SPECIAL ACCESS AUXILIARY UNITS
DESCRIPTION
TYPE F SIGNALING SYSTEM

CONTENTS PAGE

1. GENERAL

1.01 This section describes the FL_ and FPA (SD-1C231-01) and FRA and FS_ (SD-1C230-01) single-frequency auxiliary signaling units and the FPD (SD-7C039-01) and FRD (SD-7C040-01) single-frequency tandem auxiliary signaling units all of which are component parts of the Type F Signaling System.

1.02 This section is reissued to add an alarm make-busy (ALB) and an additional compromising network features to the FLC unit. These two features make the FLC compatible with the Remote Switching System (RSS). Revision arrows are used to indicate the changes. The Equipment Test List is not affected.

A. System and Unit Description

1.03 The F signaling bay used to hold these auxiliary units plus the FUA or FUD units is described in Section 179-363-101. The auxiliary units are placed in service by inserting them into the guides of the shelf and sliding them toward the rear of the bay. A locking device on the face of the unit locks the unit in place when sufficient contact with the bay mounting is made. To remove

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the unit, release the locking device and withdraw the unit.

1.04 Components in these units are mounted on a printed wiring board. The board is attached to a die cast aluminum frame approximately 10-1/2 inches by 1-1/2 inches. All interconnections between the bay and the unit are via a 40-pin connector which is part of the printed wiring board.

1.05 On the face of the FL_, FPA, FRA, and FS_ units are screw switches which allow for the selection of the internal compromise or external balancing network and network buildout capacitors (NBOC) and for impedance matching and gain-frequency equalization. ♦The FLC-L2 unit has an additional compromise network which is selected with a slide switch that is located in the area of the printed wiring board.♦ The FPD and FRD units do not have balance networks, impedance matching, and gain-frequency equalization circuits. When the 2-wire auxiliary unit is used in conjunction with the FUD, the internal compromise and NBOC switches must be opened. The FUD supplies the precision balancing network and line buildout capacitors (LBOC) as required. Screw switches also connect the carrier failure trunk release and make-busy circuit. Loop-start (LP) and ground-start (GS) screw switches on the FLA, FLB, FSA, and FSB units are used to put the unit in LP or GS operation. The FPD and FRD units use rocker switches to cut in the carrier group conditioning (ALB, ALO, and ALM), and loop-signaling-return-option (LSRO). A slide switch is used to select either LS or GS operation. These switches are located on the printed wiring board (Fig. 1 and 2). A colored coding label is also on the face of each unit. The color code for the FL_ and FPA units consists of black lettering on a cream background. Coding for the FRA and FS_ units employs red lettering on a cream background. The labels on the faceplate of the FPD and FRD units are not color coded.

1.06 Figure 3 is a photograph of an FPA and FRA unit which shows some of the components which are used in unit construction. Figures 4 and 5 give the details of the various faceplates.

B. Application and Compatibility

1.07 The special access auxiliary units, with the exception of the FPD and FRD tandem units, provide the interface with switching equipment or station on one side and the FUA or FUD unit on the other side (Fig. 6). The FPD tandem auxiliary unit was designed to interface with an FUA and analog carrier toward the PBX end and a D1, D3, or D4 tandem unit with T1 (digital) carrier toward the central office end. The FRD tandem auxiliary unit was designed to interface with an FUA and analog carrier toward the central office end and a D1, D3, or D4 tandem unit with T1 (digital) carrier toward the station end. Figure 7 illustrates the different combinations and usages of these units. An auxiliary unit, with the exception of the FPD and FRD units, plus a converter unit are required at one end of a signaling link, and a compatible type E or F unit is required at the other end. As illustrated in Fig. 7, the FPD and FRD units are never used at the ends of signaling links. It should be noted at this time that the FPD and FRD units are not interchangeable with the FPA and FRA units as usually is the case with other auxiliary units (FLB interchanges with FLA, or FAC interchanges with FAB). The FPD and FRD units are not compatible with the FUD since these units are 4-wire units. Table A lists each unit, function, application, and the type of E unit that it is capable of replacing. Table B lists the units that are compatible with each other. The FLA, FLB, FLC, FLD, and FPA units are used at the central office end of a trunk. The FSA, FSB, FSC, FSD, and FRA units are used at the station end.

1.08 The FLA, FLC, FSA, and FSC units are used for 900-ohm 2-wire applications. These units are suitable for maximum external conductor resistance of up to 1200 ohms for the FLA and FLC units and 1600 ohms for the FSA and FSC units. The FLB, FLD, FSB, and FSD units are used for 600-ohm 2-wire applications and have the same loop resistance limits as the FLA, FLC, FSA, and FSC units. Where longer extensions are required, the 4-wire units (FPA and FRA) are employed utilizing the built-in simplexed A and B leads.

