preference control circuit*** will not operate and the customer will be subjected to delayed dial tone. When a trunk becomes available, the call will continue.

(b) Seizure of the control circuit causes overall work alarm timing to begin, and the CU ***sequence circuit*** to advance one step to step 1, causing the transmission of a sequence signal to the RU. Group information is then registered and checked in the ***register circuit*** in both the RU and the CU. After registration of group information, the CU ***trunk selection circuit*** selects and makes busy the concentrator trunk which will be used to serve that call.

(c) When the CU receives sequence check signals from the RU and from its own check circuit, control pair 0 is opened and all signal relays on this pair are released, thereby preparing the ***signal circuit*** for the transmission of the next piece of information. This is followed by a sequence signal, step 2, which causes an advance in the ***sequence circuit*** in both units. A sequence check signal each from the RU and CU indicates that the system is ready for the next transmission, and closes control pair 0. The proper signal relays, as determined by contacts on the ***line lockout and identification circuit*** relays in the RU ***signal circuit,*** then operate at both ends to indicate the "B" portion of the line identification. Sequence step 3 follows, and causes the ***register circuits*** in both units to record the "B" line information. In the remote unit, this is followed by the operation of the steering level select magnets (Fig. 10) in the ***select and hold magnet operation circuit.*** Sequence checks in both units then cause control pair 0 to be opened in order to prepare it for the next transmission.

(d) Sequence circuit advance, step 4, follows the release of the signal relays. The check for this sequence advance step completes the signaling path, and the signal relays, under the control of the RU ***signal circuit,*** reflect the "A" part of the line information. Next, a sequence advance, step 5, permits the ***register circuit*** in both the RU and CU to record the "A" line information. At this time, the line level select magnets in the RU, and the line and steering level select magnets in the CU operate.

(e) A sequence check again opens control pair 0 to prepare for the transmission of trunk information and causes a sequence advance. This sequence advance, step 6, causes the release of the ***line lockout and identification circuit*** in the RU and the cutoff relays in the CU, and operates the CU hold magnet in the CU which corresponds to the selected trunk. If this trunk is the last available trunk in a group, a group-trunk-busy condition will result, blocking all subsequent requests for service from that group.

(f) When the sequence check is received, the contacts on the relays in the CU ***trunk preference control circuit*** control the operation of the signal relays to transmit the selected trunk numbers. If either trunk 9 or 19 has been chosen, the CU ***signal control circuit*** transmits an additional signal which causes a signal relay in the RU ***signal circuit*** to operate, thereby causing the selection of trunk 9 or 19. The final sequence advance, step 7, permits the RU ***register circuit*** to record the number of the selected trunk, and causes the RU cutoff and line relays to release. At this time, the RU hold magnets operate and a sequence check signal is sent back to the CU. When the CU receives this sequence check signal in addition to its own sequence check signal, the CU ***release control circuit*** sends a release signal to the RU, and initiates release work timing in the CU. The RU then proceeds to release all operated relays with the exception of the hold magnets. During the time the RU is releasing, the CU ***signal control circuit*** opens control pair 0. When the CU receives a RU release check, the CU ***release control circuit*** operates the CU release relay, which in turn stops the work alarm timers and releases all relays except the hold magnets and trunk busy relays, both of which remain operated for the duration of the call. At this point, control pair 0 is closed, putting the system in a standby condition and preparing it for the next call. The trunk supervisory relay also operates and remains operated as long as talking continues.

4.19 ***Terminating Call***

(a) A terminating call is initiated when the customer ***line circuit*** in the CU operates, followed by operation of the CU ***line lockout and identification circuit.*** If the CU ***preference control circuit,*** operated by contacts on the ***line lockout and identification circuit*** relays, assigns preference to this request, a signal to the remote unit prepares it to expect a terminating call and starts over-all work alarm circuit timing in the CU.

(b) When the RU receives this signal, its ***signal circuit*** places ground on the RU side of the signaling relays of control pair 0. This ground shunts the RU control contacts on these circuits and arranges them for CU signaling control. If a group-trunk-busy condition (all trunks in one group are busy) exists for the line group that the terminating service request is in, the call will not receive preference, and the calling party will receive overflow tone from the CU ***trunk overflow indication circuit.***

(c) Once the RU is ready to proceed with the call, the sequence of operation is identical with the sequence of operation for an originating call from sequence steps 1 through 6. These steps include trunk selection, transmission to the RU and registration in both units of called line group, line "A", and line "B" identification information, and sequencing. In the CU, sequence advance step 6 causes release of the ***line lockout and identification circuit,*** release of the ***cutoff circuit,*** release of the ***line circuit,*** and operation of the hold magnets for the trunk selected. If the trunk selected is the last available trunk, the ***overflow indication circuit*** will indicate a group-trunk-busy condition for subsequent calls to the group in which the selected trunk appears.

(d) When the sequence check is received from the RU, the CU ***signaling control circuit*** causes the signal relays to reflect the number of the selected trunk. If either trunk 9 or 19 is selected, a signal is sent from the CU to operate a steering relay in the RU ***signal circuit.*** Sequence advance step 7 causes the RU ***register circuit*** to record the trunk number, the RU ***cutoff circuit*** to release, and the RU hold magnets to operate. From the receipt of the sequence check signal following RU hold magnet operation to the completion of the cycle, concentrator operation for a terminating call is again identical with concentrator operation for an originating call.

4.20 *Disconnect*

(a) When the sum of the trunks being used on active calls and for delayed disconnect exceeds four, the ***trunk load control circuit*** will operate through the hold-off-normal contacts on the CU crossbar switches. Operation of the ***trunk load control circuit*** initiates a disconnect preference request in the CU ***preference control circuit.*** If a disconnect cycle has occurred within the previous 6 seconds, the ***preference control circuit*** will not allow the disconnect request to proceed. This time spacing of disconnects is provided to prevent continuous disconnect cycling to occur under certain trouble conditions. If preference is established, contacts on the ***preference control circuit*** relays will start over-all work timing, and will cause the ***trunk selection circuit*** to select the trunk to be disconnected. When the trunk has been selected, the CU ***line circuit*** for the line connected to that trunk operates, and then in turn operates the CU ***line lockout and identification circuit,*** thereby establishing its identity. Selection of a trunk also causes a signal to be sent to the RU to prepare it for disconnect by by-passing the RU signal control circuit for control pair 0, and by opening the RU ***lockout and identification circuit.*** At this time, the signal relays, controlled from the CU, reflect the group in which the disconnect is to occur. Sequence advance step 1 causes the group information to be recorded in the RU ***register circuits.*** When the CU receives a sequence check, it opens signal pair 0 to prepare it for the first part of the line information, and advances to sequence step 2.

(b) The receipt of the sequence check for sequence step 2 causes the signal relays to indicate the "B" line information, and sequence advance step 3 causes this information to be recorded in the ***register circuit*** in both units. After the "B" line information is registered in the RU, the RU steering level select magnets operate. When the CU receives a sequence check signal, it opens signal pair 0 to prepare it for transmission of "A" line information.

(c) Sequence advance step 4 starts the disconnect spacing timing circuit which prevents a second disconnect from occurring within 6 seconds after the first. Receipt of the next sequence check reoperates the signal relays on control pair 0 in accordance with "A" line information, and sequence step 5 permits the information to be registered in both the RU and CU. The line select magnets in the RU and the steering level select magnets in the CU also operate at this point.

(d) A sequence check then causes control pair 0 to open, and sequence advance step 6 releases the CU ***lockout and identification circuit.*** When the check for sequence advance step 6 is received, control pair 0 closes and the trunk information is reflected on the signal relays. If either trunk 9 or 19 is to be disconnected, a signal is sent from the CU to the RU to operate a trunk steering relay.

(e) Sequence advance step 7 causes the RU ***register circuit*** to record the trunk information, the RU cutoff relay to operate, and the RU hold magnets to release. Upon receipt of the sequence check, the CU hold magnets release, the CU cutoff relays operate, the CU ***line circuit*** releases, concentrator release work timing starts, and a release signal is transmitted to the RU. Receipt of the release signal in the RU causes all operated relays there to release. During this time, the CU opens control pair 0 and releases all operated signal relays. As soon as the release check is received at the CU, all operated CU relays release, over-all work and release work timing stops, and control pair 0 is returned to a normal condition in preparation for the next service request.

5. MAINTENANCE FACILITIES AND PROCEDURES

General

5.01 The basic maintenance problem associated with a concentrator system is one of minimizing the total out-of-service time experienced. The RU is located remotely from the central office and may be subjected to extremes of environmental conditions.

