REPLACING PAGE ADDENDUM
Filing Instructions:
1. REMOVE FROM THE SECTION THE PAGES NUMBERED THE SAME AS THOSE ATTACHED TO THIS PINK SHEET.
2. INSERT THE ATTACHED PAGES INTO THE SECTION IN THEIR PLACE.
3. PLACE THIS PINK SHEET AHEAD OF PAGE 1 OF THE SECTION.

ADDENDUM 951-836-100
Issue 1, May 1967
AT&TCo Standard

LINE CONCENTRATOR NO. 2A

GENERAL DESCRIPTIVE INFORMATION

1. GENERAL

1.001 This addendum supplements Section 951-836-100, Issue 1. The attached pages must be inserted in the section in accordance with the filing instructions above.

1.002 This addendum is issued to delete all references to WADS in this section.

The following changes apply to Part 1 of this section:

(a) 1.02 — revised

(b) 1.03 — revised

(c) 1.04 — revised

(d) 1.05 — revised

2. CHARACTERISTICS AND FEATURES

The following change apply to Part 2 of this section:

(a) 2.01 — revised

(b) 2.04 — added

(c) 2.06 — revised

(d) 2.07 — revised

(e) 2.09 (b) — revised

(f) 2.09 (c) — revised

(g) 2.10 — revised

(h) 2.16 — revised

4. METHOD OF OPERATION

The following change applies to Part 4 of this section:

(a) 4.54 — revised

5. MAINTENANCE FACILITIES AND PROCEDURES

The following changes apply to the figures of this section:

(a) Fig. 1 — revised

(b) Fig. 2 — revised

(c) Fig. 17 — revised

Attached:

Pages 1, 2, 3, 4, 17, dated May 1967 — revised
Page 18 dated May 1967 — reissued
Pages 27, 28, and 48 dated May 1967 — revised
Page 2.1 dated May 1967 — added

LINE CONCENTRATOR NO. 2A

GENERAL DESCRIPTIVE INFORMATION

TABLE OF CONTENTS PAGE

1. GENERAL

SCOPE

1.01 This section describes the line concentrator No. 2A, 80-line capacity remote and 160-line capacity control 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 The traffic to and from data and dial TWX (DTWX) stations served through the (2A line concentrator) must be switched through a No. 5 crossbar central office arranged for data service. Since only a small number of existing central offices will be so equipped, many of the data and DTWX stations will be located in exchanges remote from these switching centers. Stations at these locations will be served by remote exchange lines and, where economical, may be connected to the data serving office by means of a 2A concentrator.

1.03 This concentrator has been designed to provide an economical substitute for individually dedicated interoffice trunk facilities. Through the use of switching equipment, a large number of data and/or DTWX stations will be concentrated over a few trunks to a No. 5 crossbar central office arranged for data service. This concentrator is intended for permanent installation in central office.

FIELDS OF USE

1.04 From an economic standpoint, the groups of stations eligible for concentrator application of this type are those at a distance from the data serving office, where the annual charges for individual cable and/or carrier facilities exceed the annual charges for concentrators and concentrator trunks required to serve an equivalent number of stations.

1.05 Concentrators can also be economically used to reinforce existing trunks where the installation of additional trunk facilities to meet new demands of offices serving data or DTWX stations would be more expensive.

2. CHARACTERISTICS AND FEATURES

GENERAL

2.01 Data systems are expected to switch large volumes of short holding time messages over long (average 600 miles) built-up connections. The design of the concentrator has been oriented toward instrumentalities and techniques that will keep the concentrator switching time to a minimum, thus reducing the network holding time for each call. Except as discussed in 2.04 and 2.09, the concentrator places no restrictions on the transmission facility. The concentrator will function over any facility suitable for data or DTWX access lines.

2.02 The line concentrator No. 2A consists of two major units, a control unit, and a remote unit. The remote unit is designed to serve up to 78 subscriber lines with two lines reserved exclusively for test purposes. Each control unit is capable of handling two remote units, although the control unit may be arranged to serve a single remote unit on an optional basis.

2.03 Both the remote and control units employ full access magnetically latching crossbar switches as network crosspoints, flat-type double winding relays for line relays, transistor resistor logic (TRL), which, in addition to performing logic functions, acts as an interface between the wire spring network control relays and a solid state ac signaling circuit. The signaling circuit uses frequency shift pulsing to transmit information between the remote and control units. A more detailed description of this signaling mode is contained in 4.11.

2.04 ***Signaling Control Channel Requirements:*** The quality of the transmission facilities used for the signaling control channels are to be such that the impulse noise as measured with a 6-type impulse counter should not exceed 35 counts in 15 minutes at a noise level of 48-53 dbrn.

2.05 The general system layout is illustrated in Fig. 1. This system is a double-ended, concentrate-deconcentrate arrangement with individual line terminals appearing at each concentrator unit.

OVER-ALL SYSTEM CHARACTERISTICS

2.06 ***Control and Remote Unit Central Offices:*** The line concentrator No. 2A control unit is designed for use in a No. 5 XBR office arranged for data service. The remote unit is designed for use in No. 5 or No. 1 XBR or No. 1 or No. 350-type SXS offices.

2.07 ***Type of Line Served:*** The line concentrator No. 2A will serve data and DTWX stations assigned as individual lines and will function on a loop start basis.

2.08 ***Line and Trunk Terminal Capacity***

(a) ***Control Unit:*** The control unit is capable of serving two remote units. The network will switch traffic of two separate groups of 16 trunks each (maximum) to two separate groups of 80 lines each (maximum). Two of the 80 lines are reserved exclusively for test purposes. Arrangements are provided to permit either trunk group to operate with less than 16 trunks without requiring any wiring or equipment changes. The equipment design of the control unit permits the omission of most of the equipment associated with the second group of lines if it is required to function with a single remote unit.

(b) ***Remote Unit:*** The remote unit will concentrate a maximum of 80 lines to 16 trunks. Two of the 80-line terminals are reserved exclusively for test purposes. In addition, there is one trunk for control purposes. This trunk can be either a 2-wire circuit terminated in hybrids, or a 4-wire circuit.

2.09 ***Concentrator Range Limits***

(a) ***General:*** The choice of facilities for the signaling and trunk channels, in nearly all instances, will govern the maximum concentrator range. The ac signaling circuit of the concentrator is limited by the transmission facility selected and will operate satisfactorily with signals down to —30 dbm, with the additional restriction that the transmission delay shall not exceed 12 milliseconds in each direction. The output level of the signaling circuit can be varied from —10 dbm to —42 dbm. Fig. 2 illustrates the limits imposed on the concentrator range by the choice of trunk facilities.

(b) ***Auxiliary Circuit Limits***

(1) Where an auxiliary circuit (eg, SF signaling) is placed in the trunks (see part A of Fig. 2), the resistance range between the control unit auxiliary and the serving central office will be limited by the ← auxiliary or central office limits, whichever is less. The resistance range between the remote unit auxiliary and the data or ← DTWX station will be limited by the remote unit line relay or auxiliary, whichever is less.

(2) The range between the remote unit auxiliary and control unit auxiliary is a function of the trunk facility selected.

(c) ***Loop Resistance***

(1) Where auxiliaries are not used in the trunks, the total external loop resistance from the central office to the data or DTWX station will be limited by the central office range. Part B of Fig. 2 illustrates this arrangement. The TS relay at the control unit adds 20 ohms to the loop resistance. This relay will operate on external circuit loops of 4200 ohms and is not range limiting in these configurations. The TS relay winding is removed from the ring conductor after the central office portion of the call is established.

(2) Remote Unit to data or DTWX or Station Range: The normal remote unit to data or DTWX station external circuit loop resistance range is 0 to 2795 ohms. This range is determined by an optional arrangement provided by a dual winding line relay. A resistance range up to 1450 ohms is achieved with single winding operation. Dual winding operation extends the range to 2795 ohms.

(d) ***Transmission Delay:*** To assure that the remote unit is able to establish the same call preference as the control unit, the transmission delay of the ac signaling circuit control information between the control and remote units over the selected facility cannot be greater than 12 milliseconds in each direction.

(e) ***Operation With Line or Trunk Auxiliaries***

(1) Line Auxiliaries: Line auxiliaries may be used on the line side of either concentrator unit on a 1-per-line basis.

(2) Trunk Auxiliaries: Trunk auxiliaries, such as single frequency signaling circuits or DX signaling circuits, may be used in the concentrator trunks on a 1-per-trunk basis. Hybrid auxiliaries may be used to convert the concentrator signaling circuit from 4- to 2-wire operation.

2.10 ***Delayed Disconnect and Trunk Preselection:*** All but one trunk is left cut through to the last line served by each trunk. The remaining trunk is preselected for the next call. This feature insures that a minimum of 15 lines in each group of 80 are always connected to the line terminals of the data serving office, even in the event of a concentrator failure. In addition, this feature tends to reduce concentrator work time per call by eliminating the concentrator set up time for calls to or from the cut-through lines. Preselecting the next trunk eliminates the need to perform a trunk hunting sequence prior to closing a call through the concentrator.

2.11 ***Temperature and Humidity Limits:*** Both the control and remote units are designed to operate in the temperature range of +32 degrees F to +130 degrees F, and with relative humidity up to 100 per cent at 95 degrees F.

2.12 ***Power Arrangements:*** Both the control and remote units are designed to use the existing −48 volt central office power supply. Negative 48 volts is required for the electromechanical circuitry. A dc to dc converter (−48 to +12 volts) is required to power the solid state circuitry. This converter is located on the concentrator frame.

TRAFFIC FEATURES AND CHARACTERISTICS

2.13 ***Engineered Capacity.*** Each 16-trunk group has an engineered traffic capacity of about 288 ccs (hundred call seconds). The capacity for the 16 trunks is increased to about 304 ccs when the concentrator is used in conjunction with an auxiliary traffic measuring circuit. This is expected to allow operation at full line fill in most applications.

2.14 ***Auxiliary Trunk Usage Measurement:*** In order to fulfill the requirements in 2.12, an auxiliary traffic measurement circuit (SD-99327-01) which functions with the traffic usage recorder (TUR) to provide dual traffic registrations when a predetermined fraction of the total equipped concentrator trunks are in use, has been developed. This circuit counts the trunks busy as the TUR scans the first scan point assigned to each trunk. If a predetermined number of trunks are found busy, the auxiliary trunk measurement circuit functions to provide dual outputs to the traffic register circuit. As

the TUR scans the second scan point associated with each trunk, with the auxiliary trunk measurement circuit operated, two traffic registers are pegged for each busy trunk encountered. One auxiliary trunk measurement circuit is required for each concentrator trunk group. This circuit can be mounted on any standard 23-inch relay rack bay.

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. One of the terminals on this arc will be assigned to each concentrator trunk group.

2.16 *Overflow Tone:* An incoming call received during a period when all trunks in a group are busy will be connected to the new overflow tone. This overflow tone is machine recognizable and capable of being transmitted over narrow band channels.

2.17 *Line Preference*

(a) *Control Unit:* Two line preference chains are provided for each group. To prevent successive calls for a line that fails to complete satisfactorily if terminating calls to other lines are waiting, the control unit is arranged so that the selection of lines to be served is changed on four successive calls as listed in Table A.

TABLE A

	CHAIN 1	CHAIN 2
	PREFERRED LINE TENS	PREFERRED LINE UNITS
1st Call	0	0
2nd Call	7	0
3rd Call	7	9
4th Call	0	9

(b) *Remote Unit:* Line preference is alternated between the lowest and highest numbered lines on succeeding calls by means of W-Z relay operation.

2.18 *Trunk Preference:* Trunk preference is changed in the control unit after each disconnect call, and all other trunks are preferred once before a trunk used on a call is again the preferred trunk. The trunks are preferred in the following order:

00 to 14 even, 01 to 15 odd.

This preference arrangement changes the trunk selection path after each call and thus prevents a defective trunk or trunk selection path from causing a service impairment.

2.19 *Call Preference:* In cases of simultaneous or overlapping call requests, the call preference circuit determines the order in which the requests will be served. The call preference circuit also prevents a terminating or disconnect call from starting if all trunks are busy. This circuit also prevents the start of a terminating call, if (1) a trunk has not been preselected, (2) tone is absent from the remote unit, or (3) the remote signal failure alarm has operated. On terminating-type test calls where it is desired to complete the test call over a particular trunk, the call preference circuit locks out service calls until the particular trunk is selected for use on the test call.

2.20 *Remote Unit Preference:* A function of the call preference circuit provided at the control unit is to alternately prefer group 0 and group 1 for call processing. This feature prevents heavy traffic through one group from delaying calls waiting in the other group.

2.21 *Service Observing:* Installation of the line concentrator No. 2A will not alter present service observing facilities or procedures. However, observation of events on the customer loop prior to concentrator cut-through will not be possible.

3. MAJOR EQUIPMENT ELEMENTS

NEW TYPES OF APPARATUS (LOGIC AND SIGNALING CIRCUIT PACKS)

3.01 *General:* The electronic circuitry in the line concentrator is mounted on equipment units called circuit "packs." Each "pack" consists of a glass-filled epoxy or phenolic board mounting solid state devices interconnected by printed wiring with input and output leads ter-

minated on a 20-terminal plug assembly. Typical logic and signaling circuit "packs" with frames are shown in Fig. 3. There are 13 different packs used in the concentrator. Seven of these packs contain the logic circuit building blocks and six contain the ac signaling circuit units. The control and remote units both use the same type pack with the exception of the modulators and discriminators, which are designed to satisfy the requirements unique to the control or remote unit.

3.02 ***Pack Description — Circuit Pack Schematics (CPS)***

(a) Each CPS drawing contains the representation of the circuitry in the pack, a table indicating wave shapes pertinent to that pack, and/or input-output relationships, a symbol (or symbols) used to functionally represent the circuit (or circuits), a brief description of the circuit, manufacturing test requirements, and an apparatus list (see Fig. 4).

(b) On the schematic drawing, all conducting paths are brought to the edge of a rectangle enclosing the schematic. Connections to battery and ground are indicated on the perimeter of the rectangle. The potential values shown on the CPS drawings and waveforms are nominal values. Allowances should be made for nominal power supply and circuit component variations.

3.03 ***Detailed Description — Function Symbols***

The circuit packs are interconnected to perform part of the necessary logic, memory, timing, and all of the ac signaling functions required to establish a connection between the control unit and the remote unit. A logic diagram of the solid state part of the control and remote units appears in each of the respective schematic drawings. In the control and remote unit schematic drawings, functional symbols of the electronic circuits are used rather than the complete electrical schematic of the circuit. These functional symbols also appear on the circuit pack schematics, with indications of input, output, and direction of information flow through the circuit.

3.04 ***Dry Reed Relays (Fig. 5)***

A new dry reed relay (coded 293G) has been developed for use in the 2A concentrator to pass information from the solid state circuits to the electromechanical circuits. This relay is operated directly from a transistor gate. Wire spring relays operating off −48 volts serve as slaves to the dry reed relays.

CONTROL UNIT

3.05 ***Frame:*** The control unit is mounted on a two bay sheet metal type frame, measuring 5 feet 11-1/4 inches wide by 11 feet 6 inches high, intended for use in a No. 5 XBR central office. The frame is arranged to serve two remote units, although it can be initially equipped to serve only one.

3.06 ***Equipment Arrangement (Fig. 6):*** The equipment common to both remote units is mounted in the middle of the equipment pile-up of both the right and left bays. The left bay mounts the electromechanical relay equipment and the right bay the electronic circuit packs. The lamp jack and key panel is also mounted toward the center of the left bay. Beneath and above the common equipment is located the equipment necessary to serve remote units 0 and 1 respectively. The left bay contains the relay equipment and the right bay the XBR switches. Terminal strips (for connecting to the central office circuits) are located at the top of the left bay. The fuse panel for power distribution to this frame is located in the lowest position of the left bay.

REMOTE UNIT

3.07 ***Frame:*** The remote unit is mounted on a single bay bulb angle frame measuring 3 feet 0-1/4 inch wide by 11 feet 6 inches high, intended for use in No. 1 or No. 5 XBR or No. 1 or No. 350 type SXS central offices.

3.08 ***Equipment Arrangement (Fig. 7):*** The alarm and timing, and control circuits and electronic circuit packs are mounted in the lowest equipped positions of the frame. The jack, lamp, and key panel is mounted directly above the electronic circuit packs. The relays associated with the lines, trunks, register, and trouble recording units are mounted above the lamp panel. Above these relays, in the upper section of the bay, are four crossbar switches. Terminal strips for connecting to the central office circuits are mounted directly above the

crossbar switches, and the fuse panel, which is of modular design, is located at the extreme top of the frame.

4. METHOD OF OPERATION

BLOCK DIAGRAMS

4.01 The block diagram Fig. 8 shows the major functional blocks for both the remote and control units of the line concentrator No. 2A. Because some of the circuits in both the remote and control units are very similar, all the blocks of the remote unit will be discussed first. Then the blocks of the control unit will be discussed and where the blocks of the control unit are the same as the remote unit, a reference to the explanatory paragraph in the remote unit section will be given. Fig. 9 is a detailed block diagram of the solid state logic and signaling circuits. However, since the components of the solid state logic and signaling circuits are described in the control and remote unit block diagram descriptions, Fig. 9 will not be discussed separately.

REMOTE UNIT BLOCK DIAGRAM

4.02 ***Line and Line Switch Circuit (FS 1) — Fig. 10***

The line and line switch circuit consists of a double wound line relay for each of the 80 concentrated lines and four 6-wire 20 by 10 magnetically latching crossbar switches. One vertical unit is used for each line. The lines are terminated on select levels 8 and 9. Two trunks are terminated on each select level 0 to 7 and multipled to like select levels on all the crossbar switches. In this manner full access from each of the 80 lines to any of 16 trunks is achieved. When a line is connected to a trunk, the following select magnets operate.

(a) Select magnet 8 or 9, depending upon the selection of an even (8) or odd (9) trunk.

(b) One select magnet 0 to 7 depending upon the trunk selected.

After both select magnets have operated, the hold magnet corresponding to the line being served is operated closing the line to the selected trunk. A crosspoint check is made over the sleeve lead through the switching network after crosspoint closure.

4.03 ***Line Lockout Circuit (FS 2)***

The line lockout circuit consists of a 2-dimensional relay matrix. The matrix for the 80-line group consists of two groups of identity relays, line tens (LT), and line units (LU). The operation of one or more line relays will result in the identification of the highest preferred line and the lockout of all others. Line preference is alternately changed between the lowest and highest numbered line after each call. In cases of simultaneous or overlapping requests for service, the line with the highest preference for that particular call will be served.