1.09 The FLA, FLB, FSA, FSB, FPA, and FRA units can be used in either LS or GS operation. In the LS mode, the A and B leads or E and M leads may be used, while in the GS mode only the A and B leads may be used. In the FPA and FRA units, the A and B leads are associated with the receive and transmit sides of the metallic extension facility, respectively. Since this arrangement is the reverse of that found in the normal state of other metallic facility equipment units, it is not ordinarily necessary to reverse the A and B leads at the other end of the metallic extension facility when these leads are used for signaling. Selection of the GS or LS mode is made by the GS_ or LP_ switches, respectively. The FLC, FLD, FSC, and FSD units are used in the LS mode only and do not have switches.

1.10 The FPD and FRD tandem auxiliary units can be used in either the LS or GS mode. The mode of operation is set by operating the LS/GS slide switch (Fig. 1 and 2). In the LS and GS modes, the E and M circuits along with the simplex circuits are used to signal either the station end or the central office end of trunk seizure.

2. SIGNALING UNIT OPERATION

2.01 The following tables and figures are provided to accompany the description of the operation of the auxiliary units.

(1) Table C lists conditions of the E and M leads, A and B leads, and the application of 2600-Hz tone under various circuit conditions.

(2) Figure 8 shows FUD and auxiliary units without external repeater equipment versus FUA and auxiliary units plus external repeater equipment.

(3) Figures 9 through 17 show a simplified schematic of the auxiliary and FUA units transmitting and receiving circuits.

(4) Figures 18 through 22 show a simplified schematic of auxiliary and FUD units transmitting and receiving circuits.

A. FL_ and FPA Units

2.02 The FLA, FLB, and FPA units (Fig. 9, 12, and 18) can be divided into seven circuits: (1) ringing detector, (2) GS circuits, (3) seizure detector, (4) supervisory delay, (5) supervisory control, (6) loop current detector, and (7) receive pulse corrector. The FLC and FLD units contain ►only the ringing detector, seizure detector, and receive pulse corrector circuits.◄ The ringing detector circuit detects a 20-Hz ringing signal from the switching equipment and causes the FUA or FUD to send 2600-Hz tone toward the station at high level. This circuit also sends signals to the FUA or FUD unit to control the cut which is inserted in the speech transmission path. The FUD will not be used with the FPA unit since the FPA is a 4-wire unit. In GS operation, the ringing detector and GS circuits function together to change the 20 ±3 Hz ringing to 20-pps operation of the M relay which, in turn, causes the transmitted 2600-Hz tone to be interrupted at 20 pps. In the reverse direction, with GS operation, the incoming seizure detector informs the switching equipment when a station seizure has occurred. The supervisory delay circuit, also in the GS mode, recognizes a seizure or dial tone connection by the switching equipment and by operation of the H relay causes the transmitted tone to be removed. For GS operations, the supervisory delay circuit is removed from the line and the H relay is held operated during the dialing and talking conditions by an operated S relay. This relay is operated by the supervisory control circuit during pulsing and by the operated CS relay in the talking condition. The CS relay is controlled by the loop current detector circuit which operates the CS relay when loop current is flowing. The receive pulse corrector circuit provides pulse correction and guarantees a constant 56 percent break output.

2.03 In the LS mode of operation, the FL_ and FPA units do not transmit SF tone in the idle condition. When SF tone is applied toward the station end, it is for an indication of a ringing signal. However, in the GS mode, the FLA, FLB, and FPA units transmit SF tone toward the station end in the idle condition. This tone is removed as a seizure indication and interrupted at a 20-pps rate during the ringing interval.

A and B Lead—LS

2.04 To place the FLA, FLB, and FPA units in the LS mode, the LP and GS switches must be in the LP positions. In this condition, tone is received but no tone is transmitted. The FLC and FLD units have LS circuitry only and do not have LP or GS switches.

2.05 On station originated calls, the station goes off-hook causing 2600-Hz tone to be removed. Upon the removal of tone, the FUA or FUD unit at the switching end commands the seizure detector circuit to operate the R relay. This closes the loop toward the central office equipment and when the office equipment is ready to receive dial pulsing, dial tone is applied to the line and transmitted to the station end. The station end can now proceed to dial. The dial pulses are changed to tone pulses by the station unit. The FUA unit associated with the FL_ or FPA auxiliary unit receives the tone pulses and sends dc pulses to the receive pulse corrector circuit in the auxiliary unit. The FUD like the FUA unit receives tone pulses and sends dc pulses to the receive pulse corrector circuit of the FL_ unit. This circuit corrects the pulses and provides a constant 56 percent break output through contacts of the R relay which pulses the switching equipment by opening and closing the loop.

2.06 When a call is originated at the switching end, the FL_ or FPA unit is seized by the application of ringing on the ring conductor (B lead). The ringing is detected by the ringing detector circuit which operates the M relay. Through operated contacts of the M relay, 2600-Hz tone is transmitted toward the station end during the ringing cycle. A command is also sent to the FUA or FUD unit to insert a cut in the transmission path. The FUA terminates the line and drop with 600 ohms. The FUD has an electronic cut with no changes in impedance. The cut remains in during the ringing interval and releases during the silent interval.

2.07 For calls originating at the switching equipment end, the tone transmitted by the station SF unit is removed when the station end answers. The FUA or FUD unit detects the removal of tone and causes the R relay in the auxiliary unit to operate which closes the loop. The loop closure trips the ringing in the central office.