5.02 The operational reliability of the system, in terms of service to concentrated customer lines, is affected by two main factors. These are the total trouble rate and the service restoration time per trouble. A high order of operational reliability has been designed into the system, but as far as the day to day operation is concerned, maintaining an adequate quality of service depends mainly on keeping the out-of-service time per trouble to a practical minimum. The major facilities and procedures which have been provided to minimize the service restoration time per trouble are discussed herein.

Trouble Detection Facilities

5.03 Many of the trouble detection facilities now provided in central offices, either with or without minor modifications, will detect certain concentrator malfunctions. In addition, alarms have been built into the concentrator system.

5.04 ***Built-In Concentrator System Alarms:*** Four alarm indications have been provided which not only indicate that a malfunction has occurred, but also localize the source of trouble to the CU, to the RU, to the interconnecting control pair signaling circuits, or to the CU fuses. All alarm indications physically appear in the central office, none appear at the remote location. An AL (alarm) lamp and an FA (fuse alarm) lamp are provided on the CU frame. Options are provided to operate audible and visual alarms in the central office whether it is or is not arranged for alarm sending and receiving. Central office alarm transfer (sending and receiving) circuits have been modified to transmit these specific indications to the extent of their respective capabilities. These specific alarm indications permit the proper craftsmen (inside or outside) to be immediately assigned to trouble clearing. This is of particular value during unattended periods. The four alarm indications have been designated control alarm (CAL), remote alarm (RAL), signal alarm (SAL), and control circuit fuse alarm (FA).

(a) The CAL alarm indicates that the control unit circuit has failed to obtain a check of some CU function and that the CU is in trouble.

(b) The RAL alarm indicates that the remote unit circuit has failed to complete a function and that the RU is in trouble. A failure in the battery charging circuit which prevents charging current from reaching the battery also results in an RAL alarm.

(c) The SAL alarm indicates that a signal has not been sent or received. This alarm identifies a signaling circuit failure but does not localize it to the CU or RU.

5.05 The three alarms discussed above lock through the contacts of the alarm release (AR) key located on the CU. Operation of the AR key at the CU location, or the alarm release function at a remote location of central offices equipped with alarm sending and receiving circuits will release the alarm relays and the AL lamp, and retire the office alarms.

5.06 Operation of a fuse in the CU causes the FA lamp to light. Options are provided to cause this alarm to close an operating path to the audible and visual alarm circuit of the central office, whether it is or is not arranged for alarm sending and receiving. As previously discussed, a failure of the RU charging circuit causes an RAL alarm. An operated fuse in the RU will cause the circuit to block and an RAL alarm will result.

5.07 ***Automatic Line Insulation Testing:*** A minor modification is provided for the standard automatic line insulation circuit to allow time for the concentrator to complete a connection to the customer loop before making tests. This arrangement assures that all concentrated customer loops, except those busy when tested, will be tested.

Trouble Location, Service Restoration, and Repair Facilities and Procedures

5.08 This concentrator system uses standard electromechanical apparatus employing conventional switching circuitry. Therefore, conventional switching equipment maintenance procedures apply. No special test equipment or tools are required. This system has been designed so that most of the internal system tests can be conducted from the central office CU location.

5.09 ***Control Unit (Central Office) Facilities and Procedures:*** Facilities and procedures have been provided which allow craftsmen at the CU location to (a) originate terminating and disconnect calls, (b) to force connection to or release of a specific trunk, (c) to operate specific RU line cutoff relays thereby preventing that line from originating a service request, and (d) through use of the tip lead of either trunk No. 08 or 09, when idle, to initiate an originating service request at the RU on line terminal No. 49 or 99. Concentrator line terminals No. 49 and 99 will usually be used as test terminations and are initially equipped with a 33,000-ohm resistance bridged across the tip and ring at the RU. By means of tests for the presence of this specific resistance, the ability of the system to set up terminating calls to a specific line can be checked. Through use of the tip lead of trunk 07, when idle, the remote unit battery voltage and ground return resistance may be measured from the CU location. Trouble location to specific apparatus and repair follow standard central office maintenance procedures. Complete Bell System Practice coverage is provided, including a section on trouble analysis.

5.10 ***Remote Unit Facilities and Procedures:*** Craftsmen at the RU can cause originating service request calls to be initiated on individual line terminals by connecting a telephone set across the line. In those few cases where other types of calls are required to locate trouble in the RU, the assistance of a craftsman at the CU location is necessary.

(a) A combined spare parts and tool kit is provided in a suitable carrying case for use at the remote unit. It contains spare relays, wire wrapping and unwrapping tools, and similar items required to replace apparatus.

(b) A 2-step maintenance procedure for the RU is contemplated. The first step involves a craftsman going to the RU equipped with standard tools and test equipment that are normally a part of his equipment. This includes a telephone set, a multimeter, and common usage hand tools. In nearly all cases, the craftsman is expected to locate and repair the RU trouble without need for any further materials or test equipment. In those few cases where apparatus must be replaced or relays or switches readjusted, the craftsman would obtain a relay test set and/or the spare parts and tool kit from a centralized location. A tent has been made available for use at the remote unit.

5.11 ***Test Desk Considerations***

(a) In general, test desk operations on concentrated lines are identical to those on nonconcentrated lines. After a connection has been established, the line tip and ring conductors of the line are free of shunts or bridges to battery or ground (clean tip and ring). The test desk may also terminate calls to the test line terminals No. 49 and 99 if central office apparatus and directory numbers have been assigned.

(b) One new element in the connection is that the identity of the trunk used on a specific call is not known and that different trunks may be used on subsequent test calls. Except in rare cases, this factor should cause no problems and should be ignored during preliminary line testing. In those few cases where the trunk is a factor, a craftsman at the CU working in conjunction with the test desk can force calls over specific trunks.

(c) In cases of cable or similar customer loop trouble which would tie up concentrator trunks on permanent signal for long periods, the concentrator service denial feature may be applied at the CU to operate the CU cutoff relay for the line or lines in question, and the concentrator trunk restored to service without a craftsman visiting the RU. This is equivalent to pulling the heat coils at the distribution frame for a nonconcentrated line. This feature is useful in making temporary disconnects or left-in station disconnects.

6. TRAFFIC

Concentrator Trunk Usage Recorder (Fig. 6)

6.01 *Purpose:* To economically load a line concentrator to maximum line fill consistent with traffic capacity and other service objectives, an in-service measurement of ccs (hundred call seconds) load per concentrator trunk group is desired. To fill this need, a small low cost concentrator trunk usage recorder (CTUR) has been provided. This device is timer controlled and measures the traffic load or usage of ten concentrator trunk groups directly in ccs.

6.02 *Capacity:* The concentrator trunk usage recorder is capable of simultaneously measuring usage for five 100-line size or ten 50-line size line concentrators No. 1A, or combinations of both. The CTUR has provision for measuring ten groups of ten trunks with one traffic register for each 10-trunk group.

6.03 *Equipment:* The major apparatus components of the CTUR are two 206-type selector switches, four relays, and two timers. The first timer, which has a cycle of 100 seconds, controls the time for each complete trunk scan. The second timer, which is provided on an optional basis, is a seven-day timer which can control the operation of the CTUR in place of a TUR or a traffic register camera control circuit.

6.04 *Method of Operation:* The CTUR scans each trunk appearance once each 100 seconds. If the scanner finds ground on a trunk, the traffic register for the particular 10-trunk group being scanned will be advanced one unit.

Dial Tone Speed

6.05 Concentrator dial tone speed can be measured using the standard dial tone speed measuring circuit (DTS) measuring equipment. The operate or work time of the concentrator is a constant. The only concentrator caused dial tone delay condition, which is variable, will occur when all ten trunks in a group are busy. Therefore, the DTS equipment is connected to scan a contact on the group-trunk-busy relay. To make this measurement, concentrators must be treated as a separate class of service. This requires that one arc of the DTS circuit be reserved for this use. One arc has a capacity of 20 terminals.

Service Observing

6.06 Installation of the line concentrator No. 1A will not alter present service observing facilities or procedures. However, observation of events on the customer loop prior to concentrator cut-through will not always be possible.