4.04 ***Register Circuit (FS 3)***

The register circuit consists of line, trunk, and class-of-call register relays. The line identity register relays, tens (T), units (U), and units auxiliary (UA) are activated from the line lockout circuit or the shift register circuit. These relays store the line identity until it is used later in the call sequence. The trunk number register relays (TK) are divided into two groups, relays TK 0 to 7 and relays TK 8 and 9. These relays are activated from the shift register on disconnect calls and lock in the number of the preselected trunk to be used on the next call. When the preselected trunk is used on the next call, a TS relay corresponding to the preselected trunk is operated and used to initiate an early dial tone start over the selected trunk prior to the closure of the remote unit crosspoints. The terminating, disconnect, and service-denial class-of-call register relays are operated by the shift register circuit to indicate the type of call to be served by the remote unit. A service request class relay (SR) is also provided and operated in the remote unit electromechanical circuitry after the line identity has been pulsed to the control unit.

4.05 ***Checking Circuit (FS 4)***

The checking circuit provides for checking on a 2-out-of-5 basis the operation of the A, B, and C shift register output relays which are operated from the shift register. Checks for the proper registration of the line identity and trunk number are accomplished by two separate checking circuits. The line identity is checked by operation of 1-out-of-8 tens (T) relays in series with a pair of units (U) and units auxiliary (UA) relays which are operated on a 1-out-of-10 basis.

The trunk number is checked by the operation of a trunk check (TRK) relay over a path consisting of the operated TK relay 8 or 9 in series with 1-out-of-8 TK 0 to TK 7 relays.

4.06 ***Sequence Circuit (FS 5)***

The sequence circuit consists of three relays which are used to indicate the ending of various timing intervals that are used to monitor the progress of the call sequence. When a circuit function is not completed within its alotted time interval, the sequence relay normally operated at this time will remain unoperated and a time-out failure will occur.

4.07 ***Select and Hold Magnet Operation and Check Circuit (FS 6, FS 7)***

This circuit consists of the relay equipment and the select and hold magnets for closing or releasing a crosspoint. Select and hold magnet and crosspoint check relays are furnished to verify the successful operation of the respective circuits. To close a crosspoint, two select magnets, one steering select magnet 8 or 9, and one trunk select magnet 0 to 7, are operated on each of the four crossbar switches. The operation of the eight select magnets is checked through the select magnet off-normal contacts. After the select magnets have been operated and checked, the hold magnet associated with the line to be closed through the crosspoint is operated. Since the hold magnets are magnetically latching, two steering relays are provided, the operate hold (OH) and the release hold (RH), to direct the current in the operate or release direction through the hold magnet depending upon the call sequence in progress. Hold magnet operation is checked by the operation of the hold magnet check (HMK) relay through the hold magnets off-normal contact. Hold magnet release is checked by the operation of a hold magnet release check relay (HRK) which operates when the hold off-normal contacts of the hold magnet being released are opened.

4.08 ***Signal Control Circuit (FS 8)***

The signal control circuit does the following: (1) closes a path to transfer the information from the register relays to the shift register, (2) closes a path to transfer the information from the shift register output relays to the register relays, (3) closes a circuit to compare the trunk number registered in the remote unit with the trunk number in the shift register, (4) controls sending a signal to the signaling circuit to start the transmission of the trunk number back to the control unit, (5) controls the opening of the line between the modulator and the sending filter on call failures or during the normal call handling sequence, (6) sends a release pulse to the solid state circuitry, (7) sends a signal to the signaling circuit to transmit a trouble release signal to the control unit.

4.09 ***Shift Register Input and Output and Shift Register Circuits (FS 9, FS 12)***

(a) The shift register output circuit (FS 9) consists of a group of relays which operate from the shift register output relays and the signaling circuit, binary counter, and sequence control output gates. The shift register input section of this circuit consists of a contact matrix from the register relays which indicate the line identity and trunk number, the call identity and the call progress to the shift register. The shift register output relays record the information required for the proper call sequencing, the type of call, and the line identity and trunk number.

(b) The shift register (FS 12) is composed of two major sections: (1) a 12-bit shift register and (2) a 5-bit buffer register. The 12-bit shift register consists of twelve flip-flops and associated two input gates and interstage monopulsers. The 5-bit buffer register consists of five flip-flops and associated two input gates. Ten outputs from the shift-register and five outputs from the buffer register cells are individually connected to one of fifteen two input gates. The shift and buffer register equipment is mounted on circuit packs. Four two input gate circuit cards, six shift register circuit cards, and two flip-flop circuit cards are required for this circuit. The shift and buffer registers do the following:

(1) Temporarily store the type of call, line identity, and trunk information after receiving this information from the control unit, or temporarily store the line identity and trunk information in preparation for transmission to the control unit.

(2) Receive call information on a parallel basis from the electromechanical part of the remote unit prior to transmission to the control unit.

(3) Present call information to the modulator of the signaling circuit for transmission, on a serial basis, to the control unit.

(4) Receive call information from the demodulator of the signaling circuit, on a serial basis, when receiving a message from the control unit.

(5) Present call information to the electromechanical part of the remote unit, on a parallel basis, after a message is received from the control unit.

4.10 *Release Control Circuit (FS 10)*

The release control circuit consists of three relays that do the following: (1) control the start of the release on trouble or at the end of a normal call handling sequence, (2) check that the major control relays which operated during the call have released, and (3) time the interval from the start of release to completion of the release check.

4.11 *Signal Circuit (FS 11)*

The signal circuit is composed of solid state components and consists of two major sections, the sending circuit and the receiving circuit. The sending circuit includes a modulator, a send filter, a power amplifier, and an output transformer. The receiving circuit includes an input transformer, a limiter, a receive filter, a discriminator, a signal present detector, a guard interval timer, and a 20-microsecond timer. These equipment units are mounted on four circuit pack cards. The modulator and power amplifier of the sending circuit are mounted on a single circuit pack card. The receiving circuit is mounted on three circuit pack cards. One card mounts the signal present detector, the guard interval timer, the 20-microsecond timer and the input transformer. The limiter and discriminator are mounted on individual circuit pack cards. The associated input and output transformers are mounted on standard equipment plates. The signaling circuit uses frequency shift pulsing to transmit information at a 200 bit-per-second rate between the remote and control units. Two separate frequency bands are used to perform the signaling. The lower frequency band designated f_1 is used to transmit information from the remote to the control unit. The higher frequency band designated f_2 is used to transmit information from the control to the remote unit. Each band consists of a mark and a space frequency. The mark frequencies are f_{1m} = 1270 cps and f_{2m} = 2225 cps. The space frequencies are f_{1s} = 1070 cps and f_{2s} = 2025 cps. Information is transmitted between the remote and control units using binary digits coded on a 2-out-of-5 basis. Each message is preceded by a "start" (mark) pulse and is followed by a 10- or 15-bit text. Each normal message follows the same definite signaling sequence regardless of which unit, control or remote, originates the message. The unit that originates the call always transmits first. This transmission is followed by a return message from the terminating unit. Fig. 11, 12, and 13 illustrate the principle of frequency shift signaling and the signaling sequences for the various types of calls placed through the concentrator.

4.12 *Sequence Control Circuit (FS 13)*

The sequence control circuit consists of flip-flops, gates, and monopulsers. These circuit elements are arranged to perform the following:

(a) Recognize and remember the origin of a call by setting a service request or incoming call flip-flop for calls originated at the remote or control unit, respectively.

(b) Provide preference control for calls originating at the remote and control units allowing the control unit preference in all cases.

(c) Control, in conjunction with the binary counter outputs, the start and stop of the 200-pps clock pulse generator.

(d) Control the parallel gating of information into the shift register from the electromechanical circuit.

(e) Control the serial gating of information into the first position of the shift register in conjunction with the 200-pps clock pulse generator and one of its output gates.

(f) Control the shifting of information through the shift register in conjunction with the 200-pps clock pulse generator and one of its output gates.

4.13 *Clock and Clock Control Circuit (FS 14)*

(a) The clock and clock control circuit consists of a 3200-pps multivibrator accurate to ±1 per cent, four binary counter cells, and associated input and output gates.

(b) The clock control gates are activated by the sequence control, or clock pulse counter circuits to start the multivibrator. The binary cells divide the 3200-pps rate by 16 to obtain the desired rate of 200 pps. In addition to dividing the 3200-pps multivibrator repetition rate to 200 pps, the binary counter permits the selection of a sequence of up to 16 pulses during each period of 5 milliseconds. The pulses will always occur in a fixed relation to each other. In this system only 3 of the 16 available pulse positions are used to activate one of three gates. These three pulses (listed below in order of their occurrence) are used to do the following:

(1) The shift pulse advances the shift register.

(2) The write pulse enables the sampling gate of the sequence control, which in turn allows the writing of a bit into the first position of the shift register when information is being received from the control unit.

(3) Call progress counter advance pulse causes the advance of the clock pulse counter (CTR) after each bit has been received or transmitted.

4.14 *Clock Pulse Counter Circuit (FS 15)*

The clock pulse counter consists of a 5-stage binary counter having its outputs connected to two and five input gates. The clock pulse counter counts the number of times the 200-pps clock generates the shift, write, and call progress counter advance pulses. In addition, this circuit generates outputs to the electromechanical and solid state control parts of the remote unit to indicate key points of call progress, and provides an indication of the call progress to the trouble indicating circuit by causing outputs for each set of binary counters operated when trouble is encountered. The outputs are used to give the following indications:

(a) That a 6-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to gate the information from the shift register into the class-of-call buffer register on calls originating at the control unit.

(b) That an 11-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the remote unit that pulsing of the line identity to the control unit has been completed. This output also causes the 200-pps clock pulse generator to stop. These two functions are performed only when the call originates at the remote unit.

(c) That a 16-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the remote unit that pulsing of class of call and line identification has been received from the control unit. This output also causes the 200-pps clock pulse generator to stop. These two functions are performed only when the call originates at the control unit.

(d) That a 22-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the remote unit that the pulsing of trunk identification has been completed from the control unit. This output also stops the 200-pps clock pulse generator. These two functions are performed only when the call originates at the remote unit.

(e) That a 27-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the remote unit that pulsing of trunk identification has been completed to the control unit. This output also stops the clock pulse generator. These two functions are performed only when the call originates at the control unit.

4.15 *Recycle Circuit (FS 16)*

The recycle circuit consists of a transistorized recycle delay control circuit (SD-94820-01) and three relays. One relay operates under control of the recycle timing circuit to indicate a transmission or call information check failure. The remaining two relays count the first and second recycle sequences. The recycle circuit functions during a signaling sequence when a

2-out-of-5 check of the received information fails or the transmission from the remote unit fails the 2-out-of-5 check at the control unit. In either case, the recycle circuit causes a retransmission of the information that failed to meet the 2-out-of-5 check. One example of the use of the recycle feature would be if the initial transmission from the remote unit to the control unit failed to check on a 2-out-of-5 basis. In this case, the control unit would not return the trunk identity information to the remote unit. The recycle timer at the remote unit would time out and the original message would be retransmitted. If a second failure occurred, the recycle timer at the remote unit would time out and give a trouble indication which would then release the remote unit.

4.16 *Trouble Identification Circuit (FS 17)*

The trouble identification circuit consists of relays which are operated when trouble conditions prevent certain sections of the remote unit from operating, thus preventing the normal progress of the call. The operation of certain of the trouble identification relays indicates the particular function that failed or the point in the call sequence where the failure occurred. The outputs from these relays are used to (1) operate reed relays in the trouble display circuit (FS 18) which identify the type of call failure, (2) operate the central office alarm, and (3) cause a trouble release signal to be sent to the control unit.

4.17 *Trouble Display Circuit (FS 18)*

(a) The trouble display circuit consists of seven dry reed relay packages of five reeds each, which record the call failure information and light corresponding lamps on a trouble display panel at the remote unit. Also included in this circuit are trouble recorder steering relays which close the operating path from the remote unit call progress and call information relays to operate the trouble display relays.

(b) A trouble display panel, which may include all or part of the following information depending upon the progress of the call at the time of failure, is lighted from these relays.

(1) Line identity

(2) Trunk number

(3) Type of call in progress

(4) Setting of the binary counter

(5) Signaling failure

(6) Trunk check failure

(7) Display lost indication

(8) Control failure

(9) Time out failure

4.18 *Test Line Circuit (FS 19)*

The test line circuit consists of a termination to the central office 1000-cycle milliwatt supply, a jack, lamps, a key, and several relays that are required to initiate and receive test calls. The circuit is arranged to process three different test calls.

(a) Initiate a terminating test call.

(b) Terminate a terminating test call started at the control unit.

(c) Under control of the control unit, to initiate a service request call.

The description and use of these test calls is covered in Section 5, Maintenance Facilities and Procedures, 5.07.

4.19 *Power and Alarm Circuit (FS 20)*

The power and alarm circuit consists of the −48 volt power distribution fuses, fuse and operational alarm relays, lamps and the +12 volt supply, SD-81608-01. Outputs from this circuit are provided to connect to the central office alarm systems of No. 5 and No. 1 crossbar and No. 1 and No. 350 type SXS central office.

4.20 *Miscellaneous Circuit (FS 21)*

The miscellaneous circuit consists of three separate circuits. These are (1) the 48-volt frame test battery, (2) a spare jack circuit, and (3) the frame line telephone jack circuit.

CONTROL UNIT BLOCK DIAGRAM

4.21 *Line Switch and Trunk Make-Busy Circuit (FS 1)*

The line switch and trunk make-busy circuit consists of two independent switching networks. Each network contains four 200-point,

6-wire magnetically latching crossbar switches. The position of the lines and trunks and the method of crosspoint closure is the same as discussed in 4.02 of the remote unit block diagram description except that the crosspoint check is not made. Also included in this circuit are trunk relays that are used to indicate where a trunk is closed to a line, as well as trunk relays that indicate when a trunk is busy on a call. A relay per line or a total of 80 relays for each of the two switching networks is provided to signal the control unit that a line has been seized by the serving central office.

4.22 *Call Preference Circuit (FS 2)*

The call preference circuit consists of a group of interconnected relays that serve to prevent, once a call starts, another call in the same group associated with remote unit 0/1 or a call in the other group associated with remote unit 1/0 from being served until after the first call has been switched through the concentrator. Two lockout chains are provided to prevent calls in the other group from starting and also to reverse the preference between the two groups after each call. This circuit also prevents a terminating or disconnect call from starting if all trunks are busy. A terminating call is also prevented from being processed if a trunk has not been preselected. On certain test calls the call preference circuit prevents service calls from being initiated when a particular trunk is desired to insure that the test call is connected to the desired trunk. In addition, this circuit prevents a call from starting if the remote unit is not sending tone or a remote signal failure has been received.

4.23 *Line Lockout Circuit (FS 3)*

The line lockout circuit consists of a 2-dimensional relay matrix which functions to identify the calling line location on calls originating at the control unit. Two separate matrices are provided, one for each group of lines associated with remote unit 0/1. The arrangement of the relays and their function is essentially the same as covered in 4.03 of the remote unit block diagram description. Two preference chains are provided and are so arranged that the preference of selecting lines to be served is changed on four successive calls (see Section 2, 2.16a).

4.24 *Register Circuit (FS 4)*

The register circuit consists of two groups of register relays which can be operated from the line identity relays of the line lockout circuit (FS 3) on calls terminating to a remote unit or from the auxiliary input relays which are under control of the shift register on service request calls. The relays record the line location by operating a tens and a units relay.

4.25 *Line Ten and Unit Check Circuit (FS 5)*

Two line tens and units check circuits are provided, one for each group. Each of these circuits is composed of a check relay and a series check path through the contacts of the line tens and line units relays. The line check relay will operate if only one line tens and one line units relay have been operated. If the line tens and units check is successful, this circuit closes a path to the solid state logic circuitry to indicate that a terminating call is starting.

4.26 *Register Check Circuit (FS 6)*

The register check circuit consists of a check relay and a series path through the contacts of the register relays (FS 4). The check relay will operate if only one units and one tens relay is operated.

4.27 *Auxiliary Relay Circuit (FS 7)*

Certain of the auxiliary relays are operated at the beginning of terminating, disconnect, and service denial type calls, respectively. Their function is to prepare the concentrator for subsequent operations required to process the specific type of call in progress.

4.28 *Select Magnet Operation and Trunk Check Circuit (FS 8)*

(a) The select magnet operation section of this circuit consists of two separate groups of select magnets. One group of select magnets is associated with the switching network of group 0 and the other group of select magnets is associated with group 1. Also included in the select magnet operate section are relays that determine the operation of an even or odd select magnet on the steering levels (8, 9) of the group 0 or group 1 switching networks.

The select magnets associated with a particular trunk are operated as follows. The even or odd trunk that has been preselected for the next call will operate a steering relay when a call is started in the control unit. The steering relay will cause the operation of one even or odd select magnet on each of the four crossbar switches. These select magnets are associated with select level 8 (even) and select level 9 (odd). At the same time one select magnet associated with levels 0 to 7 on each of the four crossbar switches is also operated over a path through the contacts of the preselected trunk. In this manner two select magnets, one on level 8 or 9 (even, odd) and one on level 0 to 7 are operated on each of the four crossbar switches.

(b) The trunk check section of this circuit compares the number of the preselected trunk at the control unit with the number of the trunk used on the call by the remote unit. If the trunk numbers match, a trunk check relay is operated.

4.29 *Hold Magnet Operate Circuit (FS 9)*

The hold magnet operate circuit consists of a relay contact array that allows current to pass in both the operate and release directions through one particular hold magnet as selected by the line tens and line units relays. The hold magnets are magnetic latching and require a current pulse in one direction for operation and a current pulse in the reverse direction for release. The type of call being established directs the current pulses in the operate or release directions. Portions of this circuit are duplicated so that a failure in one group will not affect the ability of this circuit to function hold magnets in the second group.

4.30 *Select Magnet Check Circuit (FS 10)*

The select magnet check circuit (select magnet check relay) operates when a path is continuous through an even or odd trunk relay contact, the off-normal contacts of the corresponding select magnet even (8) or odd (9) on each of the four crossbar switches, and the off-normal contacts of a select magnet 0 to 7 on each of the four crossbar switches. A similar check path is provided for groups 0 and 1.

4.31 *Hold Magnet Check Circuit (FS 11)*

The hold magnet check circuit checks the continuity of a path through the operated hold magnet off-normal contacts and its corresponding register relays. When the register relays and the operated hold magnet match, the hold magnet check relay operates, indicating a satisfactory hold magnet check. Separate check paths are provided for hold magnets in groups 0 and 1.

4.32 *Output to Shift Register Circuit (FS 12)*

The output to the shift register circuit consists of a line, trunk, and class of call relay contact matrix which indicates the setting of these relays to the shift register over 15 leads divided into three information groups A, B, and C. The information presented over the A, B, and C leads to the shift register varies with the type of call being processed. Table B shows what information is presented over these leads for the various types of calls. Within each group of five A or B leads, two leads are always energized to permit 2-out-of-5 checking.