2.08 In the LS mode, disconnect is recognized only if it occurs at the station end. When the station end disconnects, SF tone is received and the loop is opened toward the central office equipment.

E and M Lead—LS

2.09 On a station originated call, a station seizure is indicated at the switching equipment when the received 2600-Hz tone is removed. The removal of tone is detected by the FUA or FUD unit which sends a command to the seizure detector to operate the R relay. The operated contacts of R relay ground the E lead to the switching equipment. The switching equipment responds to the ground and establishes a dial tone connection. Pulsing is the same as described in 2.05 except the output is on the E lead instead of the A and B leads.

2.10 When a call is originated at the switching end, the FL_ or FPA unit is seized by a ground on the M lead which indicates a ringing signal. The ground causes the LS circuit to operate the M relay. Through operated contacts of the M relay, 2600-Hz tone is transmitted toward the line during the ringing interval.

2.11 The conditions that follow, called party answering or disconnect, are the same as described in 2.06 and 2.07 except the operated R relay applies ground to the E lead and the released R relay removes the ground, instead of opening and closing the A and B loop.

A and B Lead—GS

2.12 To place the FLA, FLB, and FPA units transmitting circuit in the GS mode, the LP 1 and 2 screw switches must be in the open position and the GS 1 and 2 screw switches must be in the closed position. In this condition, tone is transmitted and received in the idle state. The FLC and FLD units do not have GS capabilities.

2.13 For station originating calls, when seizure occurs, the received tone is removed. The FUA or FUD unit detects the removal of tone and commands the seizure detector circuit to operate the R relay which grounds the B lead as a seizure signal to the switching equipment. When the switching equipment is ready to receive dialing, it grounds the tip conductor (A lead) and applies dial tone to the line. This activates the supervisory delay circuit which operates the H relay. Through operated contacts of the H relay, the D and M relays are released removing transmitted 2600-Hz tone and closing the loop. The FLA, FLB, or FPA unit is now ready to receive dial pulses. Dialing is the same as described in 2.04.

2.14 When a call is originated at the switching end, the FLA, FLB, or FPA unit is seized by the switching equipment when a ground is placed on the tip conductor (A lead). The supervisory delay circuit detects the ground and operates the H relay. Operation of the H relay causes the M relay to release, removing the transmitted tone. Within 4 seconds (3 seconds for PBX applications) after the ground is applied, 20-Hz ringing will be applied to the ring conductor (B lead). The ringing causes the LS and GS circuits to send dc pulses to the M relay at 20-pps rate. Through contacts of the M relay, transmitted tone is interrupted at 20-pps rate as a ringing signal to the station. A command is also sent to the FUA or FUD unit to insert a cut in the transmission path. The FUA terminates the line and drop with 600 ohms. The FUD has an electronic cut with no changes in impedance. The cut remains in during the ringing interval and releases during the silent interval.

2.15 For calls originating at the switching equipment end, the tone transmitted by the station SF unit is removed when the station end answers. The FUA or FUD unit at the central office detects the removal of tone and causes the R relay in the auxiliary unit to operate, closing the A and B loop. The loop closure trips the ringing in the office.

2.16 Disconnect signals are recognized at either the station or central office end for a call in the GS mode. If the disconnect originates from the station, SF tone is received at the central office end and the R relay releases. This results in an open loop which indicates a disconnect to the central office. The central office responds to the open loop by removing ground from the A lead. This causes the A and B lead ground detector to turn off and, after a 210-millisecond delay, causes the H relay to release. When the H relay releases, the M relay operates to transmit SF tone to the station end. If the disconnect originates at the central office, ground is removed from the A lead which causes the loop current detector (CS relay) to release. After a short delay, the H relay releases and the M relay operates, causing 2600-Hz SF tone to be transmitted to the station end. The D relay will not operate during the disconnect interval since the R relay is operated. When a disconnect signal is returned from the station, SF tone is received, the R relay releases, and the D relay operates to establish the idle condition.

B. FRA and FS_ Units

2.17 The FRA, FSA, and FSB units can be divided into six main circuits: the current detector, AM relay timing circuit, ring trip circuit, GS control circuit, ringing detector, and ringing delay circuit. See Fig. 13, 14, and 21. The FSC and FSD contain all these circuits except the GS circuits. The current detector circuit recognizes when the station goes off-hook, either as a seizure or called party answering, and causes the AM relay to release, removing tone toward the central office end. This circuit also detects station disconnect and causes the AM relay to operate and apply tone toward the central office. Commands from this circuit are sent to the FUA or FUD to control the cut inserted in the transmission path. In the GS mode, when either end disconnects, the GS circuit causes the GS relay to open the A lead toward the station. This circuit also causes the GS relay to apply ground on the A lead toward the station when a seizure occurs at the central office. For GS operation of the FSA, FSB, and FRA units, the ringing detector circuit converts the received 20-pps tone alternations to a steady on-off signal for the ringing delay circuit which applies ringing to the station by controlling the R relay. The ringing delay circuit provides immunity to voice frequencies.