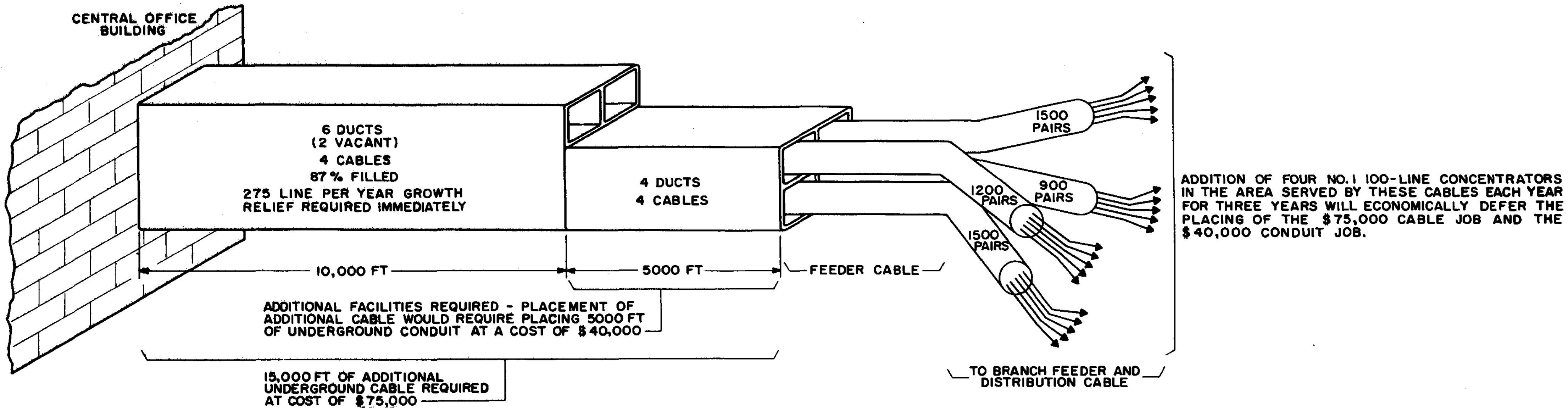


Fig. 1A – Example of Temporary Concentrator Installation

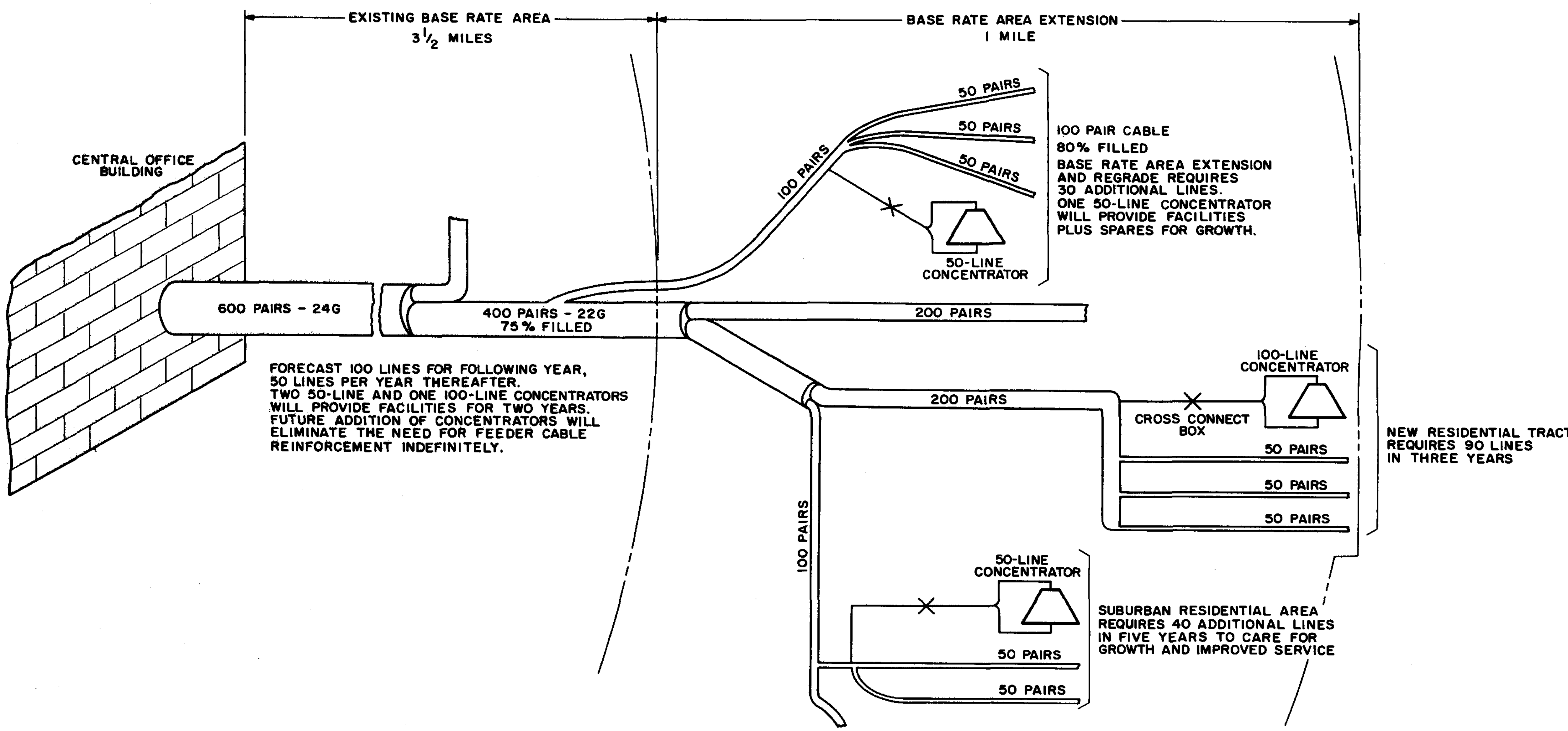
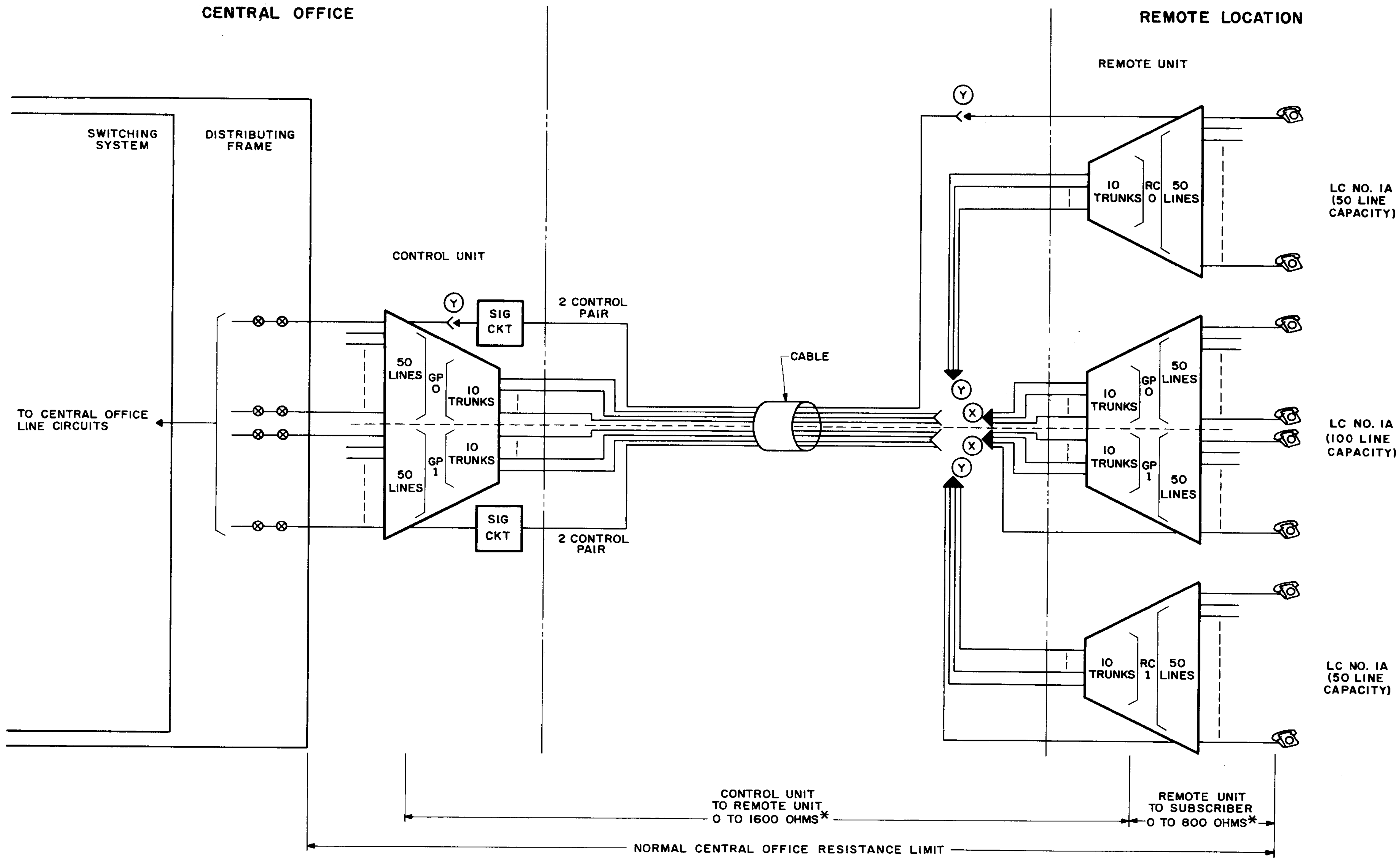


Fig. 1B – Example of Permanent Concentrator Installation



* TOTAL RESISTANCE OF (CONTROL UNIT TO REMOTE UNIT) PLUS (REMOTE UNIT TO SUBSCRIBER) SHOULD NOT EXCEED NORMAL CENTRAL OFFICE RESISTANCE LIMIT.