TABLE B

TYPE OF CALL	INFORMATION	LEADS USED
Service Request	Trunk Even or Odd	B
	Trunk Level 0-7	C
Terminating	Class of Call	C
	Line Tens	A
	Line Units	B
Disconnect	Class of Call	C
	Trunk Even or Odd	A
	Trunk Level 0-7	B
Service Denial or Release Service Denial (Permanent Signal Denial)	Class of Call	C
	Line Tens	A
	Line Units	B

Additional output leads from this circuit are connected to the No. 5 crossbar office master test frame connector. These leads are used to indicate trunk number to the No. 5 crossbar trouble

recorder when a concentrator failure occurs and a trouble record is taken.

4.33 *Auxiliary Input Relay Circuit (FS 13)*

The auxiliary input relays are operated from input relays that are activated directly from the solid state section of the concentrator. These relays indicate that various circuit functions have occurred and in turn activate the circuitry that advances the call sequence. The major functions of this circuit are:

(a) To cause the opening of the signaling path to a remote unit when a service request call is received from the other remote unit.

(b) To stop a trouble timer when the spacing frequency tone is removed from the signaling path of the remote unit not being served.

(c) To prepare a path in the electromechanical circuitry for use on release or recycle sequences in the event of a signaling failure when the "start" or preliminary pulse is received.

(d) To close a path on service request calls after pulsing the trunk number to the remote unit to open the signaling path. After pulsing line identity on terminating calls, to start a timer that awaits the receipt of a "start" pulse signal from the remote unit.

(e) To store line or trunk information on a 2-out-of-5 basis on register relays operated on a parallel basis from the reed relays connected directly to the shift register output leads.

4.34 *Shift Register Checking Circuit (FS 14)*

The shift register checking circuit is composed of two separate check circuits. The first circuit checks on a 2-out-of-5 basis, the operated A and B relays of FS 13. The second circuit performs a down check through the normal contacts of all the A and B relays. The operational check is performed after information has been received from the shift register and prior to closing the control unit crosspoints. The down check is performed prior to releasing the control unit after a call has been served.

4.35 *Control Relay Circuit (FS 15)*

The control relays in this circuit are used to perform the following concentrator functions:

(a) Detect the failure of the hold magnets to close in the allotted time interval (90 to 110 or 125 to 150 milliseconds, depending upon the type of call in progress). When this failure occurs this circuit will cause a trouble release signal to be sent to the remote unit.

(b) Recognize that a trouble release signal has been received from the remote unit. This circuit then causes a trouble record to be taken and an alarm to be sounded. The control unit is also released at this time.

(c) Starts the recycle timer when the start of a message is received from the remote unit. If the signaling is not completed and checked in the allotted interval (100 to 150 milliseconds) the control unit will not send an acknowledgment signal to the remote unit. The remote unit will time out, and retransmit the original message.

(d) A trouble signal is sent from the remote unit to the control unit when the control unit recycles and the remote unit fails to receive the correct information. This signal will operate a control relay which causes a trouble record to be made, the central office alarm to sound, and the release of the control unit.

(e) Recognizes on service request calls that the hold magnets have been operated and checked and signals the solid state circuits to start outpulsing trunk information to the remote unit.

4.36 *Open Line Signal Circuit (FS 16)*

The open line signal circuit consists of two relays, one of which opens the signaling channel to the remote unit not being served. The second relay opens the signaling channel to the remote unit being served at certain points in the call sequence.

4.37 *Trunk Selection Circuit (FS 17)*

(a) The trunk selection circuit is composed of two separate trunk selection relay configurations. One trunk selection circuit is associated with group 0 and the other trunk selection circuit is associated with group 1. These

circuits provide a path for selecting a particular trunk on disconnect or test calls through a preference chain or through a trunk selection switch respectively. Circuitry for checking the selection of one and only one trunk is included in this FS. Trunk selection occurs during a disconnect call and the trunk is left in a preselected state for use on the next service request or terminating call. On test calls the setting of the trunk selection switch bypasses the trunk preference chain to permit the selection of a specific trunk for use on a test call.

(b) After the trunk has been selected, a path is closed to check that one and only one trunk has been selected. After this check is made, a path is closed to the solid state logic circuit to start transmitting trunk information to the remote unit.

4.38 *Trunk Preference Circuit (FS 18)*

The trunk preference circuit consists of two separate sets of trunk preference relays. One set of trunk preference relays is associated with group 0, and the other set of trunk preference relays is associated with group 1. Each of these trunk preference circuits is composed of two parts.

(a) A set of five preference relays, and

(b) A W-Z relay combination.

The trunk preference circuit, through the setting of the five preference relays, and the setting of the W-Z relay combination determine the trunk to be preferred for disconnection on the next call. Each disconnect call operates or releases one or more of the preference relays which changes the preference for the next call so that a particular trunk is preferred once during 16 successive calls (see Section 2, 2.17). After eight disconnect calls have been processed, the setting of the W-Z relays is changed, and the preference is now advanced to the odd or even trunks of the group, depending upon the previous setting of the W-Z relay combination.

4.39 *Trunk Connected Circuit (FS 19)*

The trunk connected circuit consists of two sets of 16 relays. One set of relays is associated with group 0 and one set of relays is associated with group 1. The relays are operated through the trunk selected relays. When a call has been closed through the switching network, and the crosspoint closure has been checked, the trunk connected circuit relay corresponding to the trunk selected is operated, closing the ring of the subscriber line to the selected trunk.

4.40 *Released Trunk Detection Circuit and Trunk Connected Check Circuit (FS 20)*

The released trunk detection circuit consists mainly of two relays, one for each group. These relays operate when one or more trunks of a group are in the released condition. A check circuit is provided to verify that a selected trunk has been connected to a subscriber line.

4.41 *Hold Magnet Timing Circuit (FS 21)*

The hold magnet timing circuit consists of one slow release relay. When a trouble release occurs on a disconnect or service denial call, this relay will operate when the hold magnets are closed and checked. The hold magnet timing relay will remain operated for 85 to 137 milliseconds to insure that the hold magnets obtain sufficient operate current to remain magnetically latched after the operate current is removed.

4.42 *Trouble Release Circuit (FS 22)*

After a trouble record has been recorded, the control unit will trouble release except when an over-all time-out occurs. In the case of an over-all time-out, a normal release is made since the trouble causing the time-out may prevent a trouble release. If the trouble release failed, the control unit would block and deny service to all subscribers. The trouble release circuit consists of a trouble release relay and two disconnect trouble release relays, one for each group. The trouble release relay activates the circuit release on regular service calls. The two disconnect trouble release relays activate the circuit release on release service denial or disconnect calls.

4.43 *Special Call Start Circuit (FS 23)*

The circuit contains the start relays for service denial, release service denial, and test calls. The service denial and service denial release relays are operated at the beginning of these calls and close the class of call information to the solid state circuitry and start the special control unit functions for these calls. The start relays associated with the test calls close an operating path for the sleeve relay to which the

test call is being made and controls certain special circuit functions associated with the test call.

4.44 ***Release Circuit (FS 24)***

The release circuit consists of three relays. Two relays control the start of release. For example, on service request calls the operation of these relays causes the release of the line information stored in the register circuit and the trunk identity stored in the trunk selection circuit. The third relay forces the release of the control unit if the normal release sequence fails. In the normal sequence of release for a service request call, the control unit closes the signal pair to the remote unit after it has started to release. When the remote unit completes its release it closes its idle signal tone back on the signal channel to the control unit. This tone is recognized and release of the control unit is completed. If the remote unit fails to release in the allotted time interval, the release relay in the control unit releases the control unit so that it may serve calls to or from the other remote unit. The normal release failure will sound a central office alarm. A lamp (CC) is included in this circuit which indicates that the remote unit has completed its operation on service denial and test calls.

4.45 ***Disconnect Preference Circuit (FS 25)***

The disconnect preference circuit consists of a W-Z relay combination which changes the disconnect call preference between group 0 and 1 after each disconnect call. By changing the preference after each disconnect call, a call that fails to complete in one group cannot lock out calls that can be completed in the other group.

4.46 ***Terminating Preference Circuit (FS 26)***

The terminating preference circuit consists of a W-Z relay combination which changes the terminating preference between group 0 and 1 after each terminating call. By changing the preference after each terminating call, a call that fails to complete in one group cannot lock out calls that can be completed in the other group.

4.47 ***Line Lockout Preference Circuit (FS 27)***

The line lockout preference circuit consists of two separate sets of five relays, one set for group 0 and one set for group 1. Three of the relays are arranged to operate in the W-Z manner. The remaining two relays are slave relays operating from the relays in the W-Z combination. The purpose of the circuit is to change the preference of the line to be served on each of four successive calls and to prevent calls that fail to complete to a particular line from preventing other terminating calls that may be waiting from completing. (See 2.16.)

4.48 ***Send Circuit (FS 28)***

The send circuit is composed of two separate solid state modulator and filter circuits, one for group 0 and one for group 1. Each modulator is mounted on a circuit pack card. The modulator, generates the frequency shift pulses (f_2) mark or space in accordance with the setting of the output slot of the shift register (FS 30). The output of the shift register is under control of the clock pulse counter. Cross connections are provided to vary the power output of the modulator to the level required for the transmission facility to be used. The operation of this circuit is explained in further detail in 4.11.

4.49 ***Receive Circuit (FS 29)***

The receive circuit consists of two separate sets of three solid state circuit pack cards and associated input transformers. One set of circuit pack cards and a transformer works with remote unit 0 and the other set of circuit pack cards and a transformer works with remote unit 1. The circuit pack cards mount a limiter, discriminator, guard interval timer, 20-microsecond timer, and signal present detector. The limiter, guard interval timer, 20-microsecond timer, and signal present detector cards are identical to the like-designated circuit pack cards of the remote unit. (See 4.11.) The discriminators of the remote and control units are almost identical. The exceptions are that the control unit discriminator is tuned to recognize the f_1 frequencies and an inverter stage found in the remote unit discriminator is not required.

4.50 ***Shift Register Circuit (FS 30)***

The shift register circuit is composed of two major sections: (1) a 17-bit shift register and (2) two packs each containing five dry reed relays. The 17-bit shift register consists of 17 flip-flops and associated two input gates and in-

terstage monopulsers. Each output of ten of the flip-flops is connected to a gate which in turn is connected to operate one dry reed relay. The remaining seven shift register stages are used as follows:

(a) Five stages temporarily store type of call information on a 2-out-of-5 basis.

(b) A buffer stage which stores the start pulse signal that precedes each transmission.

(c) An output stage which presents call information to the signaling circuit for transmission to the remote unit.

The shift register solid state circuitry is mounted on eight shift register and one flip-flop circuit pack cards. Two additional circuit pack cards are required to mount the output gates. The functions of the control unit shift register are the same as those listed in 4.09 for the remote unit shift register. One exception is that the type of call information is temporarily stored in the shift register of the control unit. The remote shift register stores this information in a buffer register after it is received from the control unit (see 4.09).

4.51 *Sequence Control Circuit (FS 31)*

The sequence control circuit consists of flip-flops, two and five input gates, monopulsers, and mercury contact relays. The circuit elements are arranged to perform the following functions.

(a) Recognize and remember the origin of a service request or terminating call by setting a service request call flip-flop associated with the remote unit initiating a service request call or an outgoing call flip-flop when a call terminating to a remote unit is received.

(b) Provides preference control among simultaneous service request, terminating, and test calls. The other functions of the control unit sequence control are identical to those described in 4.12 for the remote unit.

4.52 *Clock and Clock Control Circuit (FS 32)*

The clock and clock control circuit consists of a 3200-pps multivibrator accurate to ±1 per cent, four binary counter cells, and associated input and output gates. The operation and the functions performed by the control unit clock and clock control circuit are the same as discussed in 4.13 for the remote unit. The clock and clock control circuits are mounted on circuit pack cards.

4.53 *Clock Pulse Counter Circuit (FS 33)*

The clock pulse counter circuit components and operation are essentially the same as the clock pulse counter described in 4.14 of the remote unit block diagram description. However, the output indications vary somewhat from those of the remote unit and are listed below.

(a) Indicates that all the clock pulse counter binary cells are in the reset state. This condition is necessary to start an originating or terminating call.

(b) Indicates that an 11-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the control unit that receipt of line identity has been completed. This output also stops the 200-pps clock pulse generator until the control unit crosspoints are closed and checked. The 200-pps clock pulse generator starts again to monitor the pulsing of trunk information from the control to the remote unit.

(c) Indicates that a 16-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required on calls terminating to a remote unit to notify the electromechanical part of the control unit that the pulsing of type of call and line information to the remote unit has been completed.

(d) Indicates that a 22-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical portion of the control unit that the pulsing of the trunk information has been completed on service request calls.

(e) Indicates that a 27-pulse sequence has been generated by the 200-pps clock pulse generator. This indication is required to notify the electromechanical part of the control unit that pulsing of trunk identity has been received from the remote unit. The output stops the clock pulse generator.

4.54 ***Line Overflow Circuit (FS 34)***

The line overflow circuit consists of two separate circuits composed of a relay contact array, a gas tube, and a tone applying network. One of these circuit groupings is associated with group 0, the other circuit grouping is associated with group 1. The purpose of this circuit is to return the special overflow tone (2025 cps — ← shifted to 2225 cps at 20 cycle/second with 120 interruptions per minute) over the tip and ring of the called line to the calling line when all concentrator trunks are busy. Briefly, this circuit operates as follows: when all trunks are busy and a terminating call is received, the tip and ring of the called line are closed through to a gas tube which trips the ringing and maintains on-hook supervision to prevent charging the calling line. The special overflow tone is ap- ← plied over the tip and ring through the contact array to the called line.

4.55 ***Trunk Group Busy Circuit (FS 35)***

The trunk group busy circuit consists of two separate one-relay circuits. One circuit recognizes an all trunks busy condition in group 0 and the other circuit recognizes an all trunks busy condition in group 1. When all concentrator trunks of a group are busy, a path is closed through the operated contacts of all the trunk busy relays (00-15 group 0 or 00-15 group 1) to operate a trunk group busy relay. This relay closes all trunk busy indications to all "Call Allotter and Make-Busy Circuits," which utilize this indication to cancel a make busy timer.

4.56 ***Trunk Busy Register Control Circuit (FS 36)***

This circuit consists of 32 leads, one lead through the operated contacts of each of the 16 trunk busy relays of group 0 and group 1. These individual trunk busy indicating leads are connected to the traffic usage recorder for traffic measuring purposes.

4.57 ***Dial Tone Speed Register Control Circuit (FS 37)***

This circuit consists of two leads which close through an all trunks busy indication for trunk group 0 and/or group 1. These indications are used by the dial tone speed register control circuit to measure dial tone delay.

4.58 ***Test Calls Circuit (FS 38)***

The test calls circuit provides two separate sets of test line jacks, indicator lamps, keys, and control relays for the two test lines groups 0 and 1. These equipment units are used by the maintenance force to establish test connections between the remote and control units. The use of this circuit is more fully described in Section 5, Maintenance Facilities and Procedures.

4.59 ***Recycle Circuit (FS 39)***

The recycle circuit consists of a transistorized time delay control circuit SD-94820-01 and a group of relays which recognize a failure condition that would require the retransmission of information at certain stages in the normal sequence. This recycle feature can occur at either of the following points in a call.

(a) The initial transmission fails to pass a 2-out-of-5 check at the receiving circuit.

(b) The return trunk identity transmission fails to pass a 2-out-of-5 check at the circuit which originated the call.

For example, on a terminating call if the initial transmission of type of call and line identify from the control to remote unit fails to check on a 2-out-of-5 basis, the remote unit will not return the trunk identity transmision and the recycle timer at the control unit will time out. After the time out the original message will be retransmitted from the control unit to the remote unit. If the transmission again fails to meet the 2-out-of-5 check at the remote unit, the control unit will time out as before. The control unit will wait for a trouble signal from the remote unit or an over-all timeout and then give a trouble indication, and release the control unit.

4.60 ***Trouble Recording Circuit (FS 40)***

The trouble recording circuit consists of preference, control, and connector relays which control the seizure of the No. 5 crossbar trouble recorder and pass call failure information from the control unit to the trouble recorder. The functions of this circuit in the order of operation are as follows:

(a) Detects a failure in the control unit that requires a trouble record.

(b) Starts a trouble record timer (FS 41).

(c) Operates a trouble recorder preference relay which bids for the trouble recorder among other circuits such as markers, and transverters in the No. 5 crossbar office.

(d) Close the trouble recording leads to the trouble recorder when the trouble recorder is seized.

(e) Recognizes when the trouble record is complete and releases the control unit.

If the control unit cannot gain preference to the trouble recorder a display lost (DL) lamp will be lighted at the control unit and the central office alarm will be sounded.

4.61 *Trouble Recording Timing Circuit (FS 41)*

The trouble recording timing circuit consists of transistorized time delay control circuit SD-94820-01, a timing interval resistance-capacitance network, and a timing failure relay. When a request for a trouble record is started, the timing circuit starts to time for the completion of a trouble record. If the trouble record is not complete in 2.2 to 2.6 seconds, a timing relay will operate which will cause the DL lamp to light, sounds the central office alarm, and starts to release the control unit.

4.62 *Over-all Timer Circuit (FS 42)*

The over-all timer circuit consists of a transistorized time delay control circuit SD-94820-01, a timing interval resistance-capacitance network and a timing failure relay. The timing circuit starts timing when a call is started in the control unit. If the call is not completed in 12 to 14 seconds, the timing failure relay will operate. The operation of the timing failure relay will cause the seizure of the trouble recorder if a previous request for a trouble record had not been made. If a previous request for a trouble record had been made the DL lamp will be lighted, the central office alarm will be sounded, and the control unit will be released.

4.63 *Remote Signal Failure Timer Circuit (FS 43)*

The remote signal failure timer circuit consists of transistorized time delay control circuit SD-94820-01, a timing interval resistance-capacitance network, and a group of relays which are operated when a timing failure occurs. This circuit operates as follows. When a call starts, the signaling path to the remote unit not being served is opened, and the remote signal failure timer starts. If the remote unit does not respond by opening the signaling path back to the control unit in 265 to 300 milliseconds, a timing failure relay will operate. The operation of the timing failure relay will prevent other calls from starting to the remote unit that failed to remove its spacing frequency and will light the remote signal failure lamp associated with the circuit that failed and sound the central office alarm. This circuit also starts timing when the control unit opens the line to the remote unit that is serving the call. If the remote unit does not complete its functions and open the signaling path in the allotted time interval, the timing failure relay will operate and cause a trouble record to be taken.

4.64 *Alarm Circuit (FS 44)*

The alarm circuit consists of alarm relays and indicating lamps. The alarm relays are operated when a fuse is operated or there is a failure in the call sequence. Connections are provided from this circuit to the central office alarm and to the alarm sending circuits.

4.65 *+12 Volt Supply Circuit (FS 45)*

The +12 volt supply circuit is shown on SD-81608-01, "+12 Volt Power Supply Circuit." This power supply furnishes a regulated +12 volts to the solid state circuits.