2.18 The FRA and FS_ units transmit SF tone toward the central office end in the idle condition for the LS mode. The FRA, FSA, and FSB also transmit SF tone toward the central office end in the idle condition for the ground-start mode. When SF tone is transmitted toward the central office, it is an indication of an on-hook condition.

A and B Lead—LS

2.19 To place the FSA, FSB, and FRA units in the LS mode, LP 1 screw switch must be in the closed position and GS 1 and 2 screw switches must be in the open position. In this condition, tone is transmitted but no tone is received in the idle state. The FSC and FSD units do not have these switches but are conditioned for LS.

2.20 When the station goes off-hook (loop closed), the current detector recognizes the closure and releases the AM relay which removes tone toward the central office end. The office will make a dial tone connection and return dial tone to the station allowing the station to dial. The AM relay follows the pulsing, applying and removing 2600-Hz tone toward the central office end.

2.21 When a call is originated at the central office end, tone is transmitted to the station end as a ringing signal. The FUA or FUD [FUD for the FS( ) units] unit recognizes the tone and commands the ringing delay circuit to operate the R relay. The operated R relay connects 20-Hz ringing voltage to the B lead which rings the telephone set at the customer's premises.

2.22 If the customer answers during the silent interval, the auxiliary unit is informed of the condition by the loop being closed. The answer condition causes the current detector to release the AM relay. A command is also sent to the FUA unit to release the CT relay. The FUD unit does not have a CT relay, but the same command that operates the CT relay in the FUA unit operates a transistorized cut circuit in the FUD unit. The release of the AM relay removes the tone toward the central office as indication of the customer answering. The release of the CT relay (transistorized cut circuit in FUD) cuts through the transmission path. If the customer answers during the ringing interval, the ring trip detector operates the RT relay. Break contacts of the RT relay remove the ringing. Supervision now proceeds as previously described for answering during the silent interval.

2.23 For LS operation, the converter plus the auxiliary unit is under control of the station end. This is true for either station end disconnect or central office end disconnect. No supervision is returned from the central office in either case. When the station end goes on-hook, the loop is opened (A and B lead operation). This is detected by the current detector which initiates operation of the AM relay. The operated AM relay applies tone to the line toward the central office.

E and M Lead—LS

2.24 To place the FSA, FSB, or FRA unit receiving circuit in the LS mode, the LP 1 screw switch must be in the closed position and the GS 1 and 2 screw switches must be in the open position. In this condition, 2600-Hz tone is transmitted but no tone is received in the idle state. The FSC and FSD units do not have the LP and GS switches but are conditioned for LS.

2.25 A call originated at the central office end causes tone to be transmitted toward the station as a ringing signal. The FUA or FUD [FUD for the FS( ) units] unit commands the ringing delay circuit to operate the R relay. The operated R relay opens the E lead. The E lead is opened during the ringing cycle and grounded during the silent cycle. Station answer is the same as described in 2.20 except when the customer answers battery is placed on the M lead for a ring trip signal which in turn removes 2600-Hz tone toward the central office end. Tripping is accomplished, in this case, only at the central office.

2.26 Disconnect is the same as described in 2.23, except, when the station end goes on-hook battery is removed from M lead instead of the loop being opened.

A and B Lead—GS

2.27 To place the FSA, FSB, or FRA unit in the GS mode, the LP 1 screw switch must be in the open position and the GS 1 and 2 screw switches must be in the closed position. In this condition, tone is received and transmitted in the idle state. The FSC and FSD units do not contain GS capabilities.

2.28 When the station goes off-hook, the B lead is grounded. The ground activates the current detector and releases the AM relay, thus removing tone toward the central office end. The received 2600-Hz tone is removed when the dial tone connection at the central office is made. The FUA or FUD [FUD for the FS( ) units] unit detects the removal of tone and commands the GS control circuit to release the GS relay. The GS relay releases following a short delay and grounds the A lead, closing the A and B lead loop. Dial tone can now be heard by the subscriber at the station. The customer may now proceed to dial. The AM relay follows the pulsing and applies and removes 2600-Hz tone toward the central office end.

2.29 When a call is originated at the central office end, the received 2600-Hz is removed. The FUA or FUD unit detects the removal of tone and commands the GS circuit to release the GS relay placing a ground on the A lead toward the station. Within 4 seconds (3 seconds for PBX applications), the ringing signal is applied from the central office end toward the station end. This ringing signal is 2600-Hz tone at a 20-pps rate. DC pulses from the FUA or FUD unit are passed on to the ringing detector circuit which responds to pulses within a range of 20 ±3 pps. This circuit commands the ringing delay circuit to operate the R relay. The operated R relay applies 20-Hz ringing to the station. At the end of the ringing cycle, the R relay will release. When the station end answers the call (goes off-hook), the ringing is tripped and the transmission path is cut through.