Ⓧ LC NO. 1A – 100 LINE CAPACITY REMOTE UNIT

Ⓨ LC NO. 1A – 50 LINE CAPACITY REMOTE UNIT

Fig. 2 – General System Layout

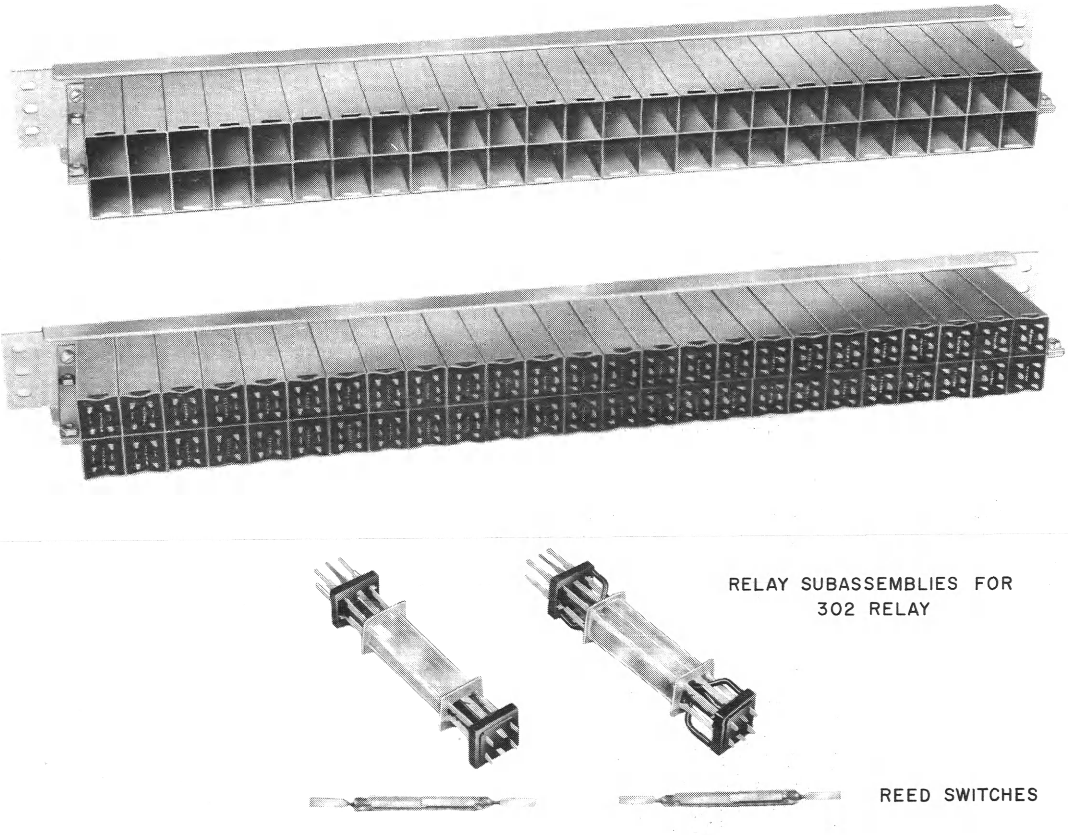


Fig. 3 – Dry Reed Relays

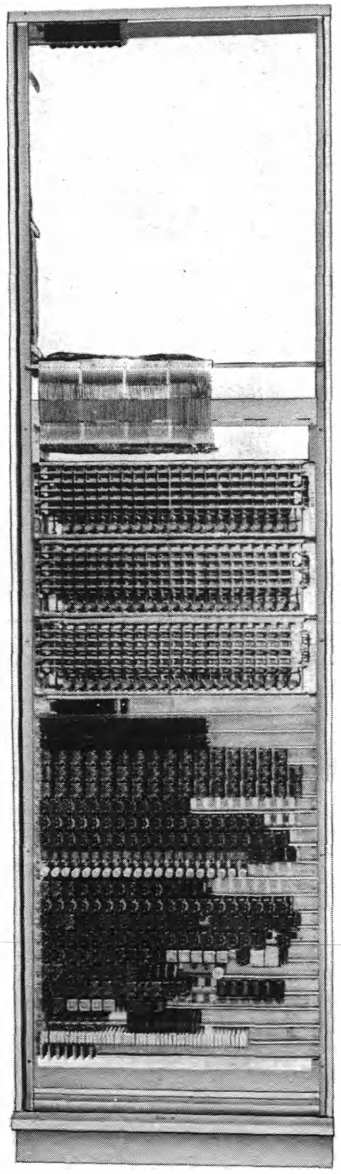


Fig. 4 — Central Office Frame