ESTABLISHING A CONNECTION

4.66 *General*

In the following section a description of system operation for typical calls is presented in terms of the block diagram, Fig. 8, and the functional sequence charts of Fig. 14, 15, and 16. The description will follow the sequences shown on Fig. 14, 15, and 16, but there will be no direct references made to them in the text.

4.67 *Service Request Call*

(a) A service request call is started by a customer going off-hook. This causes the line relay in the ***line and line switch circuit*** to operate, which in turn activates the ***line lockout circuit.*** The ***line lockout circuit*** identifies the calling line and denies service to other lines until the call in progress is completed. The ***line lockout circuit*** also causes the ***sequence***

control and signal control circuits to operate. The ***sequence control and signal control circuits*** prepare the ***shift register*** to receive the calling line identity and, when the calling line has been identified and checked, cause transfer of the line tens and units information on a parallel lead basis from the ***shift register input and output circuit*** to the ***shift register.***

(b) The ***sequence control circuit*** activates the ***signal circuit*** and effects the serial readout of the line identification from the ***shift register*** to the ***signal circuit*** which transmits this information serially to the control unit in an 11-bit message consisting of a start pulse and two 2/5 codes that identify the line tens and units digits. (See Fig. 12.)

(c) The start pulse is received at the control unit ***signal circuit*** and passed on to the ***sequence control circuit*** which determines if this call should be given preference over any other call that may be present. If this call gains preference, the ***sequence control circuit*** identifies the group, activates the ***auxiliary input relay circuit*** which operates the ***signal control circuit,*** disables the signaling pair to the other remote unit, and causes (1) release of any previously started call, and (2) operation and check of the select magnets in the ***select magnet operation and check circuit.*** Line information is received by the ***signal circuit*** and passed on to the ***shift register*** through the ***sequence control circuit*** on a serial basis.

When the last bit of line information has been transmitted, the remote and control units perform the following overlapping functions:

(d) In the remote unit, end of pulsing is recognized by the ***sequence control circuit*** which causes operation of the ***shift register input and output circuit.*** This activates the ***register,*** which in turn causes the ***checking circuit*** to operate, and in conjunction with it, causes the ***line and line switch circuit*** to place a bridge on the preselected trunk to minimize dial tone delay and to protect the switch crosspoints. The ***checking circuit*** also causes the select magnets associated with the preselected trunk to be operated and checked in the ***select magnet operation and check circuit.*** In addition, the ***register circuit*** activates the ***line lockout circuit*** and causes the transfer of line identity from the ***line lockout circuit*** to the ***register,*** where it is stored and checked.

(e) When the ***checking and select magnet operation check circuits*** have operated, the hold magnet associated with the calling line operates. This results in a crosspoint check in the ***line and line switch circuit.*** The ***sequence circuit*** now marks the progress of the call through the hold magnet operation stage and causes release of the early dial tone bridge circuit.

(f) Release of the early dial tone bridge releases the crosspoint check and the line relay. The remote unit is now ready for the reception of trunk information from the control unit.

(g) In the control unit the ***sequence control circuit*** recognizes the receipt of the last bit of line information and under control of the ***control relay circuit,*** passes the line number on a parallel lead basis to the ***auxiliary input relay circuit*** which causes the ***register circuit*** to store this information. These registrations are checked by the respective check circuits. The preselected trunk is also made busy at this time.

(h) Operation of the ***register check circuit*** enables the ***hold magnet operation circuit.*** This causes operation of the hold magnet which in turn activates the ***hold magnet check circuit.*** This, in turn, effects the release of the operated select magnets, activates the ***trunk connected circuit,*** which cuts the central office line circuit through to the trunk, and causes the release of the line tens and units information stored in the ***shift register*** through operation of the ***control relay*** and ***sequence control circuits.*** Release of this information from the ***shift register*** causes the line tens and units information to be released from the ***auxiliary input relay circuit.***

(i) When this action is completed, the connected trunk information is passed from the ***output to shift register*** to the ***shift register*** on a parallel lead basis under control of the ***control relay circuit.*** In addition, the ***control relay circuit*** causes the ***sequence control circuit*** to cause a serial readout of trunk identification from the ***shift register*** to the ***signal circuit*** for transmission to the remote unit.

(j) The ***signal circuit*** transmits trunk identity to the remote unit in 11 bits (one start pulse and two 2/5 codes identifying trunk select level number and trunk steering level number). When the trunk identity has been transmitted, an end of pulsing signal is sent from the ***sequence control circuit*** to the ***auxiliary input relay circuit*** which causes the ***open line signal circuit*** to remove tone from the signal pair to the remote unit.

(k) In the remote unit the start pulse is received and passed on to the ***sequence control circuit*** which activates the ***sequence circuit.*** The ***sequence circuit*** marks the progress of the call through the start of reception of trunk information and causes the line lockout and signal control relays to release. When this occurs, it is registered in the ***signal control circuit.*** At the same time, the trunk identification is being passed from the ***signal circuit*** to the ***shift register*** through the ***sequence control circuit.***

(*l*) When the ***sequence control circuit*** determines that the reception of trunk identification information is complete, the ***shift register*** transfers the information to its ***input and output circuit.*** The ***checking circuit*** checks that the two 2/5 message was received, and the ***sequence circuit*** marks the progress of the call through the successful reception of trunk information. Also, at this time a check is made in the ***register*** between the trunk number received and the trunk number stored in the ***register.***

(m) The absence of all tone, due to the control unit opening its signaling pair, causes the ***shift register input and output circuit*** to operate under control of the remote unit ***signal circuit.*** This plus the trunk check and correct operation of the sequence relay activates the ***release control circuit*** which causes release of the trunk relays in the ***register circuit.*** The released trunk relays cause release of the select magnets and select magnet check relay. This, in turn, opens the hold magnet operate path which in turn releases the hold magnet check relay. At this time the ***release control circuit*** causes the ***signal control circuit*** to open the signaling pair to the control unit.

(n) The absence of tone on the signaling pair from the remote unit is recognized by the control unit ***signal circuit*** and passed on to the ***auxiliary input relay circuit*** which activates the ***release circuit.*** The ***release circuit*** effects release of the register relays and opens the operate path of the hold magnets. Tone is now restored on the signaling pair to the remote unit.

(o) The restoration of tone on the signaling pair to the remote unit is an indication for the remote unit to complete its release function. The ***register, shift register, sequence checking and sequence control circuits*** restore to normal, and the remainder of the release control relays release. The complete release of the remote unit puts tone back on the signal pair to the control unit. This occurs after a timed interval to allow the other remote unit to release and start a call first.

(p) The presence of tone on the signal pair from the remote unit enables the ***sequence control circuit*** in the control unit to restore to normal. This releases any associated auxiliary input relays. In addition, the remaining release and shift register checking relays serving the call release. The release of the auxiliary input relays causes tone to be applied on the signaling pair to the remote unit not being served. When tone is returned from the remote unit not being served, the relays blocking service to this circuit release and the concentrator is ready to serve other calls from or to either remote unit.

4.68 *Terminating Call*

(a) A terminating call is started by the central office placing ground on the sleeve lead, which operates the sleeve relay in the ***line switch and trunk busy circuit*** of the control unit. This causes operation of the ***line lockout circuit,*** which identifies the line tens and units digits of the calling line and activates the ***call preference circuit.*** Identification of the line tens and units digits is verified in the ***line check circuit.*** The ***call preference circuit*** prevents other calls from starting.

(b) The ***call preference circuit*** causes the ***terminating preference circuit*** to operate, which changes preference between groups after each call. In addition, the ***call preference cir-***

cuit activates the ***auxiliary relay and select magnet operation circuits.***

(c) Operation of the ***auxiliary relay circuit*** results in the transfer of the line tens and units digits from the ***line lockout circuit*** to the ***register*** and causes operation of the ***open line signal circuit,*** which opens the signaling pair to the remote unit not being served. The line identity is checked in the ***register check circuit.*** In addition, the ***sequence control circuit*** is activated by the ***auxiliary relay circuit*** and the line identity information is transferred from the ***output to shift register circuit*** to the ***shift register.***

(d) The ***sequence control circuit*** now causes the serial readout of class of call and line tens and units digits information from the ***shift register*** to the ***signal circuit,*** which transmits this information to the remote unit in 16 bits, 1 start pulse, and three 2/5 codes, identifying class of call and calling line tens and units digits (see Fig. 13).

(e) The select magnets are operated and checked in the ***select magnet operation and check circuits*** while line identity is being transmitted to the remote unit. After the select magnet operation check is complete, the hold magnet associated with the line tens and units digits stored in the ***register*** is operated in the ***hold magnet operation circuit.*** This causes release of the line sleeve relay and makes the trunk busy in the ***line switch and trunk busy circuit.*** The operated hold magnet causes the ***hold magnet check circuit*** to operate which verifies the operation of the hold magnet and causes the release of the select magnets. The ***hold magnet check circuit*** causes the ***trunk connected circuit*** to operate which closes the trunk to the central office and causes the operation of the ***trunk connected checking circuit.***

(f) The start pulse signal is received by the remote unit ***signal circuit*** and passed on to the ***sequence control circuit*** where it is stored and passed on to the ***shift register input and output circuit.*** Operation of the ***shift register input and output circuit*** causes the release of any service request call that may have started and prepares the circuit to follow the sequence for calls originated at the control unit. In addition, the ***sequence control circuit*** establishes call preference at this time.

(g) The class of call and line identification information are received by the ***signal circuit*** and passed on to the ***shift register*** by the ***sequence control circuit.*** As soon as all of the class of call information is received by the ***shift register,*** the ***sequence control circuit*** will cause the information to be transferred to the ***input and output circuit*** and the ***shift register*** to be cleared so that it can receive the line information. The class of call digits received are verified in the ***checking circuit*** which causes the ***register*** to record that a terminating call has started. This in turn causes verification in the ***checking circuit*** that a trunk has been preselected and causes the operation of the ***signal control circuit*** which prepares a path for the transfer of line information from the ***shift register*** to the ***register.***

(h) The ***trunk check circuit*** causes the ***register circuit*** to open the trunk path through the ***line and line switch circuit*** to protect the switch crosspoints. In addition, the select magnets associated with the preselected trunk are operated by the ***checking circuit*** and checked in the ***select and hold magnet operation and check circuit*** at this time.

(i) The receipt of the last bit of information by the remote unit is recognized by the ***sequence control circuit,*** which causes the transfer of the line tens and units digits from the ***shift register*** to the ***input and output circuit*** on a parallel lead basis. In addition, the line tens and units digits received by the ***input and output circuit*** are verified by the ***checking circuit*** and registered in the ***register circuit.*** The ***check circuit*** operates the ***sequence circuit,*** which marks the progress of the call through the successful reception of class of call and line information, and operates the ***signal control circuit,*** which prepares a path for the transfer of trunk information to the ***shift register.*** At this time the ***checking circuit*** verifies the line number stored in the ***register.***

(j) Operation of the ***checking circuit*** for line number registration causes the hold magnet associated with the called number to be operated and checked in the ***select and hold magnet operation and check circuit.***

(k) The hold magnet operation causes the line relay to operate and the ***hold magnet checking circuit*** causes the ***crosspoint check circuit*** to operate in the ***line and line switch circuit.*** The ***sequence circuit*** now marks the progress of the call through the successful hold magnet operation stage.

(*l*) The ***sequence circuit*** also causes release of the line relay and ***crosspoint check circuit.*** In addition, the ***sequence circuit*** causes the release of the line information from the ***shift register input and output circuit*** and operation of the ***signal control circuit.***

(m) The ***signal control circuit*** causes the ***sequence control circuit*** to allow the transfer of the preselected trunk information from the ***input and output circuit*** to the ***shift register*** and to start the serial readout of trunk information from the ***shift register*** to the ***signal circuit*** for transmission to the control unit. This message consists of 11 bits (one start pulse and two 2/5 codes identifying trunk select level and trunk steering level).

(n) The start pulse signal is received by the control unit ***signal circuit,*** which causes the ***sequence control circuit*** to operate. The ***sequence control circuit*** causes the ***auxiliary input relay circuit*** to operate which, in turn, operates the ***control relay circuit.*** While the trunk identity is being passed to the ***shift register*** from the ***signal circuit*** under control of the ***sequence control circuit,*** the ***control relay circuit*** causes the ***open line signal circuit*** to remove tone from the signal pair to the remote unit.

(o) The absence of tone is recognized by the remote unit ***signal circuit,*** which registers this condition in the ***shift register input and output circuit.*** When the last bit of trunk identity has been transmitted, the ***sequence control circuit*** causes a second registration in the ***shift register input and output circuit.*** This completes a path in the ***signal control circuit*** for the removal of tone from the signal pair to the control unit.

(p) In the control unit, the receipt of the last bit of trunk information is recognized by the ***sequence control circuit,*** which causes the trunk identity to be recorded in the ***shift register,*** which in turn causes the trunk identity to be recorded in the ***auxiliary input relay circuit*** and checked in the ***shift register checking circuit.***

(q) The ***trunk checking circuit*** now checks the trunk number received against that connected to the line. A satisfactory comparison of trunk information, the operation of the previous ***trunk connected checking circuit*** and recognition of the removal of tone from the remote unit signal pair by the ***signal circuit*** plus the registration of this information in the ***auxiliary input circuit*** will cause the operation of the ***release circuit.***

(r) The ***release circuit*** opens the hold magnet operate path, releases the tens and units digits stored in the ***line lockout circuit*** and ***register,*** starts the general release of the ***electromechanical circuit,*** and causes the open ***line signal circuit*** to restore tone to the signal pair to the remote unit.

(s) The restoration of tone is recognized by the ***signal circuit*** in the remote unit and is passed on to the ***shift register input and output circuit,*** which causes the ***sequence circuit*** to mark the call progress. In addition, the ***sequence circuit*** operates the ***release control circuit,*** which causes the release of the preselected trunk number stored in the ***register.*** This in turn causes release of the select magnets and opens the operate path of the hold magnet.

(t) The ***release control circuit*** now operates the ***signal control circuit,*** which starts the general release functions in the remote unit and releases the line identity stored in the ***register.*** When the release function is completed, tone is restored to the signal pair to the control unit.

(u) The presence of tone is detected by the ***signal circuit*** in the control unit and passed on to the ***shift register input and output circuit.*** This causes release of the digits stored in the ***shift register*** and results in tone being applied by the ***open line signal circuit*** to the signal pair to the remote unit not being served.

(v) When tone is restored to the signal pair from this circuit, the control unit completes its release function and restores to normal. The concentrator is now ready to serve the next call from or to either remote unit.

4.69 *Disconnect Call*

Normally, after every service request or terminating call, sixteen trunks will be connected and a disconnect call will be made.

(a) A disconnect call is started in the control unit when the disconnect relay in the ***call preference circuit*** is operated and a trunk is idle. The disconnect relay is operated during the release of a service request or terminating call and serves to activate all functions of the ***call preference circuit*** upon completion of the service request or terminating call.

(b) The ***call preference circuit*** establishes call preference, prevents calls from starting in the other group, activates the ***auxiliary relay circuit,*** causes registration of a disconnect call in the ***output to shift register circuit*** and results in the operation of the preferred trunk relay in the ***trunk selection circuit.***

(c) The ***trunk selection circuit*** transfers the preselected trunk number to the ***output to shift register circuit*** and checks that 1/15 trunks has been selected. This sends a signal to the ***sequence control circuit*** to start transmission of trunk information if the ***auxiliary relay circuit*** has caused the operation of the ***open line signal circuit*** which opens the signal pair to the remote unit not being served.

(d) The ***sequence control circuit*** now causes the ***shift register*** to receive the class of call and trunk identity information on a parallel lead basis and a serial readout from the ***shift register*** to the ***signal circuit,*** which transmits this information to the remote unit in 16 bits, one start pulse, and three 2/5 codes, identifying class of call and trunk select level and trunk steering level (see Fig. 13).

(e) The ***trunk selection circuit*** causes the line sleeve relay in the line switch and ***trunk busy circuit*** to operate. This results in the identification of the line tens and units digits in the ***line lockout circuit,*** which in turn causes registration of this information in the ***register.*** Line identification and then registration are verified in the respective ***check circuits.***

(f) When the ***register check circuit*** operates, the hold magnet and then the sleeve relay associated with the identified line are released.

(g) The start pulse signal is received by the remote unit ***signal circuit*** and passed on to the ***sequence control circuit,*** where it is stored and passed on to the ***shift register input and output circuit,*** which in turn causes the release of any service request call that may have started and prepares the circuit to follow the sequence for calls originated at the control unit. In addition, the ***sequence control circuit*** establishes call preference at this time.

(h) The class of call and line identification information are received by the ***signal circuit*** and passed on to the ***shift register*** by the ***sequence control circuit.*** As soon as the class of call information is received by the ***shift register,*** the ***sequence control circuit*** will cause the information to be sent to ***the input and output circuit*** and clear the ***shift register.*** The class of call digits received are verified in the ***checking circuit,*** which causes the ***register*** to record that a disconnect call has started.

(i) The ***register*** causes the ***signal control circuit*** to operate, which steers the trunk information when it is received from the ***shift register*** to the ***register.*** This results in trunk preselection. When the trunk identity is received in the ***shift register,*** the ***sequence control circuit*** will cause it to be recorded in its ***input and output circuit,*** whereupon the information is recorded in the ***register circuit*** and checked in the ***checking circuit.*** This causes the ***sequence circuit*** to mark the progress of the call through the successful reception of class of call and trunk information stage.

(j) The trunk identity is verified in the ***checking circuit,*** which causes the ***register*** to activate the ***line and line switch circuit.*** This results in a crosspoint check and operation of the line relay.

(k) The operation of the line relay results in identification and check of the line associated with the preselected trunk in the ***line lockout circuit.*** When the line identity is checked, the ***register*** records the line tens and units digits. This record is verified in the ***checking circuit,*** which activates the ***hold magnet operation and check circuit,*** which causes release of the crosspoint check, line relay, and hold magnet associated with the preselected trunk. Hold magnet release is verified in the ***hold magnet operation and check***

circuit. The ***sequence circuit*** now marks the progress of the call through successful release of the hold magnet.

(*l*) The operation of the ***sequence circuit*** causes release of the number stored in the ***line lockout and shift register input and output circuits*** and operation of the ***signal control circuit.***

(m) The ***signal control circuit*** signals the ***sequence control circuit*** to effect the transfer of the preselected trunk number from the ***register*** to the ***shift register*** and to start the serial readout of trunk identity from the ***shift register*** to the ***signal circuit*** for transmission to the control unit. This message consists of 11 bits (1 start pulse and two 2/5 codes, identifying trunk select level and trunk steering level).