2.30 A disconnect signal can be recognized from either the station end or the central office end. If the station end goes on-hook (loop opened), the current detector recognizes the condition and operates the AM relay. The operated AM relay applies tone to the line via the FUA or FUD unit. After the central office releases the customer's line circuit, the central office signaling unit responds by applying tone to the line toward the station end. The GS circuit receives the tone and operates the GS relay. This opens the tip toward the customer. If the disconnect is originated at the central office, the line circuit at the central office end is released, opening the loop to the SF unit at the central office end and causing SF tone to be transmitted toward the station end. The signaling unit at the station end does not wait for the station to go on-hook before applying tone toward the central office. Instead, the AM relay is operated, applying tone toward the central office immediately after the GS relay operates and opens the tip toward the customer.

C. FL_, FPA, FRA, and FS_ Units—TOUCH-TONE Operation

TOUCH-TONE Operation—Transmitting Toward the Central Office

2.31 When TOUCH-TONE signals are to be transmitted by the FRA or FS_ unit, battery is put on the M lead, the A and B loop is closed for LS operation, or the B lead in the FSA, FSB, or FRA unit is grounded for GS operation. This signal initiates the release of the AM relay, which removes the 2600-Hz tone transmitted toward the central office end. A signal is also sent to the FUA or FUD unit to activate the cut circuit. When the cut circuit is activated, the transmission path is cut through to the line facility. TOUCH-TONE signals can now be passed through the transmit path of these units.

TOUCH-TONE Operation—Receiving From the Station

2.32 When the 2600-Hz tone is removed from the line facility by the station-end signaling unit, the FUA or FUD unit at the central office end detects it and sends a signal to the FL_ auxiliary unit to operate the R relay. When the FUA unit is associated with the FPA unit, this same signal is used to operate the R relay in the FPA unit. The operated R relay informs the switching equipment of the incoming call. In GS operation of the FLA, FLB, or FPA units, when the central office is ready to receive the TOUCH-TONE signals, ground is applied on the tip conductor causing the signaling unit to remove tone toward the station end which closes the station loop. For both LS and GS operations, when the A and B loop is closed and the central office is ready to accept the tone signals, the central office sends dial tone to the station.

D. FPD Units

2.33 The FPD tandem auxiliary signaling unit (Fig. 1) contains no relays. Electronic interface is accomplished with transmission equipment devices (TED), optical isolators, transient voltage and current protected transistor switches, and other discrete circuitry. The voice frequency interface is comprised of two transformers and their associated matching pads, which results in a matched 600-ohm circuit. The circuits of both transformers have approximately 2.5 dB transmission loss in both directions. Before the FPD tandem auxiliary unit can be cut into service, the option switches of the D1, D3, or D4 tandem channel unit must be operated per Table D or E. The cable length between the FPD tandem auxiliary unit and the D1, D3, or D4 tandem channel unit must not exceed 2000 feet. Table F illustrates the level of the Transmission Level Point (TLP) between the FPD and tandem channel unit and between the FPD and the FUA converter unit. The FPD unit can be divided into six main circuits: the tone control, ground detector and cut control, audio and simplex circuit, -12 Vdc reference supply, pulse corrector, and receiver logic.

2.34 The tone control circuit modulates the 2600-Hz signal to the FUA unit and operates in both the LS and GS modes. In the LS mode, the 2600-Hz signal is modulated by the 2 seconds on and 4 seconds off ringing signal. The tone control operates the same in the GS mode, except, the 2 seconds on period of the 2600-Hz signal is interrupted at a 20-Hz rate by the 20-Hz ringing signal from the central office ringing supply. The tone control circuit also supplies the cut control circuit with two precut signals, one for LS and the other for GS.

2.35 The ground detector circuit supplies a negative voltage to the input of the tone control and the receiver logic circuits. This negative voltage is due to the ground detector responding to the central office, seizing the trunk and grounding the tip. This negative voltage at the input of the tone control circuit turns on the gating circuits allowing the 20-Hz ringing signal to pass through the tone control circuit.

2.36 The cut control circuit is activated anytime a 2600-Hz signal is transmitted in the direction of the central office to the PBX (or station). In the LS mode, the cut control circuit is active only during trunk seizure and ringing. In the GS mode, the cut control circuit is active only when the trunk is idle or during ringing. The cut control circuit is also under the control of the pulse corrector circuit. During dial pulsing from PBX (or station), the pulse corrector break-single-shot-negative pulse and make-single-shot-positive pulse activates the cut control circuit. Anytime 2600-Hz tone is transmitted in either direction, central office to PBX (or station) or PBX (or station) to central office, the voice path in the FUA units is cut.

2.37 The audio and simplex circuits incorporate the use of two voice frequency transformers with primary windings center tapped. The center taps are used for simplexing. Resistors in the T and R paths match the internal ac resistance of the transformers to 600 ohms in each direction. The ring ground signal is simplexed from the FPD to the D1, D3, or D4 tandem channel unit over the T and R leads. The ringing is simplexed from D1, D3, or D4 tandem channel unit to the FPD unit over the T1 and R1 leads.

2.38 The -12 Vdc reference supply consists of a 3-section operational amplifier (op amp). These op amps are connected across the -24 Vdc power supply and are configured as voltage followers with a gain of 1, which gives an output of 50 percent of the -24 Vdc supply voltage. Three separate op amps are needed to meet the current requirements of the FPD unit.