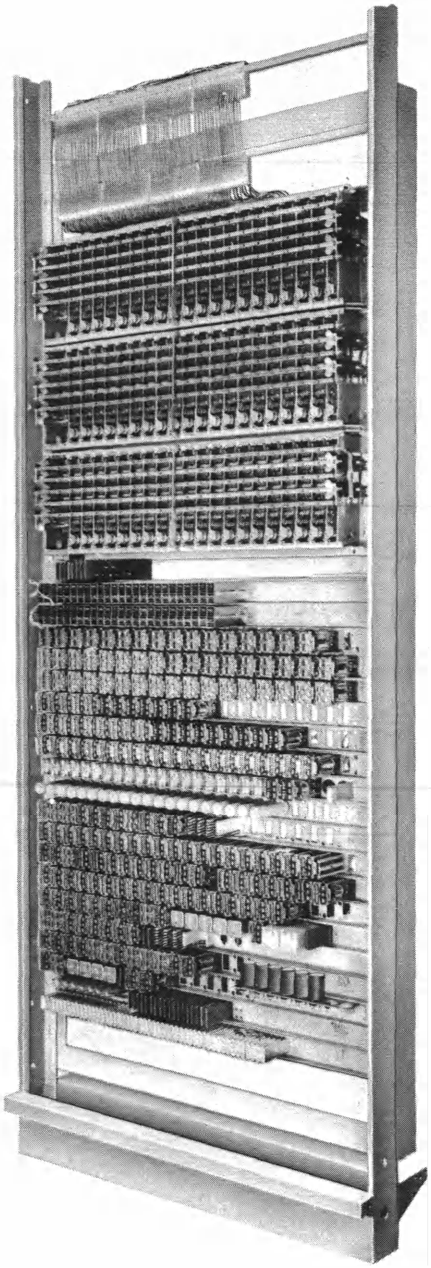


Fig. 5 – Central Office Control Unit

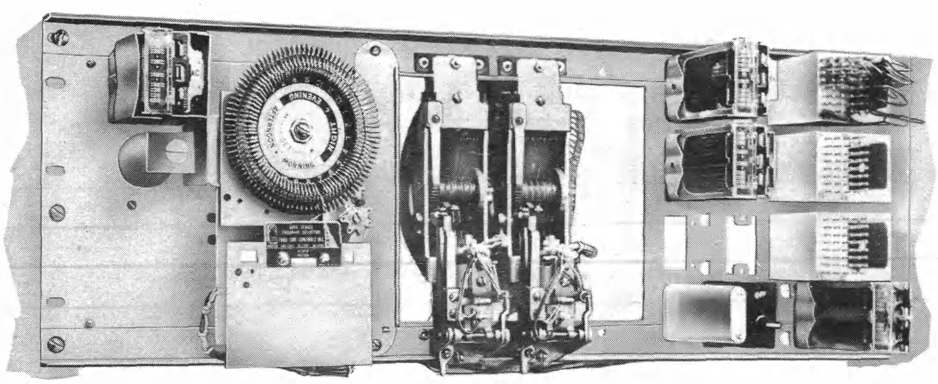


Fig. 6 — Concentrator Trunk Usage Recorder

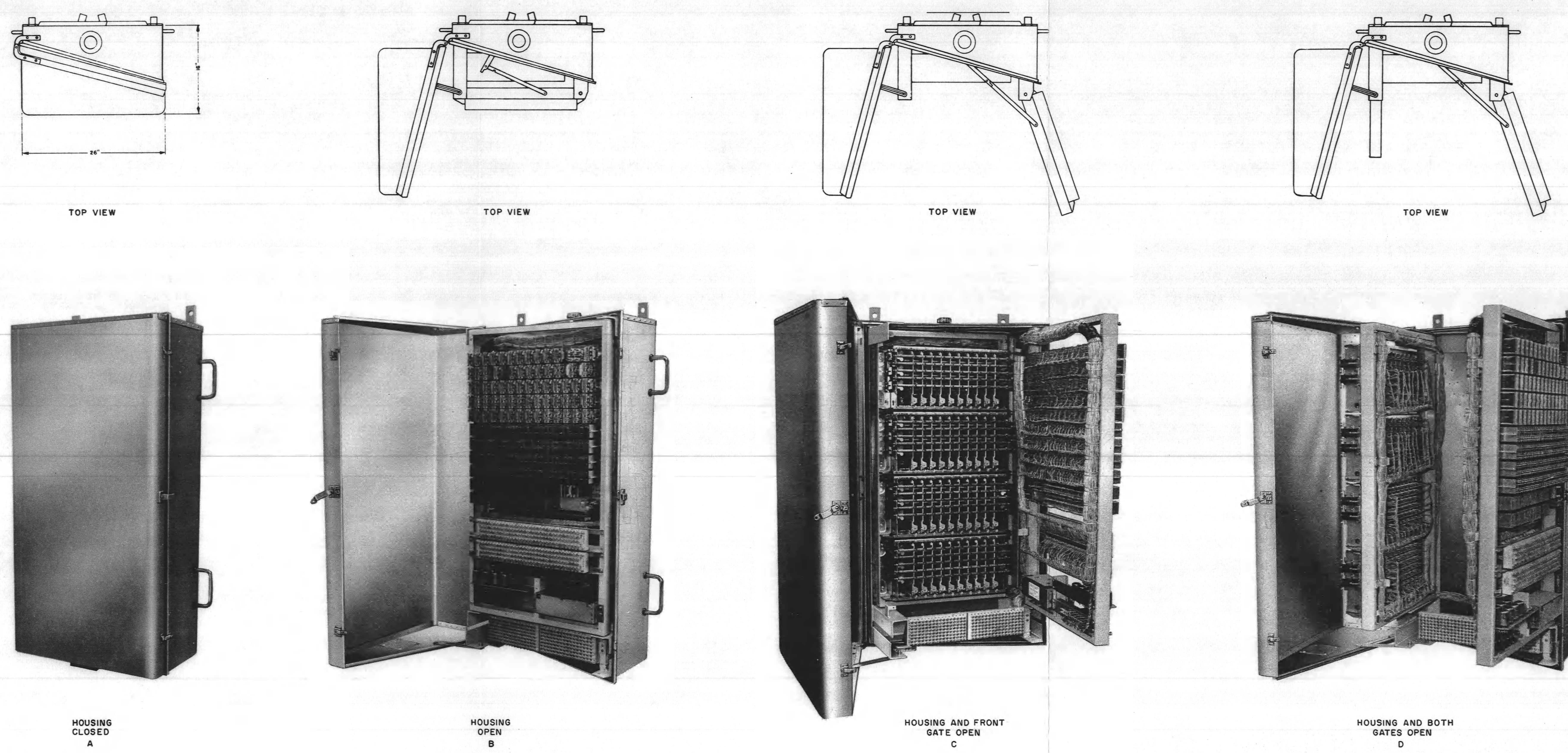


Fig. 7 – 100-Line Capacity Remote Unit

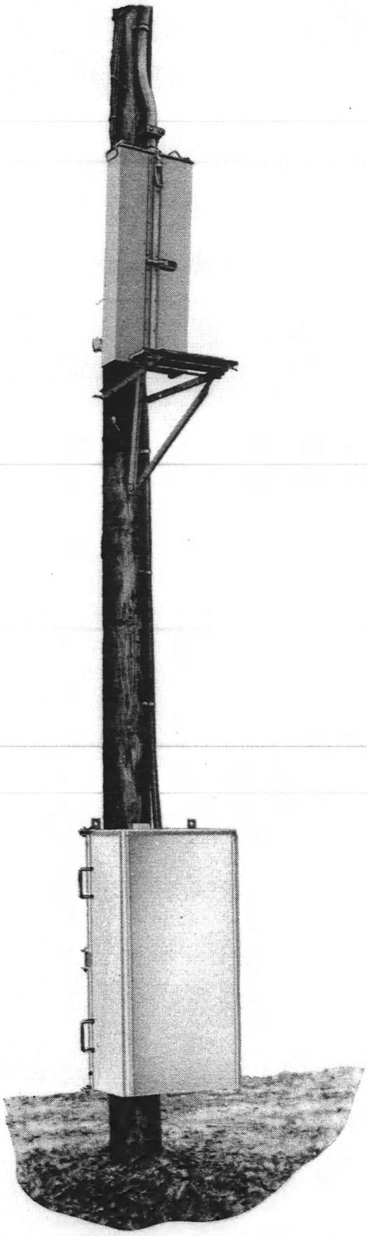