(n) The start pulse is received by the control unit ***signal circuit,*** which causes the ***sequence control circuit*** to operate. The ***sequence control circuit*** causes the ***auxiliary input relay circuit*** to operate, which in turn operates the ***control relay circuit.*** While the trunk identity is being passed to the ***shift register*** from the ***signal circuit*** under control of the ***sequence control circuit,*** the ***control relay circuit*** causes the ***open line signal circuit*** to remove tone from the signal pair to the remote unit.

(o) The absence of tone is recognized by the remote unit ***sequence control circuit,*** which registers this condition in the ***shift register input and output circuit.*** When the last bit of trunk identity has been transmitted, the ***sequence control circuit*** causes a second registration in the ***shift register input and output circuit,*** which completes a path in the ***signal control circuit*** for the removal of tone from the signal pair to the control unit. The ***signal control circuit*** also activates the ***sequence control circuit*** to register the progress of the call.

(p) The receipt of the last bit of trunk information is recognized by the ***sequence control circuit*** in the control unit, which causes the trunk identity to be recorded in the ***auxiliary input circuit*** if the ***shift register checking circuit*** has previously checked that the ***auxiliary input relay circuit*** was normal. This information is checked in the ***shift register checking circuit.***

(q) The ***trunk checking circuit*** now checks the trunk number received against that stored in the ***trunk check circuit.*** A satisfactory check results in the activation of the ***release circuit.***

(r) The ***release circuit*** opens the hold magnet release path, releases the tens and units digits stored in the ***line lockout circuit*** and ***register,*** starts the general release of the ***electromechanical circuit,*** and causes the open ***line signal circuit*** to restore tone to the signal pair to the remote unit.

(s) The restoration of tone is recognized by the ***signal circuit*** in the remote unit and passed on to the ***shift register input and output circuit,*** which causes the ***sequence circuit*** to mark the progress of the call through the successful trunk check operation. In addition, the ***sequence circuit*** causes the ***release control circuit*** to operate.

(t) The ***release control circuit*** operates the ***signal control circuit.*** The operation of these two circuits starts the general release function in the remote unit, releases the line identification stored in the ***register*** and opens the hold magnet release path. When the release function is completed, tone is restored to the signal pair to the control unit.

(u) The presence of tone is detected by the ***signal circuit*** in the control unit and passed on to the ***auxiliary input relay circuit,*** which in turn results in tone being applied by the open ***line signal circuit*** to the signal pair to the remote unit not being served and causes the control unit to complete its release function.

(v) When tone is restored to the signal pair from the remote unit not being served, the concentrator is ready to serve the next call from or to either remote unit.

5. MAINTENANCE FACILITIES AND PROCEDURES

GENERAL

5.01 The maintenance facilities and procedure of the line concentrator No. 2A are intended to provide for high-speed detection, analysis and clearing of service affecting failures. These objectives are achieved by the use of the No. 5 crossbar trouble recorder at the

control unit central office, a lamp display panel at the remote unit which provides a visual record similar in detail to the record printed on the trouble recorder card, audible alarms at both remote and control unit locations to alert the maintenance personnel of the trouble condition, and call-through and transmission test procedures to facilitate analysis of the trouble.

TROUBLE DETECTION

5.02 ***Control Unit:*** Certain control unit failures are recorded on punched cards by the No. 5 crossbar trouble recorder. Since the concentrator control unit may be placed in offices which use either a single- or double-sided trouble recorder card, different locations on each card have been designated to indicate a concentrator failure. Location S7-56 on the single-sided card and location S2-23 on the double-sided card have been reserved to indicate that the trouble request is emanating from a concentrator. A set of the same coordinates on both the single-sided and double-sided cards are used to identify the concentrator, the group within the concentrator, the line, the trunk, the type of call in progress, and the progress of the call. A reading mask (see Fig. 17) imprinted with the required failure identity designations is arranged so that the concentrator generated trouble recorder cards can be inserted and read through the mask slots. The control unit also is arranged to light a display lost lamp in the event that a trouble occurs when the No. 5 crossbar trouble recorder is busy or out of service.

5.03 ***Remote Unit:*** To provide a uniform method of recording a concentrator failure, each remote unit is equipped with a lamp display panel, which identifies the line identity, trunk number, type of call in progress, and the progress of call. This display must be released after each usage, otherwise only the first of any repetitive troubles will be recorded.

5.04 ***Alarms:*** Both the remote and control units are arranged to sound audible and visual central office alarms in conjunction with the trouble recording function. However, the remote and control units are also arranged to sound central office alarms without making a record in case of the following troubles:

(a) The call fails to complete in the allotted time after one trouble has been recorded.

(b) Trouble occurs during the release function of the call.

(c) Fuse operation.

In addition, the concentrator is arranged so that an alarm will sound in the control unit central office in the event that the transmission path is opened while the unit is idle. The remote and control units are arranged for connection to the alarm sending circuit so that the alarms may be transmitted to a distant maintenance center during unattended hours.

5.05 ***Remote and Control Units***

Both the remote and control units are arranged for trouble release (reversal of hold magnet state, ie, either operate or release) in the event that a trouble is encountered. If trouble is encountered prior to the transmission of trunk information, the A digit 8 and B digit 0 will be transmitted to the distant unit instead. If trouble occurs after the transmission of line information from the originating unit or trunk information from the terminating unit, a mark pulse will be sent instead of the open line signal or spacing frequency depending upon the progress of the call.

5.06 ***Solid State Circuit Maintenance:*** Portions of the circuitry in both the remote and control units employ solid state devices to meet the objectives of high speed switching through the concentrator. This circuitry is arranged on plug-in cards to facilitate replacement. The outputs of each card are brought out to a terminal strip for monitoring. The 908A test box (see Fig. 18) has been developed for testing the circuit outputs on a "good" or "bad" basis, and for checking the clock, timing, and signaling frequencies employed by the concentrator. For periodic routine maintenance, an electronic counter will be used to obtain more precise frequency measurements.

CALL THROUGH AND TRANSMISSION TEST PROCEDURES

5.07 In addition to the trouble detection facilities which provide immediate audible alarms and visual records as discussed above, the concentrator has facilities for call-through

and transmission testing. The type of test call and a brief description of each is contained in the following paragraphs.

(a) ***Terminating Test Call Started at Remote Unit:*** A terminating test call is started at the remote unit by plugging a headset into jack 79 and operating the terminating key. This results in the start of a service request call over line 79, which when registered in both the remote and control units is recognized as a test call causing both units to release and the control unit to initiate a terminating call over line 79. This line is closed at the control unit to a 1000-cps tone source and, when the call is completed, verification of the connection may be made at the remote unit by monitoring the line for the presence of tone.

(b) ***Terminating Test Call Started at Control Unit:*** A terminating test call is started at the control unit by plugging a headset into jack 79 and operating the test (TST) key. When the call is completed, a 1000 cps tone source is connected to the line at the remote unit. Verification of the connection is made at the control unit by monitoring the line for the application of this tone. In addition, a terminating test call can be made to any line by connecting the test call (TC0/1) terminal to the selected subscriber sleeve terminal and operating the TC0/1 and TST0/1 keys. When this call is completed, the CC lamp will light.

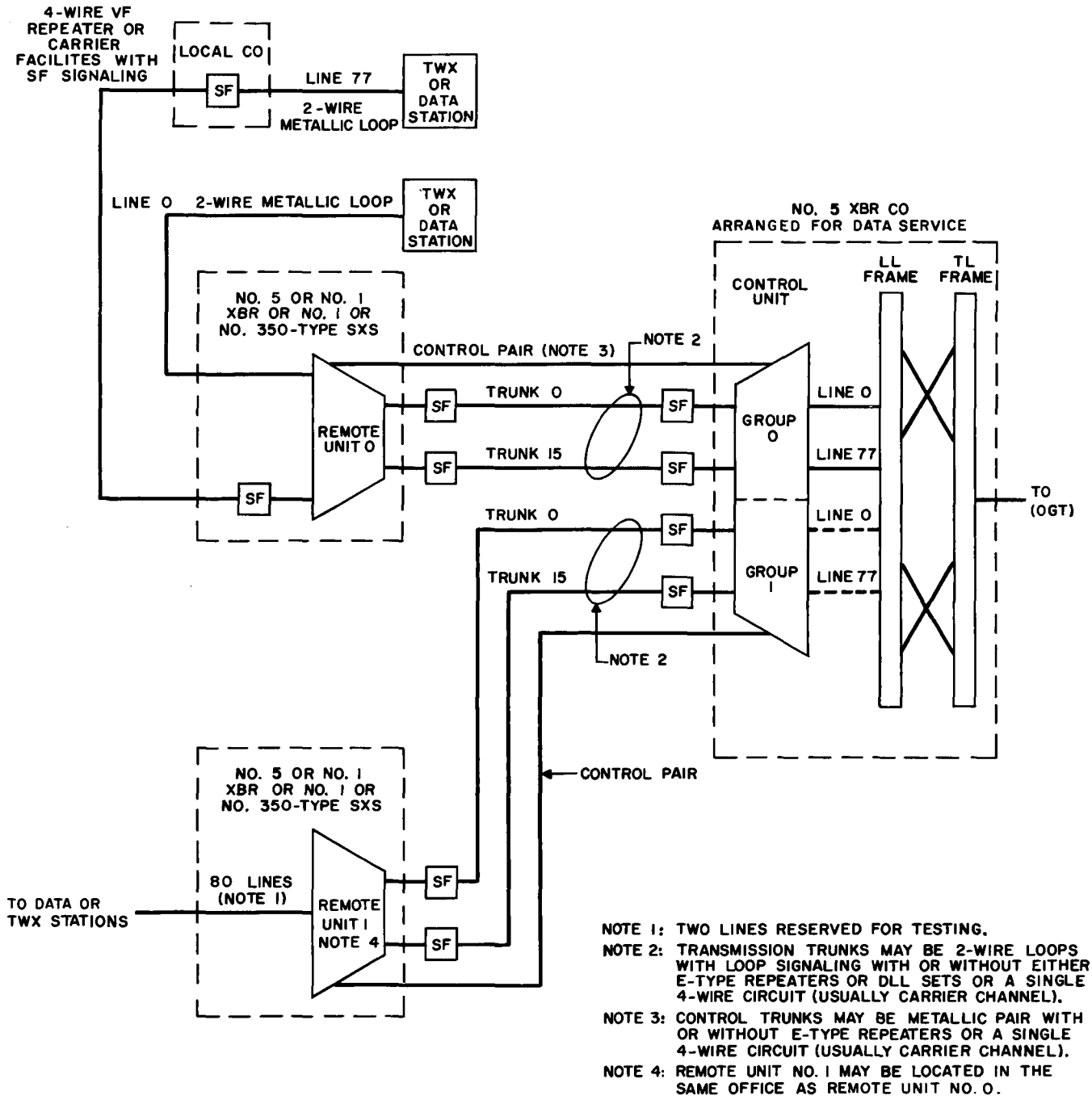
(c) ***Service Request Test Call Started at Control Unit:*** A service request test call is started at the control unit by plugging a headset into jack 78 and operating the SRT (Service Request Test) key. When line information is registered, both the remote and control units recognize this registration as a test call and release. The remote unit now closes the loop on line 78 through a 1000 cps tone source, thus initiating a service request. The line is monitored at the control unit for the application of tone to verify the connection.

(d) ***Service Request Test Call Started at Remote Unit:*** A service request test call is started at the remote unit by connecting a headset across any line terminals except 78 and 79. This call will then progress as any other normal service request call. Verification of the connection is made at the remote unit by monitoring the line for the application of dial tone.

(e) ***Service Denial Calls:*** To prevent a line in trouble from holding trunks out of service to working lines, the concentrator is arranged to make service denial calls. This call is initiated by maintenance personnel at the control unit and is effected by the operation of the hold magnet (no select fingers engaged) associated with the line to be denied service. The call is started by connecting the sleeve lead of the line to be denied service to a service denial terminal and operating the service denial key. The connection between the selected line and service denial terminal should be removed when the call is completed. A release service denial call must be initiated by maintenance personnel at the control unit to restore service to the affected line. This call is started by connecting the sleeve lead of the line to be released to a release service denial terminal and operating the release service denial key. The connection between the selected line and release service denial terminal should be removed when the call is completed.

(f) ***Loop Around Test:*** The concentrator is arranged to check the transmission quality of trunks in both directions at the control unit. A loop around test is started by initiating a service request test call [see 5.07(c)] and a terminating test call [see 5.07(b)] at the control unit. When both calls are completed, lines 78 and 79 are connected together at the remote unit and the tone source disconnected. The tip of each line is connected to the ring of the other, instead of tip to tip and ring to ring, to hold the transmission facilities in the trunks.

(g) ***Trunk Selection:*** To make busy a particular trunk or select a particular trunk for test calls or loop around testing, the control unit is equipped with one make-busy jack per trunk and a trunk selector switch. Setting the trunk selector switch to a particular trunk will make that trunk preferred to calls initiated from the test lines.



NOTE 1: TWO LINES RESERVED FOR TESTING.

NOTE 2: TRANSMISSION TRUNKS MAY BE 2-WIRE LOOPS WITH LOOP SIGNALING WITH OR WITHOUT EITHER E-TYPE REPEATERS OR DLL SETS OR A SINGLE 4-WIRE CIRCUIT (USUALLY CARRIER CHANNEL).

NOTE 3: CONTROL TRUNKS MAY BE METALLIC PAIR WITH OR WITHOUT E-TYPE REPEATERS OR A SINGLE 4-WIRE CIRCUIT (USUALLY CARRIER CHANNEL).

NOTE 4: REMOTE UNIT NO. 1 MAY BE LOCATED IN THE SAME OFFICE AS REMOTE UNIT NO. 0.