2.39 The pulse corrector processes the dial pulses and corrects the pulses to a constant 56 ±2 percent break. Pulse correction occurs over a speed of 7.5 pps to 12.5 pps. The pulse corrector is divided into two sections, pulse corrector 1 and pulse corrector 2. Pulse corrector 1 contains an operate timer and a release timer. The release timer is under the control of the FUA on the GA and GC leads and has a delay time of 55 ms to bridge tone gaps. When tone is removed, the delay time of the release timer is 29 ms which is the same as the delay for the operate timer when tone is applied. Pulse corrector 2 contains make- and break-single-shot operational amplifiers. Pulse corrector 2 is under control of the FUA on the GB lead, and from dial pulse signals from the operate timer. Pulse corrector 2 controls the make and break interval of the dial pulses to 56 ±2 percent for dial pulses between 7.5 and 12.5 pps.

2.40 The receiver logic circuit enables the FPD unit to transmit loop closure and ring ground from the PBX (or station) toward the T1 carrier and central office. This is accomplished by two optical isolators (OI) in the receiver logic circuit. Loop closure and ring ground is transmitted when the optical isolators are turned on grounding the E and RG/RS leads. The LSRO switch in the receiver logic circuit either grounds both OI return circuits or allows the return circuit to be grounded at the D3 or D4 tandem channel unit. When the D1 tandem unit is used, the LSRO switch must be operated since there is no ground lead from the D1 unit to the FPD unit. There is a resistive protection circuit in the receiver logic circuit which protects the OI circuits from burn out due to an inadvertent short to central office battery. Option switches alarm-make-busy (ALB), alarm (ALM), and alarm-override (ALO) in the receiver logic circuit may be selected as required by operating them to the ON position. If CGA occurs, it is necessary to remove loop closure and ring ground, release the trunk, and enable the ALB. Either ALO or ALM and ALB may be selected. ALB makes the trunk busy 2 seconds after CGA occurs. ALM releases the trunk by removing the ring ground and loop closure. ALO also releases the trunk but allows manual restoral at the fuse and alarm panel.

LS Mode

2.41 To place the FPD unit in the LS mode, the LS/GS switch must be operated to the LS position. When in the LS mode, tone is received but no tone is transmitted.

2.42 When originating a call, the station goes off-hook causing the 2600-Hz to be removed from the analog carrier in the direction of the central office. Removal of 2600-Hz tone activates the pulse corrector, cut control, and receiver logic circuits. When these circuits are activated, loop closure is sent to the central office FXO which closes the loop to the central office. Dial tone is returned to the station indicating that the central office is ready to receive dial pulse information. The station dial pulses are stretched to 52-ms minimum pulse width by the FR( ) or FS( ) units. The make- and break-single-shot operational amplifiers in the pulse corrector circuit of the FPD unit convert the dial pulses to 56 percent break, which is constant over 7.5 pps to 12.5 pps. The receiver logic circuit sends the corrected dial pulses out on the loop closure lead. At the FXO unit, the dial pulses are converted to loop open and loop closed pulses.

2.43 When the central office originates a call, the terminating portion of the central office is connected to the tip and ring of the station. A 20-Hz ringing signal is transmitted from the central office to the FXO unit, where the 20-Hz is detected and only the envelope is transmitted to the D1, D3, or D4 tandem channel unit. The tandem channel unit converts the envelope to either an open (no ringing) or 1000-ohm ground (ringing). This open or ground is transmitted to the audio and simplex circuit of the FPD unit by way of the T1 and R1 leads. The simplexed 20-Hz signal envelope is injected into the tone control circuit where it is used to modulate the 2 seconds on and 4 seconds off 2600-Hz tone. The modulated 2600-Hz tone is converted to a negative voltage from the FUA to the FR( ) or FS( ) unit which gates on a local 20-Hz ringing supply for 2 seconds on and 4 seconds off.

2.44 When the station answers (goes off hook), continuous tone is removed from the station end of the analog carrier to the FPD end. Removal of the tone places an ***open*** on the E1 lead to the pulse corrector. An ***open*** on the E1 lead activates the pulse corrector, cut control, and receiver logic circuits. With the optical isolators activated in the receiver logic circuit, the E lead is grounded sending loop closure toward the central office. At the FXO unit, the loop is closed, ringing is tripped, and the talking path is completed.

GS Mode

2.45 To place the FPD unit in the GS mode, the LS/GS switch must be operated to the GS position. In the GS mode, tone is transmitted and received in the idle state.

2.46 When the PBX originates the call, ring is grounded seizing the trunk. Seizure of the trunk removes the 2600-Hz continuous tone to the FPD and FUA units. Removal of 2600-Hz tone activates the pulse corrector and receiver logic circuits which in turn grounds the ring circuit. Ring ground is transmitted over the simplexed T and R leads to the D1, D3, or D4 tandem channel unit and FXO unit. The FXO unit supplies ring ground to the central office.