Fig. 8 — Typical Concentrator Installation

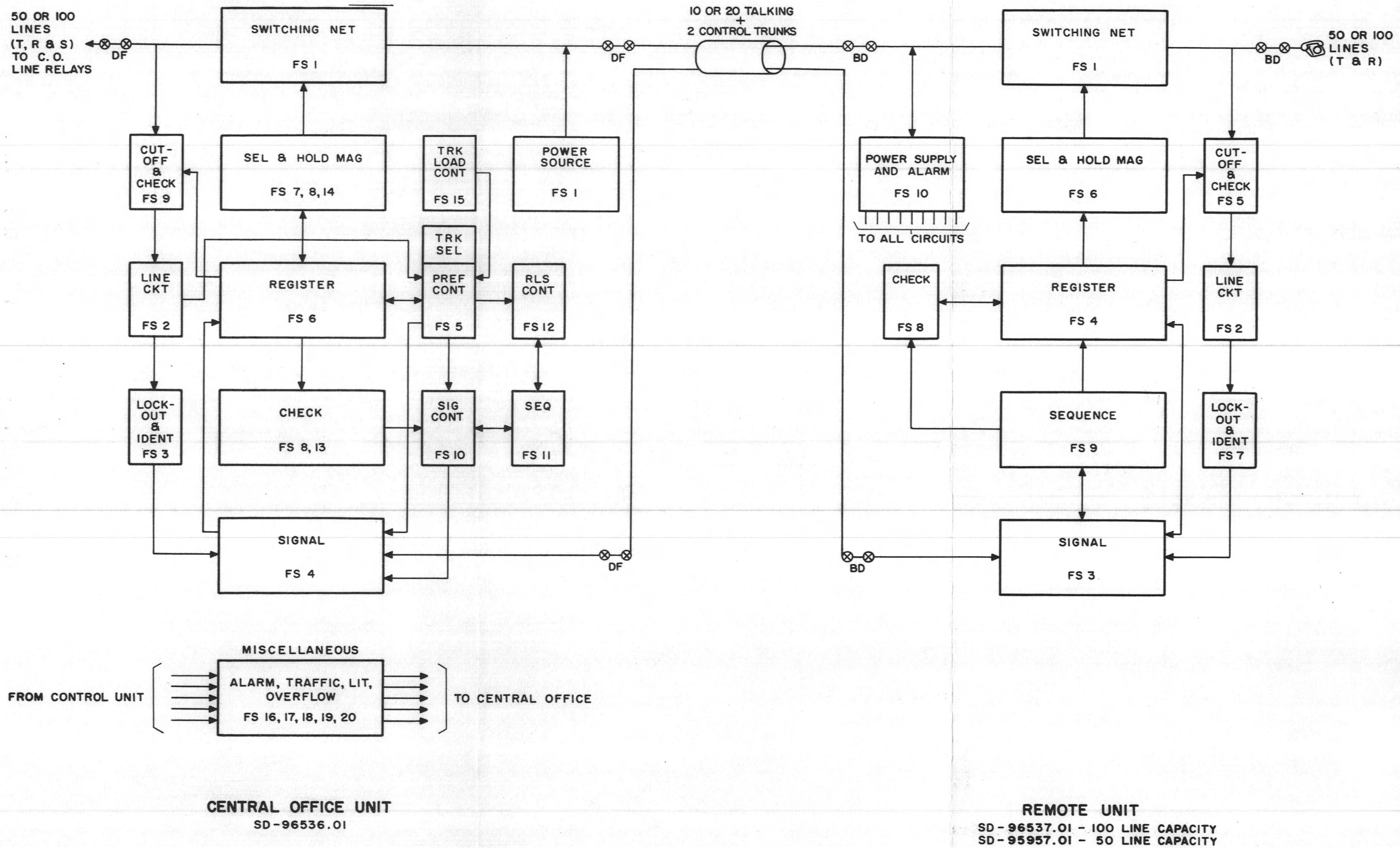


Fig. 9 — Block Diagram

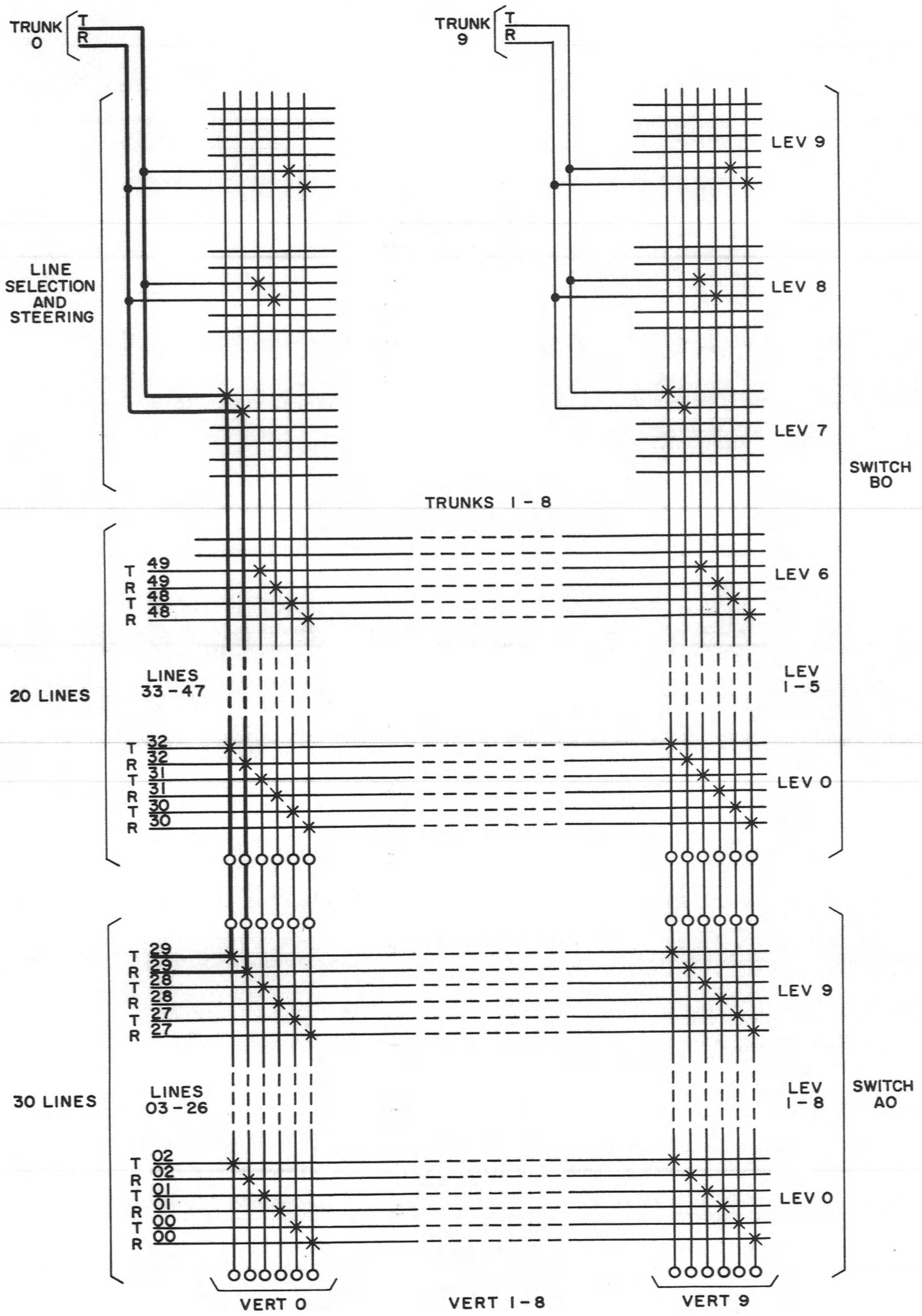


Fig. 10 – Switching Network

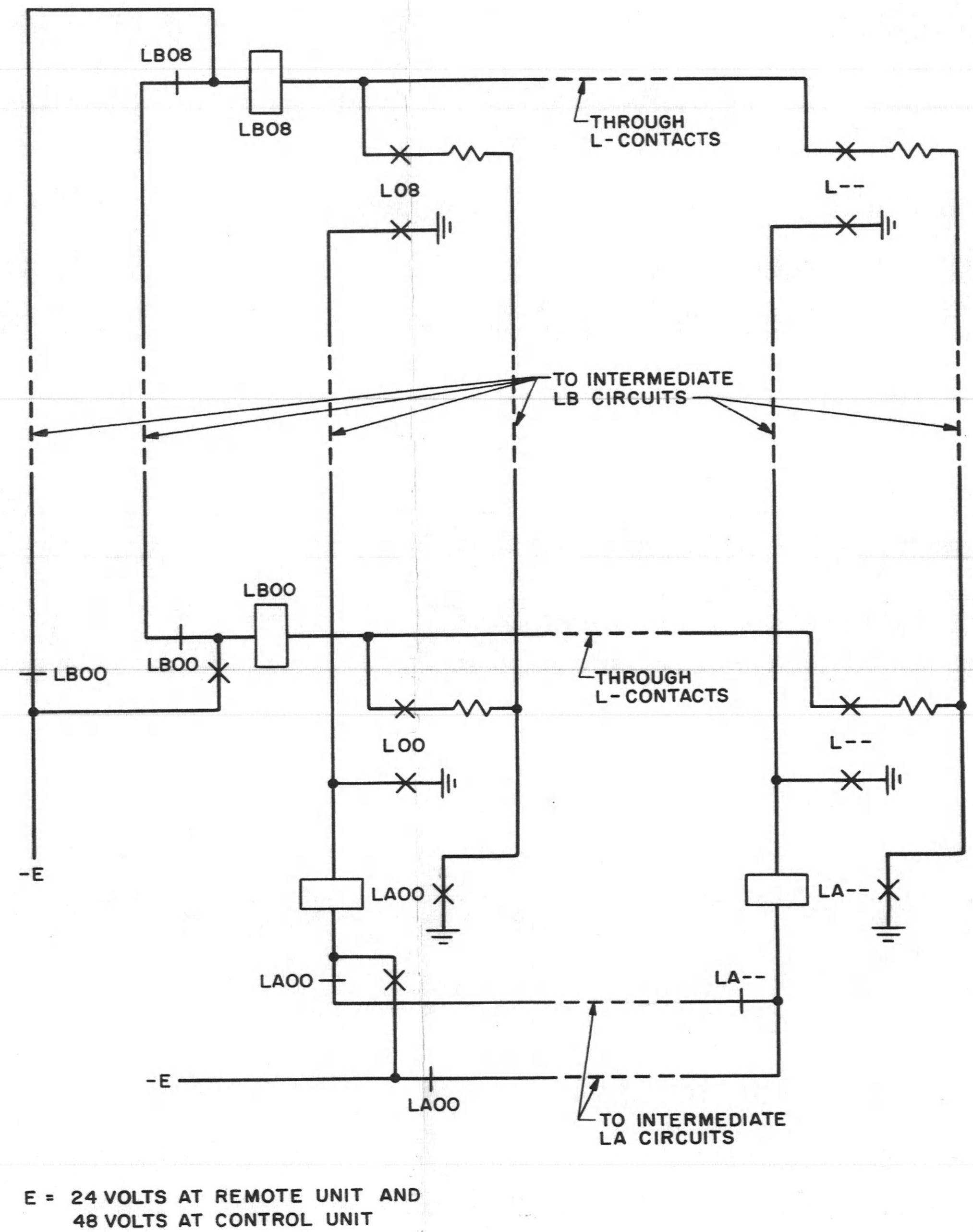
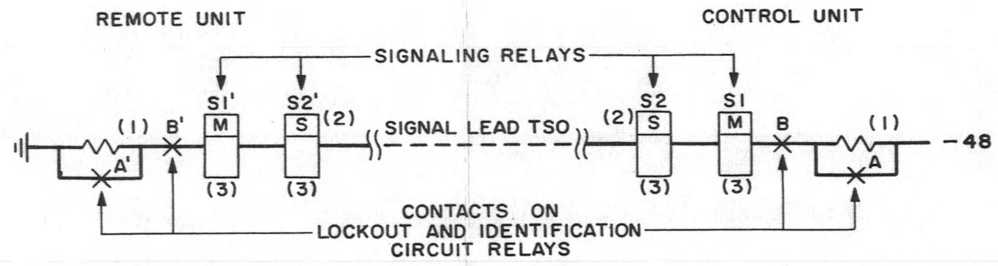