Fig. 1 — General System Layout

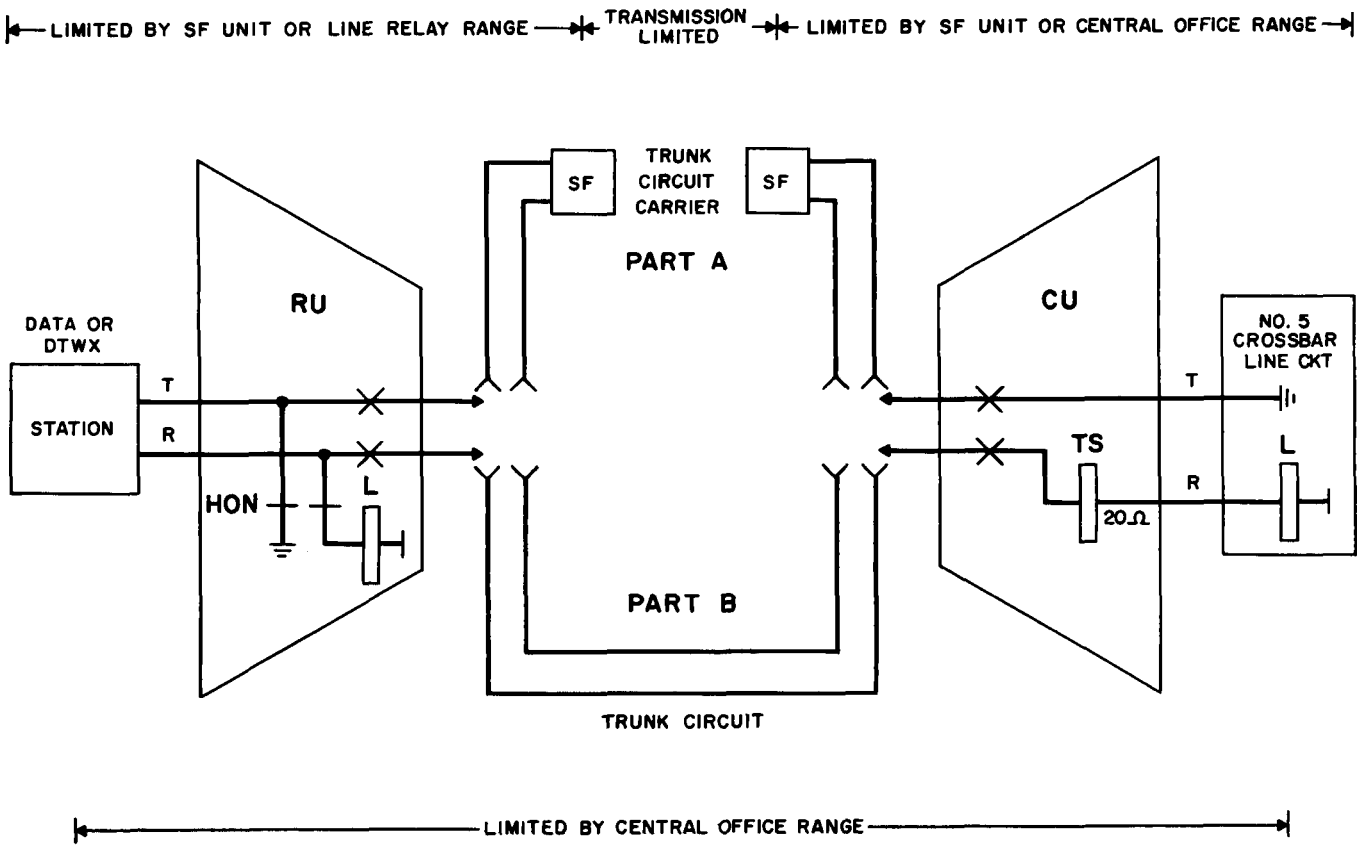


Fig. 2 — Resistance Range

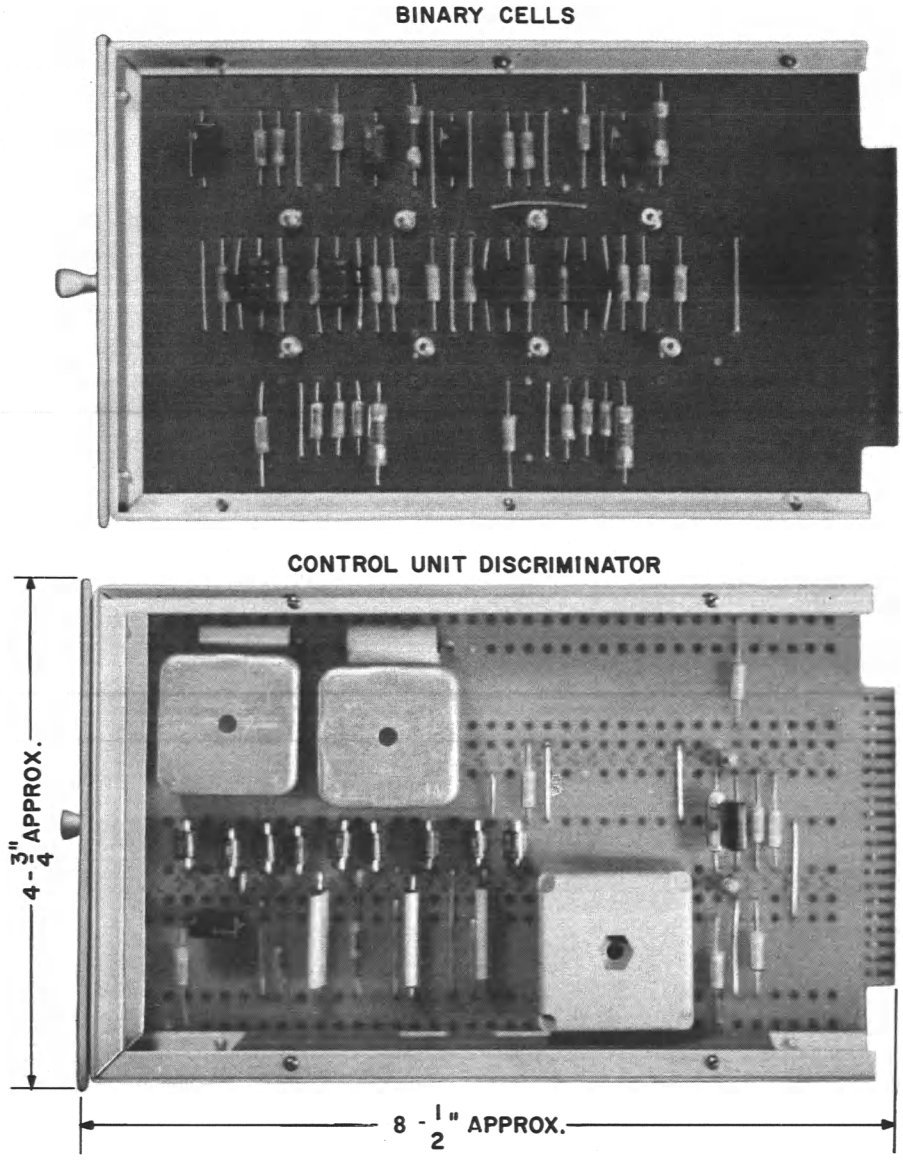


Fig. 3 – Typical Solid State Circuit Packs

CPS 4

2-BIT SHIFT REGISTER MODULE

APPARATUS LIST

CAPACITOR

DESIG	CODE
C1,2,3,4	570JR,.0056

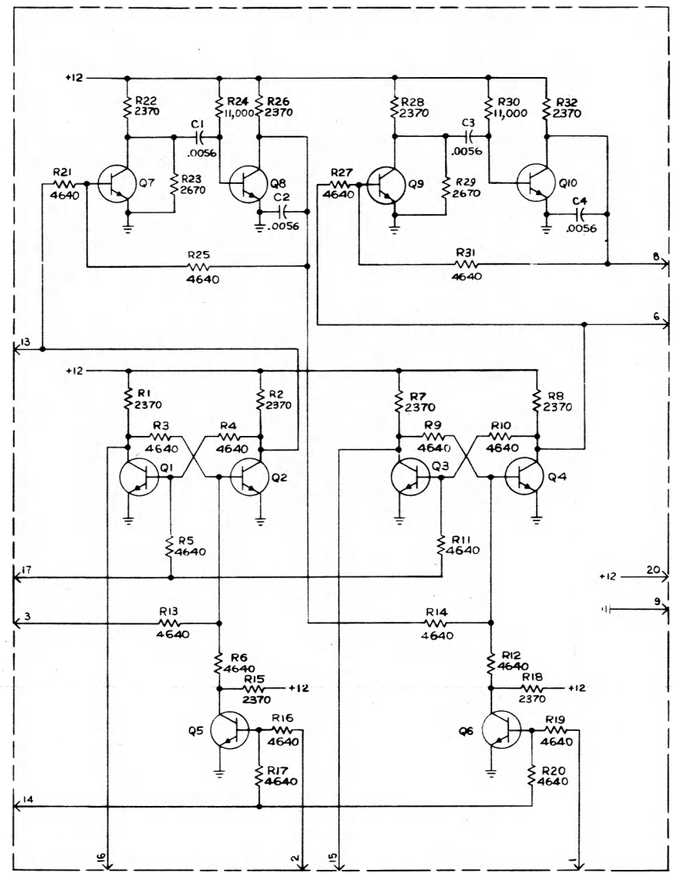
RESISTOR

DESIG	CODE
R1,2,7,8, 15,18,22, 26,28,32	237A,2370
R23,29	237A,2670
R3,4,5,6,9, 10,11,12,13, 14,16,17,19, 20,21,25,27, 31	237A,4640
R24,30	237A,11,000

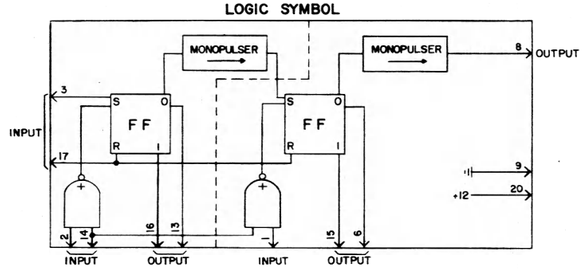
TRANSISTOR

DESIG	CODE
Q1-Q10	16A

NOTES:
1. UNLESS OTHERWISE SPECIFIED RESISTANCE VALUES ARE IN OHMS, CAPACITANCE VALUES ARE IN MICROFARADS, VALUES PRECEEDED BY THE SYMBOL +(PLUS) OR -(MINUS) ARE IN VOLTS; ALL COMPONENTS ARE ±5% E.O.L.



LOGIC SYMBOL



DESCRIPTION

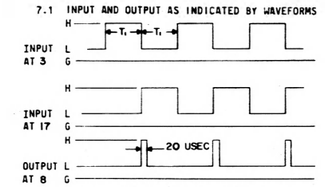
TWO FLIP-FLOP CIRCUITS, TWO MONOPULSER CIRCUITS AND TWO OR-NOT GATE CIRCUITS ARE PROVIDED IN THIS PACKAGE. THESE CIRCUITS ARE INTERCONNECTED TO FORM TWO CELLS OF A SHIFT REGISTER WITH GATED INPUTS AND THE ASSOCIATED INTER-CELL DELAY. THE RELATIONSHIPS BETWEEN INPUT AND OUTPUT ARE INDICATED IN THE TABLE BELOW (MANUFACTURING TEST REQUIREMENTS).

MANUFACTURING TEST REQUIREMENTS

1. UNLESS OTHERWISE SPECIFIED TEST VOLTAGES ARE MINIMUM, IN SERVICE, LOADED CIRCUIT VALUES.
2. THE SUPPLY VOLTAGE USED FOR TESTING SHALL BE +12±0.12 VOLTS.
3. VOLTAGE MEASUREMENTS OF STEPS 1-6 IN THE TABLE BELOW ARE TO BE MADE WITH A HEWLETT-PACKARD VOLTOMETER, MODEL 412A, OR EQUIVALENT. MEASUREMENTS FOR STEP 7 ARE TO BE MADE WITH A TEKTRONIX OSCILLOSCOPE, MODEL 535A, OR EQUIVALENT.
4. THE INPUT WAVEFORMS FOR STEP 7 SHALL MEET THE FOLLOWING REQUIREMENTS:
   - 4.1 MAXIMUM REPETITION RATE = 10,000 PPS
   - 4.2 MINIMUM VALUE OF OFF GROUND INPUT = +10 VOLTS
   - 4.3 MAXIMUM VALUE OF NEAR GROUND INPUT = + 0.3 VOLTS
5. OUTPUT TERMINALS ARE TO BE PADDED EXTERNALLY WITH 1100±1% OHMS
6. STATIC TEST

	INPUT					OUTPUT	
STEP	2	1	14	3	17	16	15
1	G	G	H	G	H*	L	L
2	H	G	G	G	H*	L	H
3	G	H	G	G	H*	H	L
4	H	G	H	G	H*	L	L
5	G	H	H	G	H*	L	L
6	G	G	H	H	H*	H	L

   - 6.1 LEGEND
     G=GROUND=0.0V
     H=OFF-GROUND≥3.0V
     L=NEAR-GROUND≤0.3V
     H*=OFF-GROUND PULSE OF DURATION GREATER THAN 40 USEC AND LESS THAN 1 MSEC.
   - 6.2 THE INPUT AT 17 SHALL BE APPLIED AFTER ALL OTHERS IN EACH STEP.
7. DYNAMIC TEST
   - 7.1 INPUT AND OUTPUT AS INDICATED BY WAVEFORMS



   - 7.2 T1 SHALL NOT BE LESS THAN 100 USEC.
   - 7.3 OFF-GROUND POTENTIAL MUST BE APPLIED AT 14 FOR THIS TEST.

Fig. 4 – Typical Circuit Pack Schematic Drawing

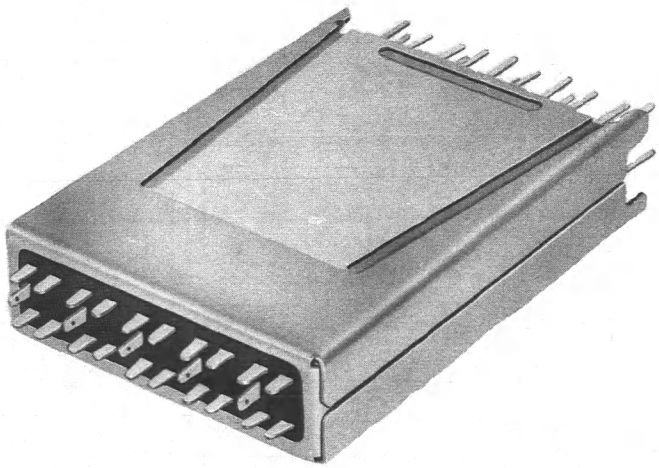


Fig. 5a – 293-Type Dry Reed Relay

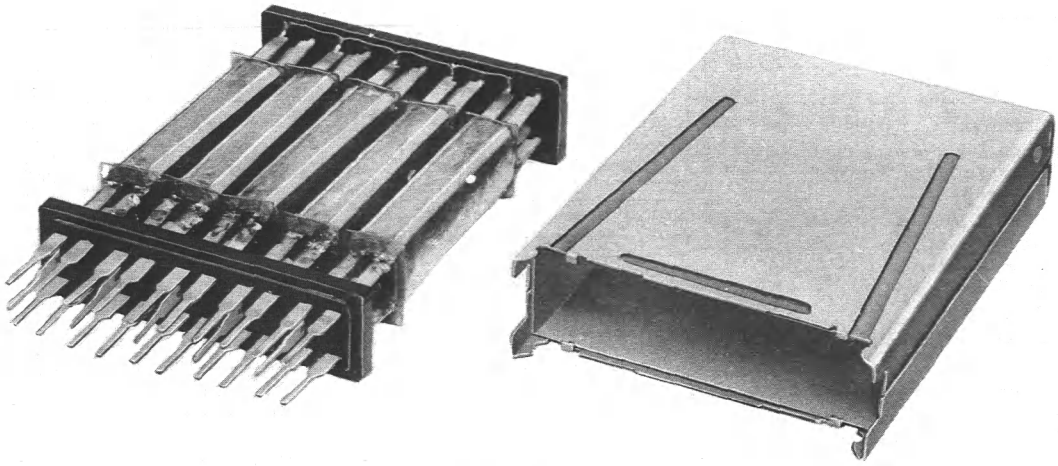


Fig. 5b – 293-Type Dry Reed Relay (With Cover Removed)

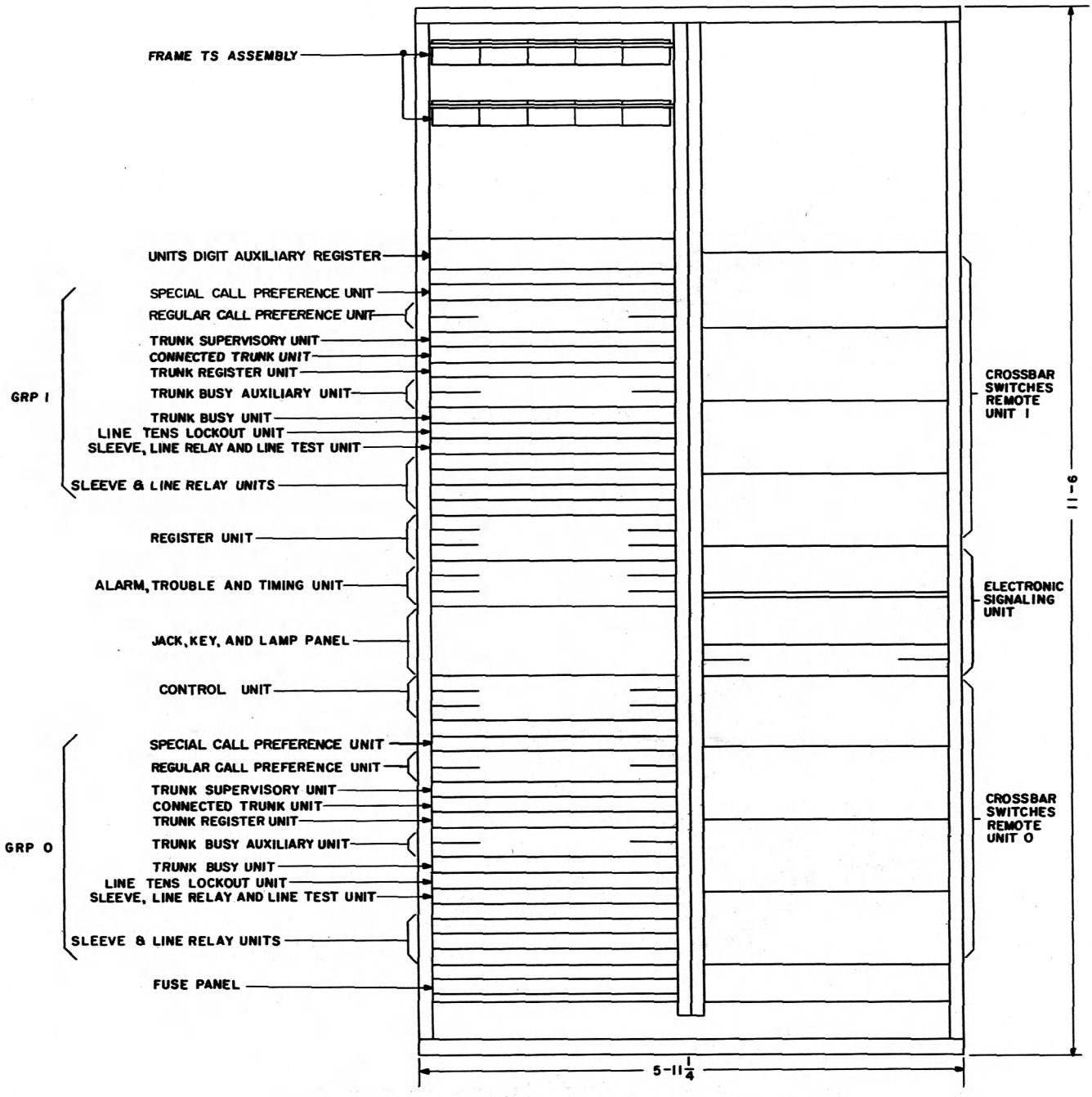


Fig. 6 – Control Unit Equipment Arrangement (Front View)