2.47 When the central office answers, tip is grounded toward the PBX. Tip ground at the FPD unit activates the ground detector circuit. When the ground detector circuit is activated, three things happen simultaneously. First, the tone control circuit is activated removing the 2600-Hz tone that was being transmitted to the PBX. Removal of 2600-Hz tone causes tip ground to appear at the PBX, which removes voice path cut and establishes tip-ring loop. Second, ring ground is removed from the D1, D3, or D4 tandem channel unit and third, loop closure is transmitted back to the central office to maintain off-hook supervision. Dial tone is then sent from the central office to the PBX to indicate readiness to receive dial pulse information.

2.48 When central office originates the call, to prevent simultaneous seizure of the trunk by the central office and PBX, tip ground is applied toward the PBX by the central office. Also, the central office applies 20-Hz ringing to the ring lead to be transmitted to the PBX. The tip ground activates the ground detector and receiver logic circuits which opens the ring ground signal lead preventing the PBX from transmitting ring ground (trunk seizure) to the central office. The envelope of the 20-Hz ringing signal is applied to the input of the tone control circuit as a control voltage for the interrupter circuit. The ringing control voltage controls the local 20-Hz ringing supply as it pulses the interrupter at a 20-Hz rate which modulates the 2600 Hz from the FUA on for 2 seconds and off for 4 seconds. At the PBX end of the trunk, the tone signal is converted to a 20-Hz square wave signal of 2 seconds on and 4 seconds off by the FUA. The FR( ) or FS( ) auxiliary unit checks the 20-Hz signal for accuracy and if it is within 20 ±3 Hz, ringing from a local 20-Hz supply is applied to the PBX.

E. FRD Units

2.49 The FRD tandem auxiliary signaling unit (Fig. 2) contains no relays. Electronic interface is accomplished with transmission equipment devices, optical isolators (OI), transient voltage and current protected transistor switches, and other discrete circuitry. The voice frequency interface is comprised of two transformers and their associated matching pads, which results in a matched 600-ohm circuit. The circuits of both transformers have approximately 2.5 dB transmission loss in both directions. Before the FRD unit can be cut into service, the option switches of the D1, D3, or D4 tandem channel unit must be operated per Table D or E. The cable length between the FRD unit and the D1, D3, or D4 tandem channel unit must not exceed 2000 feet. Table F illustrates the levels of the TLP between the FRD and tandem channel unit and between the FRD and the FUA converter unit. The FRD unit can be divided into six main circuits; the tone control, ground detector and cut control, audio and simplex circuit, -12 Vdc reference supply, ringing detector and GS control, and receiver logic.

2.50 The tone control circuit simulates the AM relay which modulates the 2600-Hz tone. Also, the tone control supplies a drive signal to the FUA which activates the high- and low-tone boost. There are two inputs to the tone control circuit, one for LS and the other for GS. The GS input responds to PBX seizure of the trunk while the LS input responds to dial pulses from the PBX or station in both LS and GS modes. The LS input of the tone control also responds to loop closure in the GS mode when the PBX has seized the trunk and central office has answered with tip ground. When in the idle condition for LS and GS, the tone control allows 2600-Hz tone to be transmitted continuously from the PBX or station toward the central office. Signals to the two inputs drive the pulse shaper which has delay characteristics of 11 ms for tone off and 16 ms for tone on. The delays of the pulse shaper serve as noise gates. The pulse shaper controls the 52-ms minimum pulse width circuit which insures a minimum tone on interval of 52 ms during dial pulsing.

2.51 The ground detector and cut control circuits provide signals for the two inputs of the tone control circuit plus a cut control signal to the FUA unit. These output signals are developed by the logic circuits when a ground or open is detected at either the loop closure or ring ground lead of the ground detector and cut control circuit. The ground detector and cut control circuit has a 40-ms delay timer which delays removal of the ring ground signal until the loop closure signal is established. This situation occurs when the PBX seizes the trunk first and the central office answers. In the FRD, central office (tip to ground) removes the PBX ring ground control of the tone, to allow loop closure to gain control, in preparation for dial pulsing. The tip ground signal from the FRD must pass through at least one T1 carrier link (maximum of three links) to the FXS unit at the PBX end of the trunk. The FXS unit returns loop closure to the FRD back through the T1 links. Each T1 carrier link can have up to 7-ms round trip delay giving a maximum delay of about 21 ms (for three links in tandem) until loop closure is established. The 40-ms delay timer gives a 19-ms delay guardband.

2.52 The audio and simplex circuits incorporate the use of two voice frequency transformers with primary windings center tapped. The center taps are used for simplexing. The resistors in the T and R path match the internal transformer ac resistance to 600 ohms in each direction. The 2-second envelope of 20-Hz ringing signal is simplexed from the FRD to the D1, D3, or D4 tandem channel unit over the T and R leads. Ring ground signal is simplexed from the D1, D3, or D4 tandem channel unit to the FRD unit over the T1 and R1 leads.