Fig. 11 – Simplified Line Lockout and Identification Circuit



OPERATING NOTES

1. NO MORE THAN ONE RESISTOR WILL BE IN THE CIRCUIT AT ANY TIME. WHEN THE REMOTE UNIT IS SIGNALING, THE RESISTOR IN THE CONTROL UNIT WILL BE SHUNTED. WHEN THE SIGNALS EMANATE FROM THE CONTROL UNIT, THE RESISTOR IN THE REMOTE UNIT WILL BE SHUNTED.
2. THE SENSITIVE RELAYS WILL OPERATE IN SERIES WITH A RESISTOR, THE MARGINAL RELAYS WILL NOT.
3. THE RELAYS OF THE RSO LEAD OF CABLE PAIR ZERO ARE LABELED S3, S3', S4, AND S4'.

OPERATING CONDITIONS

1. NO RELAYS OPERATED AT EITHER END – EITHER CONTACT B OR B' OPEN.
2. ONE RELAY OPERATED AT EACH END – CONTACTS B AND B' CLOSED AND A OR A' OPEN.
3. TWO RELAYS OPERATED AT EACH END – ALL CONTACTS CLOSED.

POSSIBLE SIGNALING COMBINATIONS FOR TWO WIRES

(NUMBER OF RELAYS OPERATED AT EACH END)