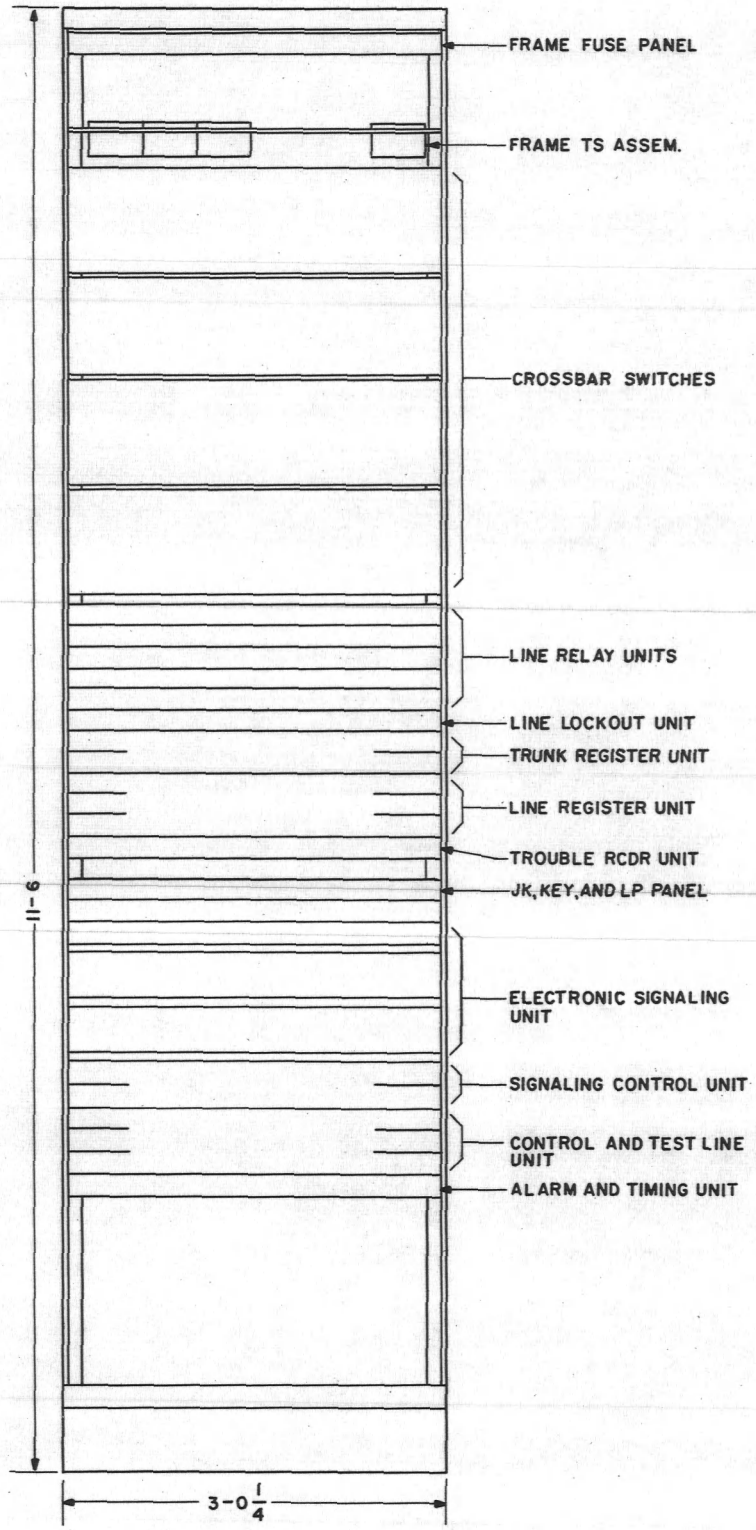


Fig. 7 – Remote Unit Equipment Arrangement

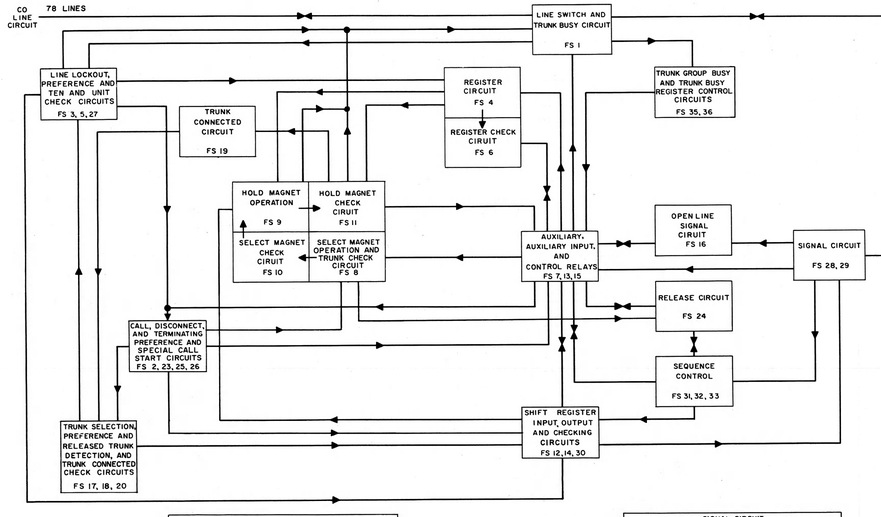


Fig. 8 – Block Diagram

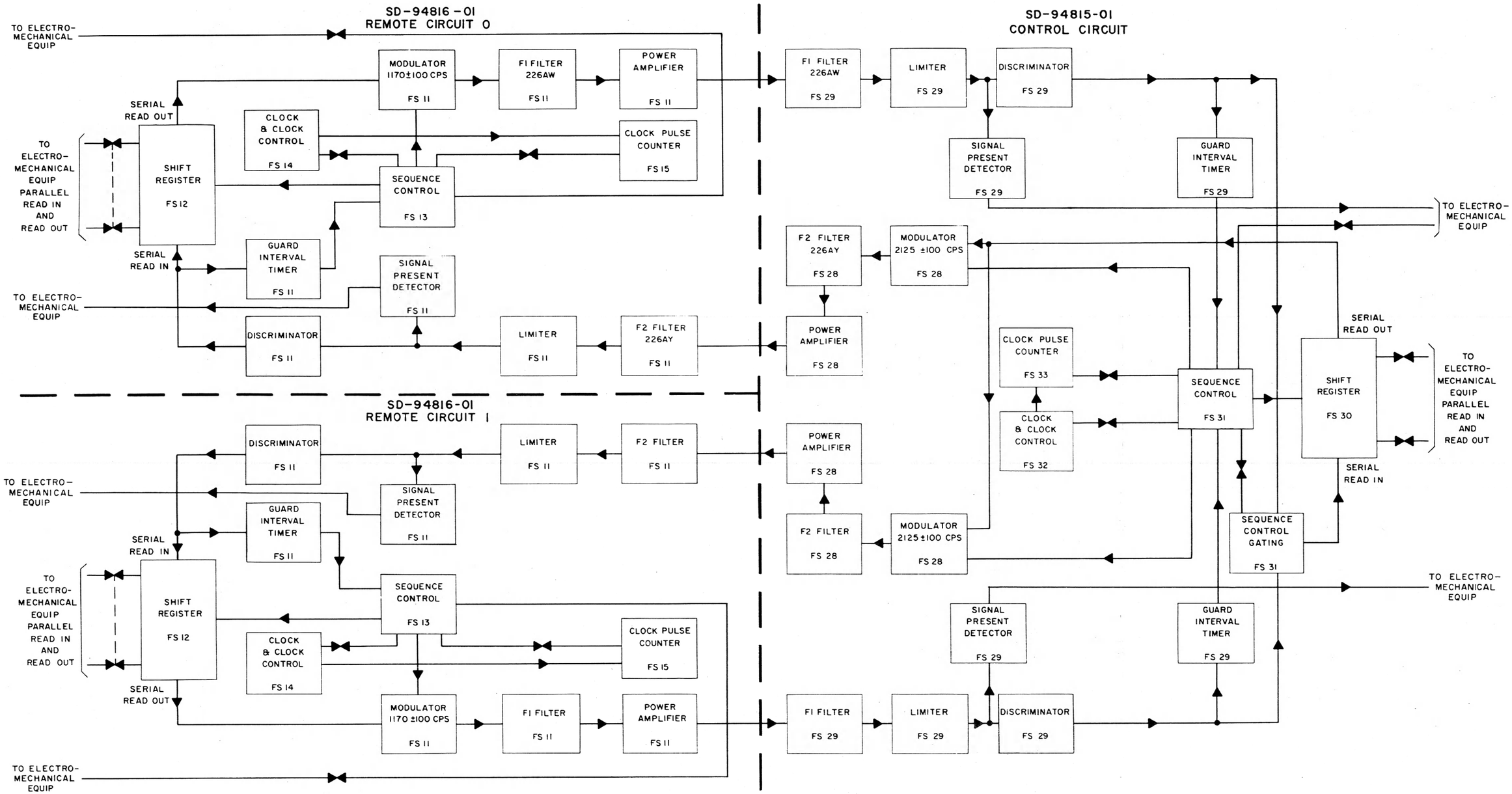


Fig. 9 – Block Diagram, Logic and Signaling Circuit

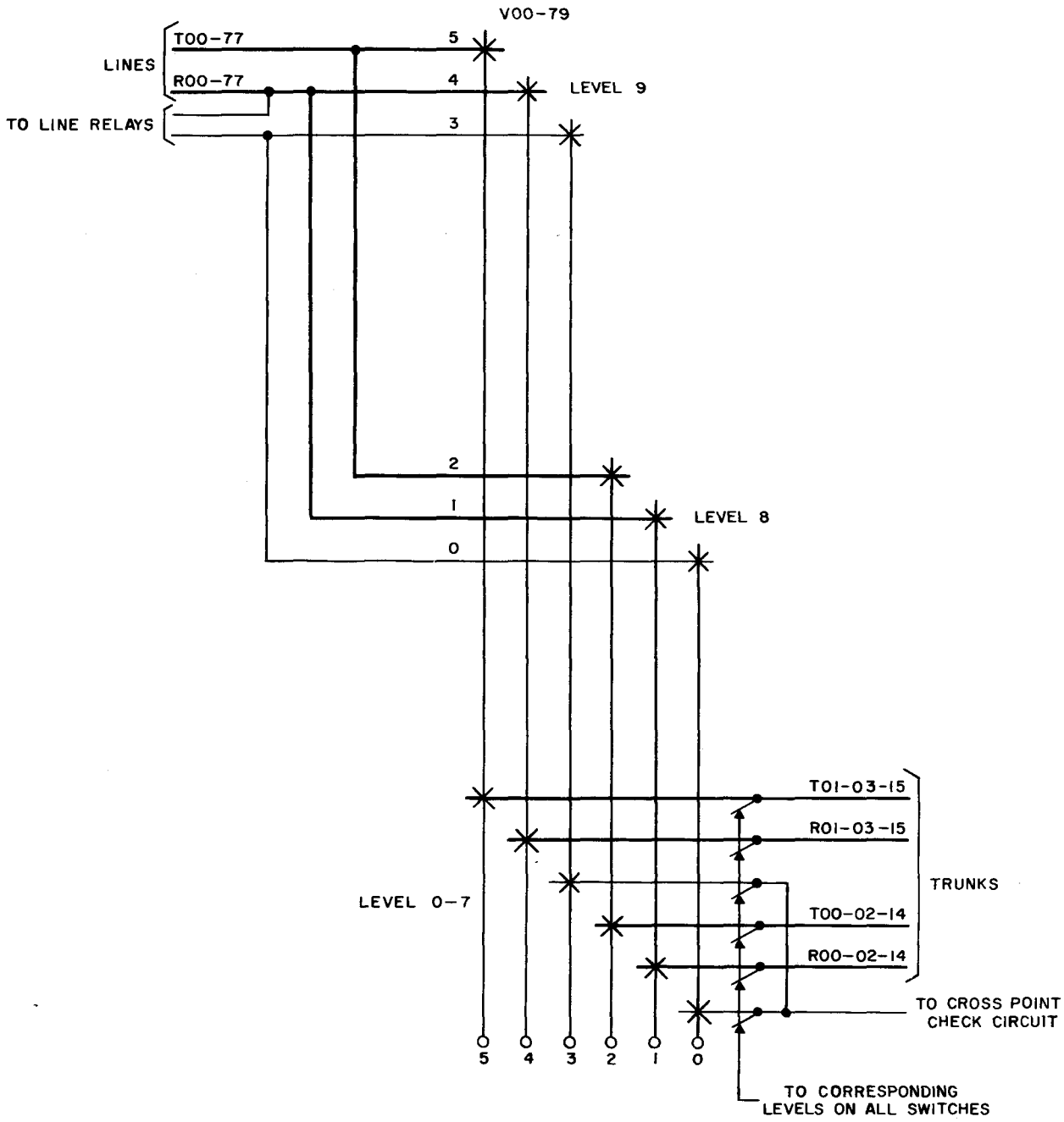
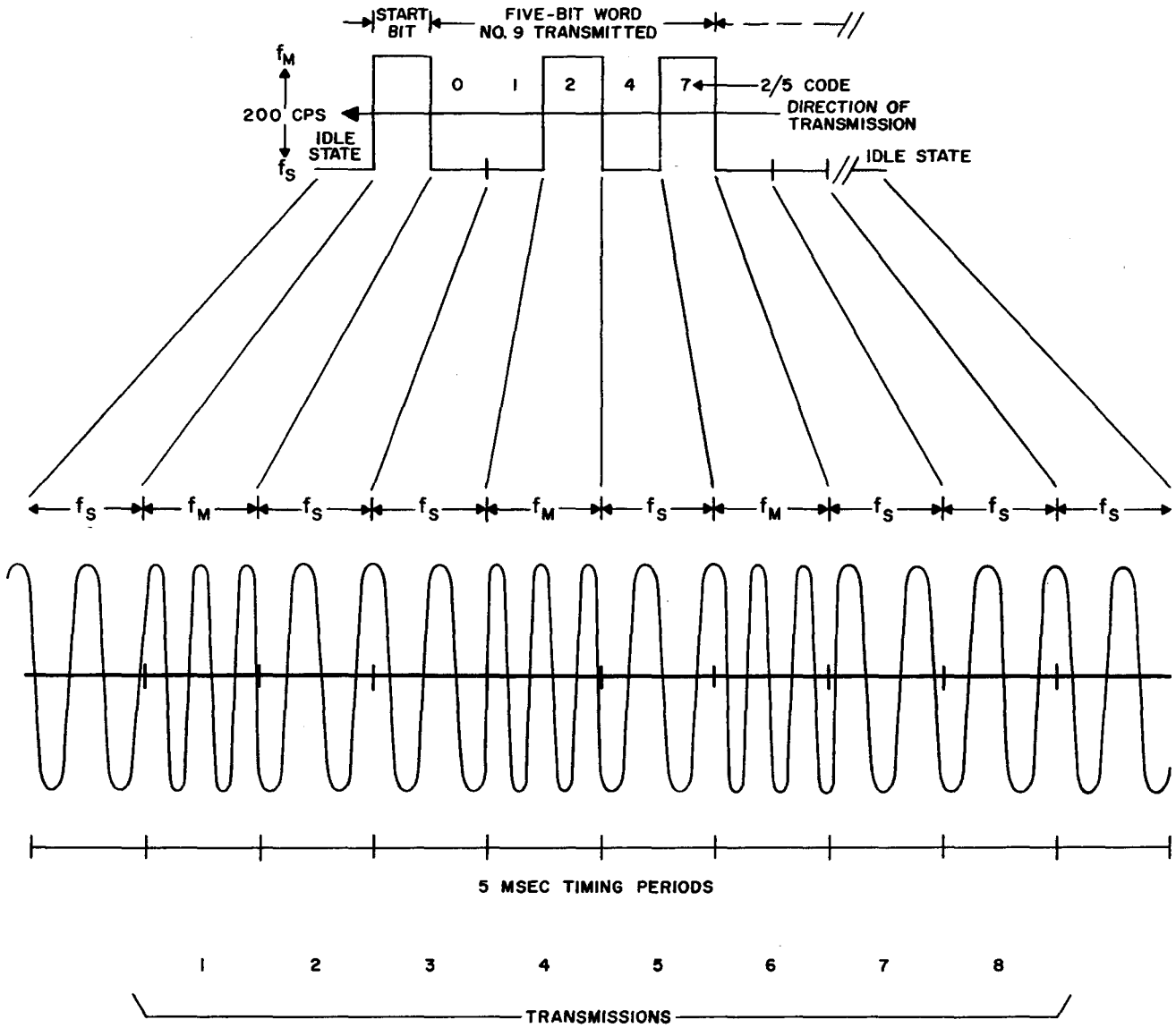


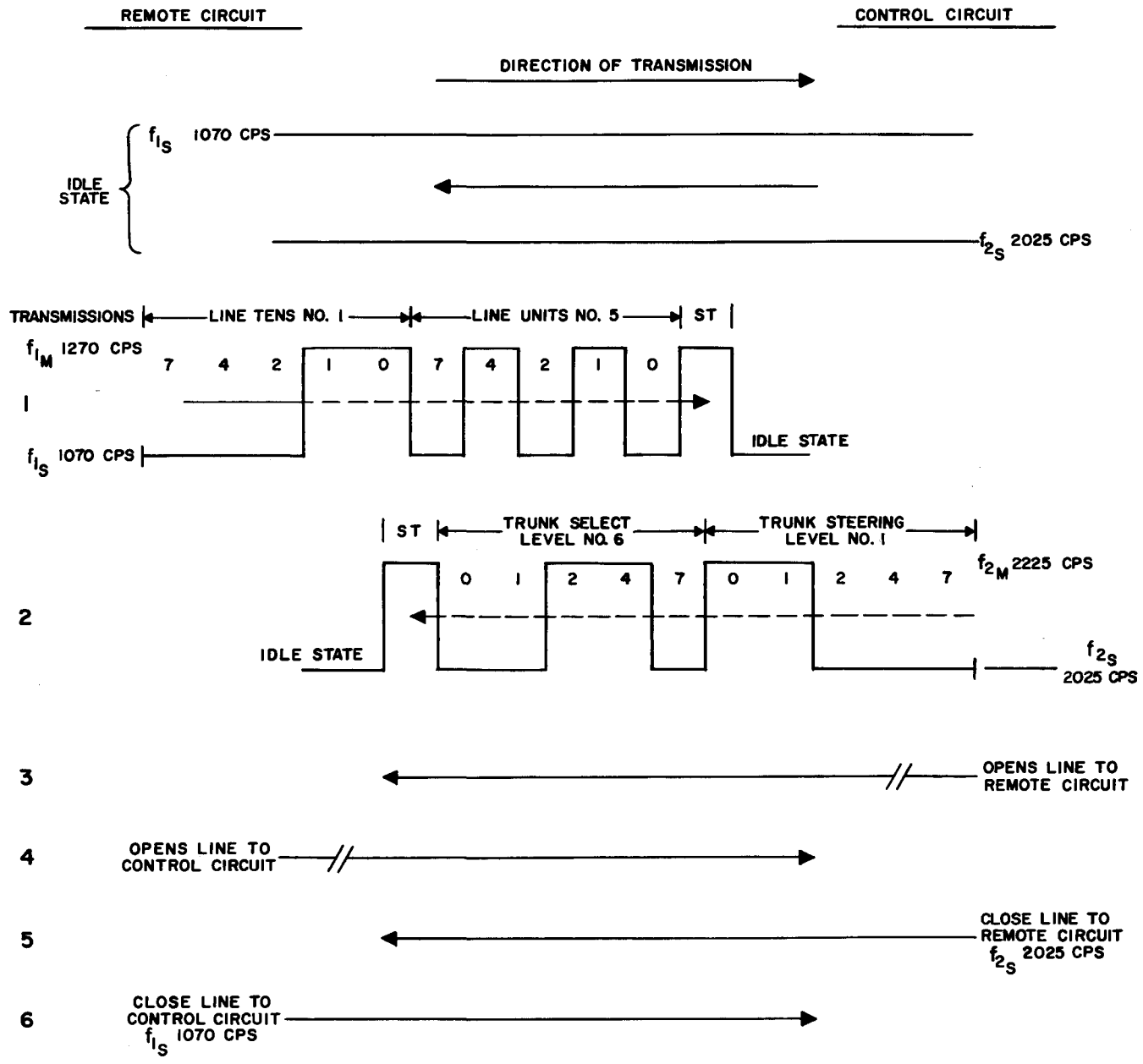
Fig. 10 – Switching Network, Remote Unit



f_M = MARK FREQUENCY

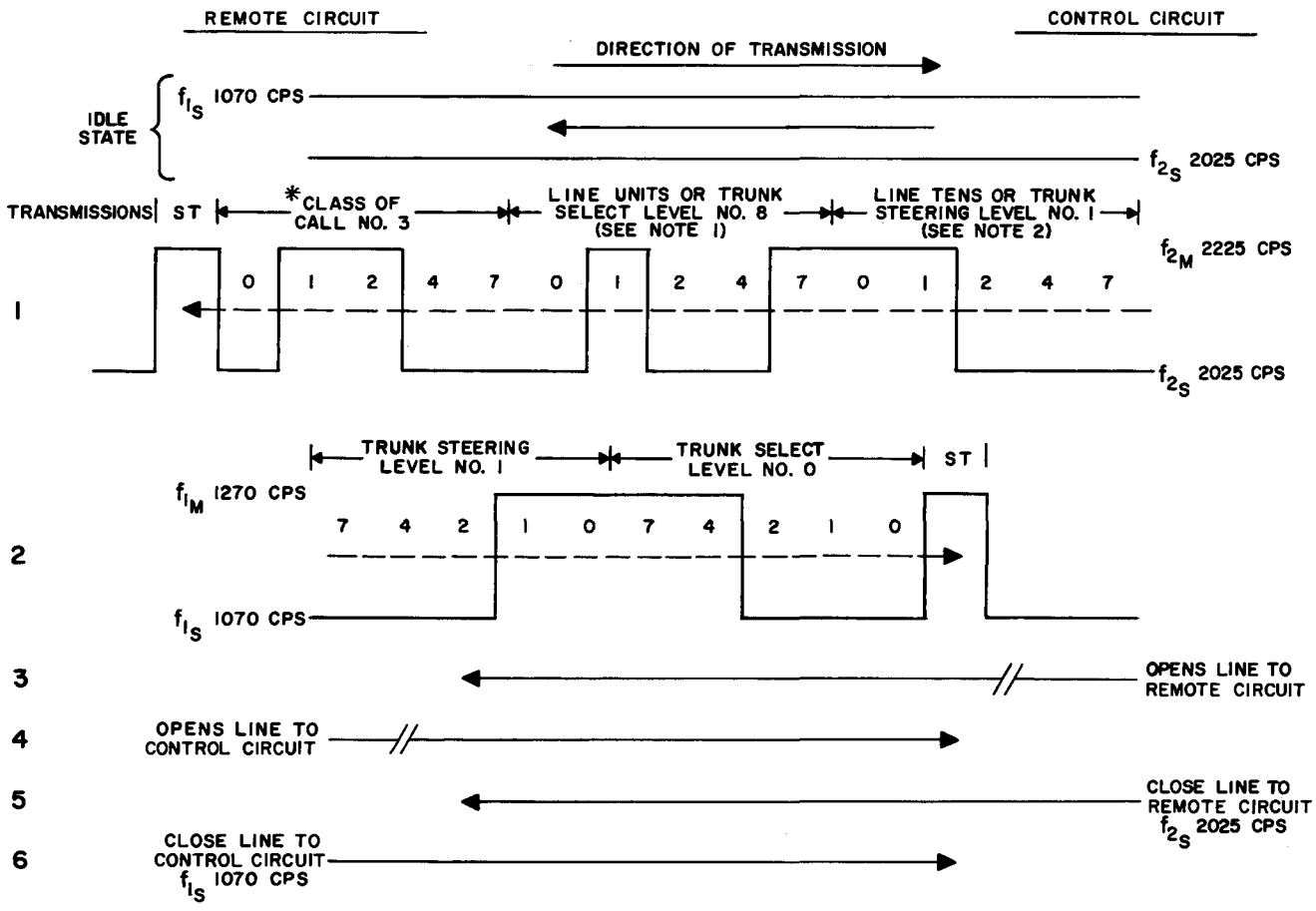
f_S = SPACE FREQUENCY

Fig. 11 – Signaling Mode-Frequency Shift Pulsing, 200 Bits/Second, 2/5 Code



FOR CIRCUIT ACTION BETWEEN TRANSMISSIONS
SEE SEQUENCE CHART FIGURE 14

Fig. 12 – Signaling Service Request Call



FOR CIRCUIT ACTION BETWEEN TRANSMISSIONS, SEE SEQUENCE CHART FIGURE 15 OR 16

*TERMINATING	0
DISCONNECT	1
DISCONNECT	2
SERVICE DENIAL	3
SERVICE DENIAL RELEASE	4

NOTE 1. LINE UNIT NUMBER ON TERMINATING AND SERVICE DENIAL CALLS; TRUNK SELECT LEVEL NUMBER ON DISCONNECT CALLS.