COMBINATIONS	123	456	789
WIRE 1 (TSO)	000	111	222
WIRE 2 (RSO)	012	012	012

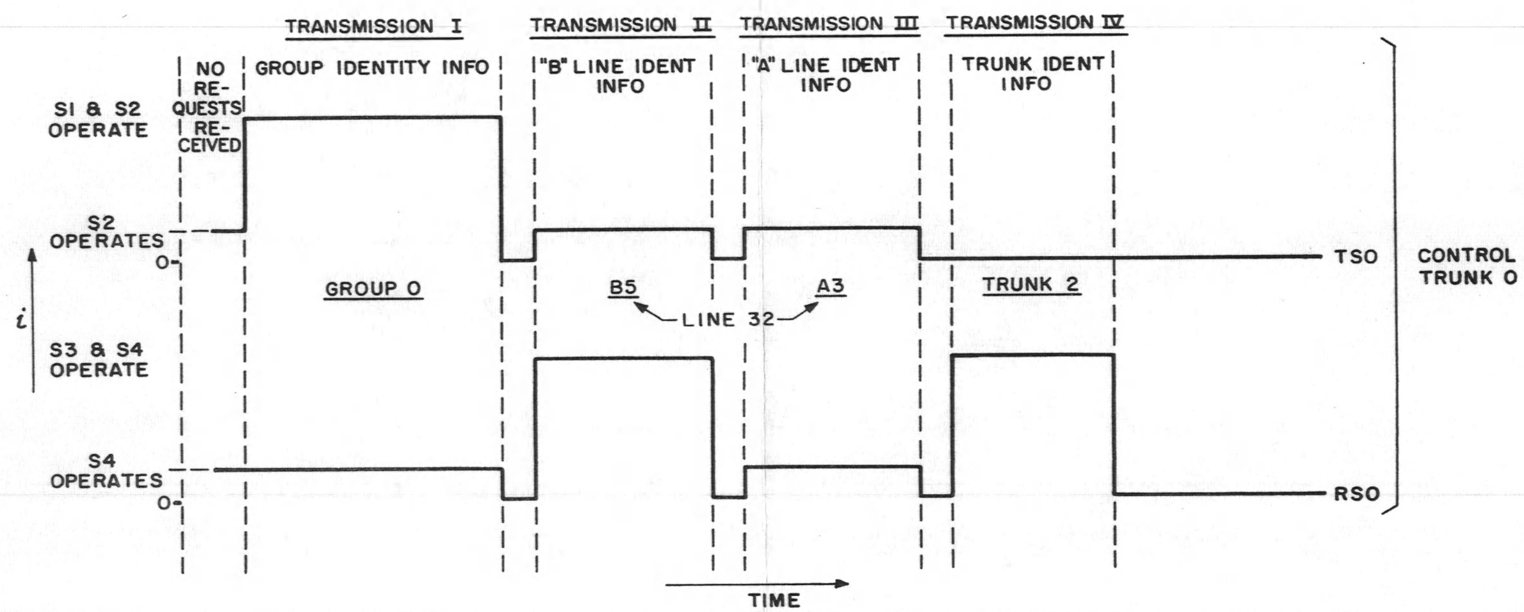


Fig. 12 – Simplified Signal Circuit

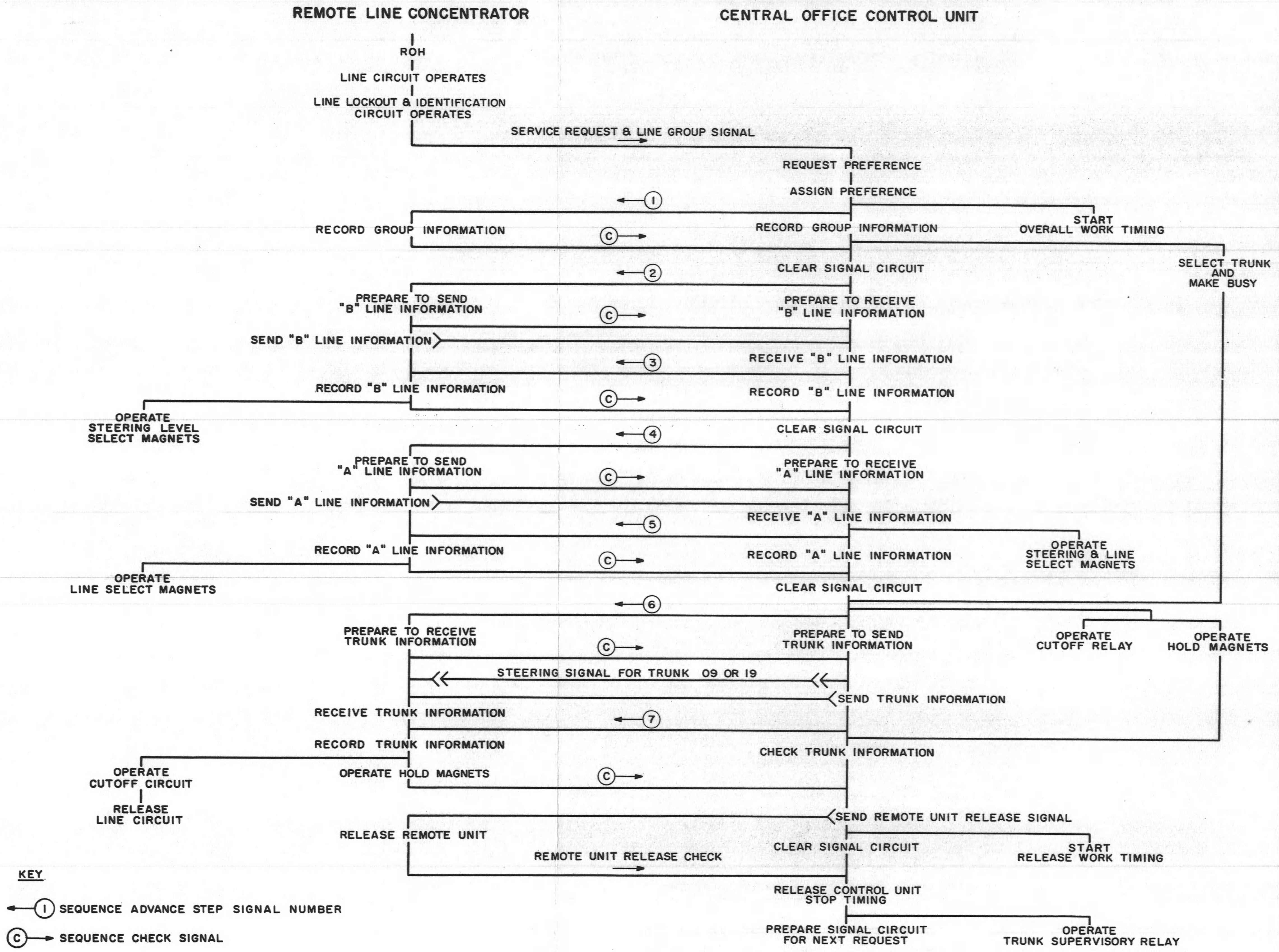


Fig. 13 — Functional Sequence Chart Originating Call

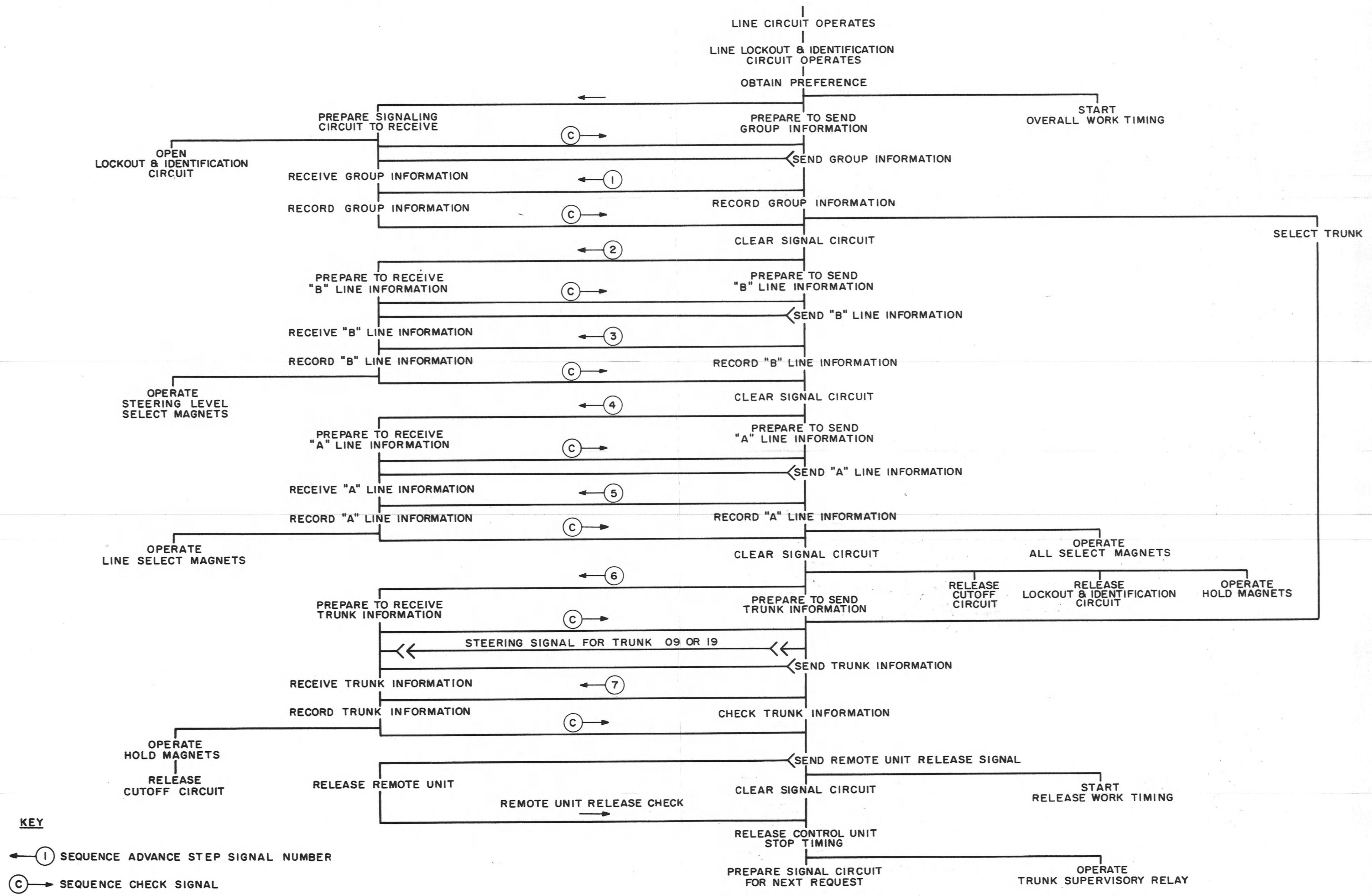


Fig. 14 — Functional Sequence Chart Terminating Call

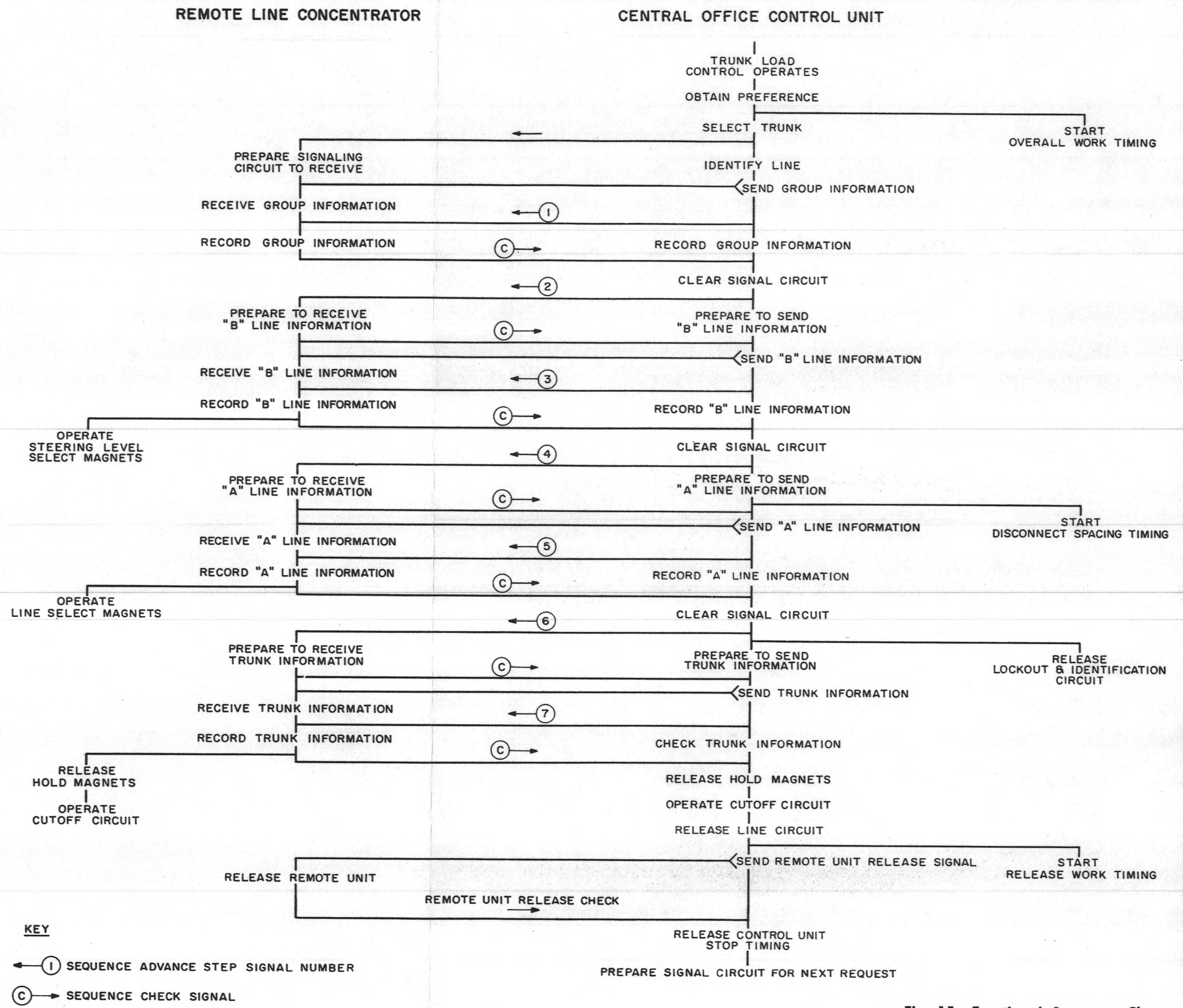


Fig. 15 — Functional Sequence Chart Disconnect Request