NOTE 2. LINE TENS NUMBER ON TERMINATING, AND SERVICE DENIAL CALLS; AND TRUNK STEERING LEVEL ON DISCONNECT CALLS.

Fig. 13 – Signaling-Terminating Service Denial, Test and Disconnect Calls

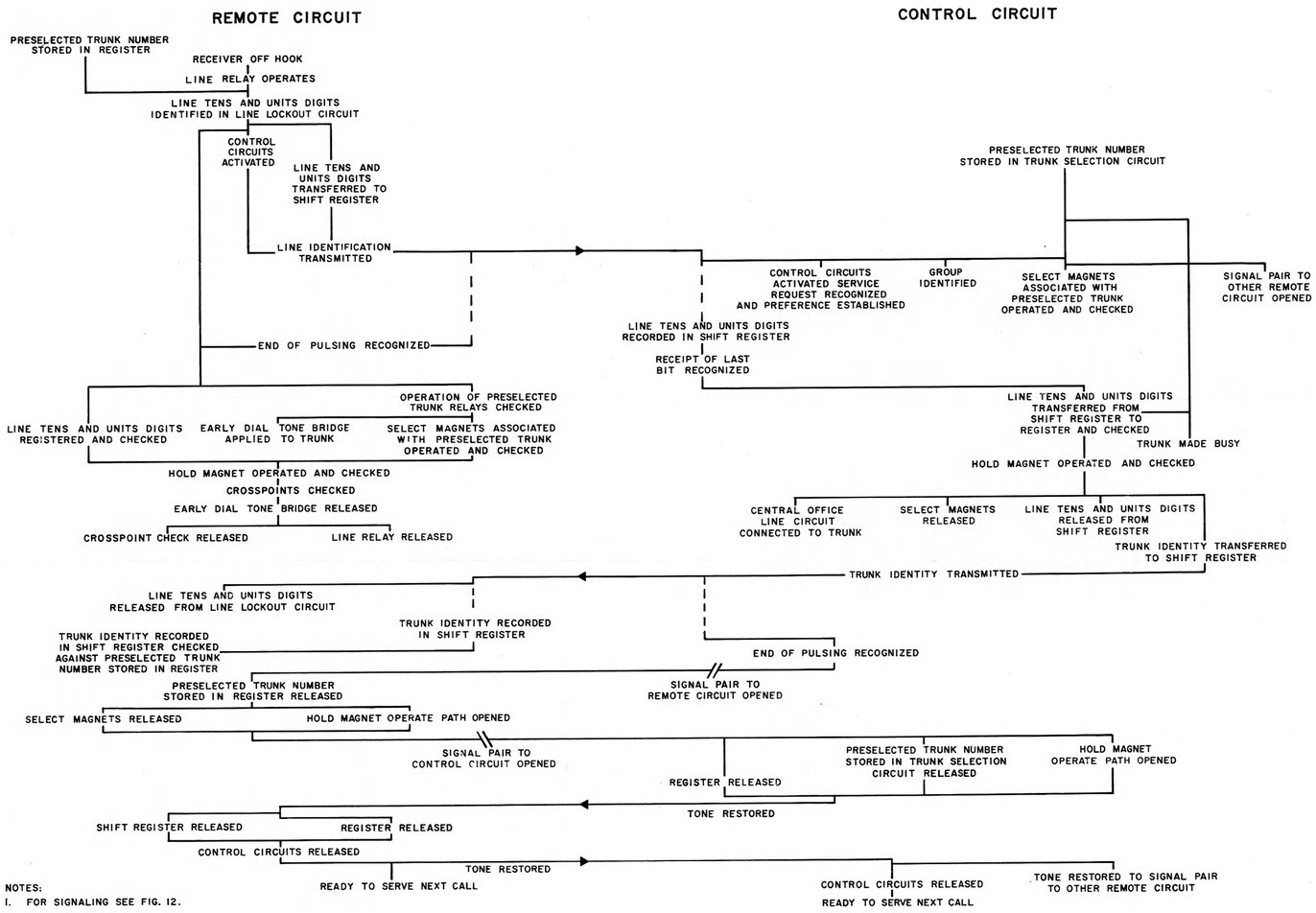
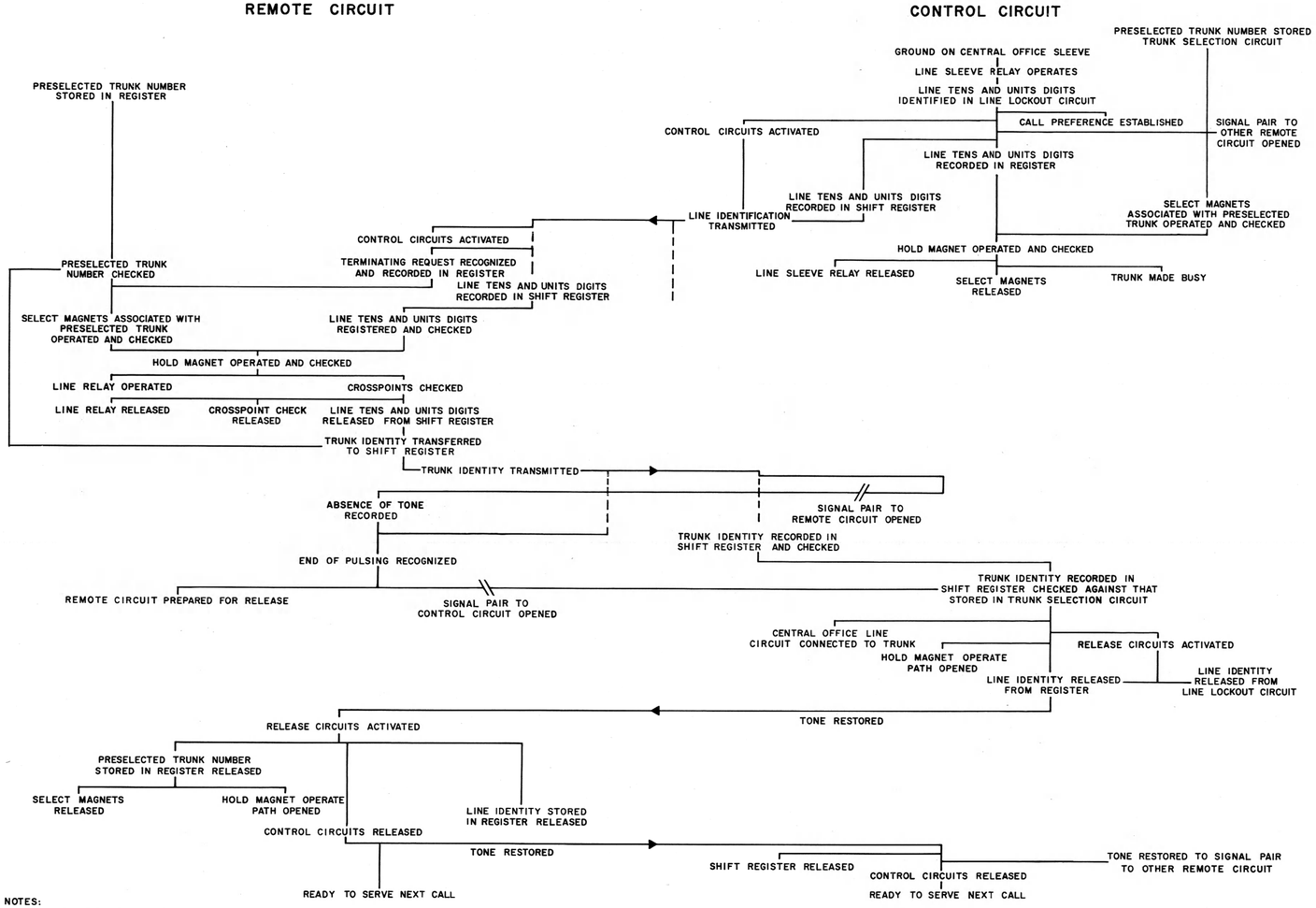


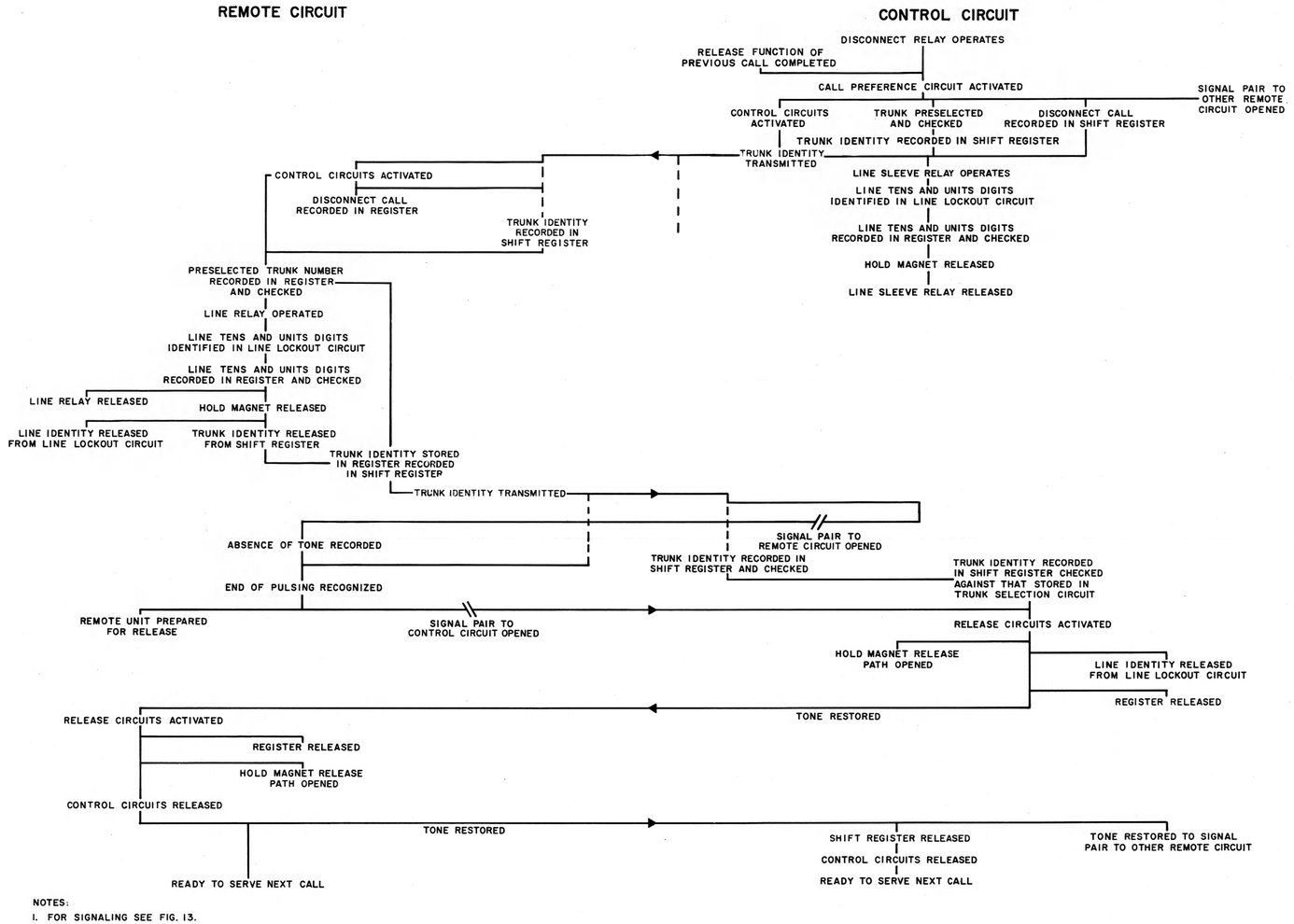
Fig. 14 – Functional Sequence Chart, Service Request Call



NOTES:

1. FOR SIGNALING SEE FIG. 13.

Fig. 15 – Functional Sequence Chart, Terminating Call



NOTES:

1. FOR SIGNALING SEE FIG. 13.

Fig. 16 – Functional Sequence Chart, Disconnect Call

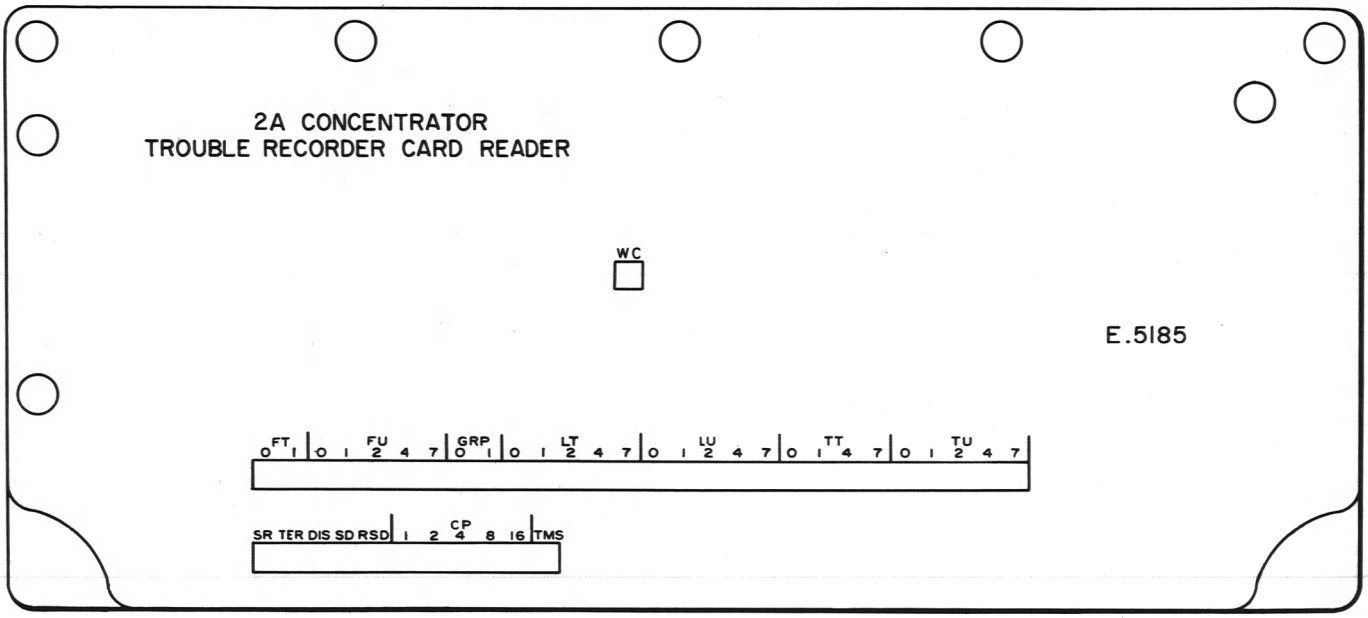


Fig. 17 — 2A Concentrator, Trouble Recorder Card Reader E.5185 Mask

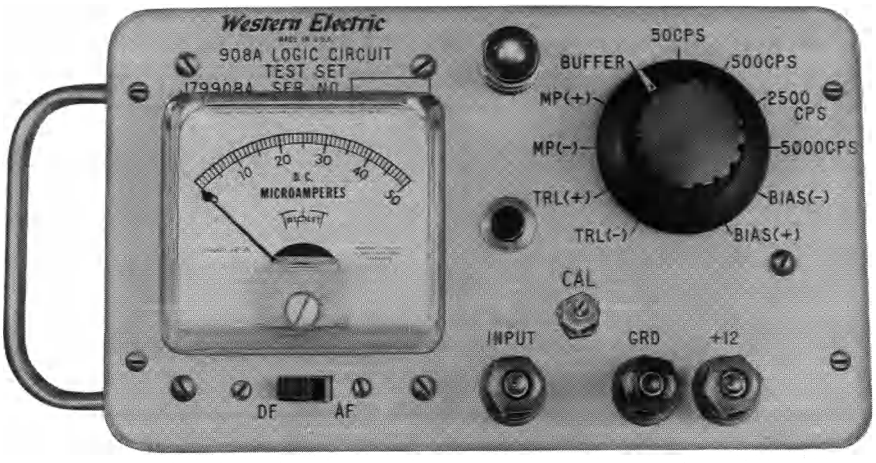


Fig. 18 — 908A Test Box