2.53 The -12 Vdc reference supply for the FRD unit is the same as that discussed in 2.38 for the FPD unit.

2.54 The ringing detector and GS control circuit contains a buffer amplifier, ringing delay circuit, two delay timers, GS seizure and disconnect, 10-Hz suppression and width corrector, clipper, single-stage active filter, fullwave rectifier, integrator, and output comparator. All of these circuits respond to GS whereas the LS uses only the buffer amplifier and ringing delay circuits. When in the LS mode, the central office transmits a ringing signal of 2 seconds of continuous 2600-Hz tone which appears as a negative voltage at the E-1 lead of the buffer amplifier. Due to previous delays, the pulse width of this signal has been compressed 150 ms. The compressed pulses from the buffer amplifier are fed into the ringing delay circuit where the pulses are expanded in width by 150 ms. The ringing delay circuit has a 210 ms delay which serves as a noise gate so that speech or noise simulations of 2600-Hz will not cause ringing. The ringing delay circuit provides the same function in the GS mode as it does in the LS mode. The GS seizure and disconnect delay circuits have 150 ±7.5 ms delay and 210 ±10.5 ms delay, respectively. The seizure delay is necessary to prevent tone from seizing the trunk. The disconnect delay prevents noise or speech simulations of tone from causing false disconnect. During GS, 20-Hz ringing is applied to the clipper circuit which drives the single-stage filter circuit. The filter circuit drives the threshold detector and fullwave rectifier circuits. The rectifier circuit output frequency is doubled and is fed into the integrator circuit causing the integrator voltage to be greater than the reference voltage. With the integrator voltage being greater than the reference voltage, this causes the comparator to switch states denoting detection. Due to the transient delays in these circuits, the 20-Hz ringing signal envelope is slightly expanded. In order to compensate for the 20-Hz ringing envelope distortion, the output of the comparator is fed into the 10-Hz suppression and width corrector circuit which compensates for this unwanted envelope distortion. The 10-Hz suppression is necessary as the duty cycle of the signal may degrade. At 10 pps and a 25/75 duty cycle, the signal appears as "single cycles" of 20 Hz. The suppression circuit blocks response to this unwanted signal. The loop closure input to the ringing delay circuit changes the delay of the ringing delay from 210 ms to 360 ms for off-hook ringing. The outputs of the ringing detector and GS control circuits supply input signals for the ground detector and cut control circuit and the receiver logic circuit.

2.55 The receiver logic circuit controls the transmission of ground or open on the tip path and ringing on or off on the ring path from the central office toward the PBX or station by virtue of the logic and optical isolator circuits. The receiver logic circuit is controlled by signals received from the ringing detector and GS circuit and the fuse and alarm circuit. Tip ground or ringing is transmitted when the optical isolators are turned on, grounding the E lead to the D1, D3, or D4 tandem channel unit and the RG/RS lead, which is simplexed to the FUA unit. When in the GS mode, both optical isolators are switched on and off as required. In the LS mode, the E lead is permanently grounded when the LS/GS switch is operated to the LS position. The return circuits of the optical isolators can be grounded by operating the LSRO switch or they can be grounded at the D3 or D4 tandem channel unit. When the D1 tandem channel unit is used, the LSRO switch must be operated since there is no ground lead from the D1 unit to the FRD unit. There are zener diodes across the outputs of the optical isolator which protect against high voltage transients when the optical isolators are in the turned off state. There are also resistors in the output of the optical isolators that protect against high forward current in case of inadvertent short to central office battery when the optical isolators are in a turned on state. Continuous central office battery will not damage the optical isolators but will burn out the resistors. The CGA function of the receiver logic circuit is controlled by operating the ALM, ALO, and ALB switches to the ON position depending on which function is desired. These switches are located on the printed wiring board. If CGA occurs, it is necessary to remove ringing, release the trunk, and enable the ALB. Either ALO or ALM and ALB may be selected. When ALB is selected, the trunk is made busy 2 seconds after CGA occurs. ALM releases the trunk by removing the ring ground and loop closure. ALO also releases the trunk but allows manual restoral at the fuse and alarm panel.

LS Mode

2.56 To place the FRD unit in the LS mode, the LS/GS switch must be operated to the LS position.

2.57 When originating a call, the station goes off-hook causing the loop to be closed to the D1, D3, or D4 tandem channel unit. The D1, D3, or D4 tandem channel unit applies loop closure to the input of the ground detector and cut control circuit. The output of the ground detector circuit activates the tone control circuit which in turn opens the circuit between the 2600-Hz tone supply and the FUA unit. Removal of 2600-Hz tone from the FUA unit stops the transmittal of tone to the central office end of the trunk. Upon removal of tone to the central office, the tip and ring of the station is connected to the central office at which time dial tone is transmitted to the station. The station transmits dial pulse information in the form of loop open or ground which is applied to the input of the ground detector. (Loop open corresponds to the break interval.) The output of the ground detector circuit is applied to the input of the tone control circuit, activating the pulse shaper which guarantees a minimum break interval of 52 ms. The pulse shaper circuit also has delay characteristics which act as a noise filter. The output of the ground detector and cut control circuit activates the cut relay in the FUA unit which maintains voice path cut during dial pulsing and restores voice path at the completion of dial pulsing.

2.58 When the central office seizes the trunk, the station tip and ring (T and R) paths are effectively connected to the central office and 20-Hz ringing signal is transmitted toward the station. The ringing signal appears at the FUA unit as 2 seconds of 2600-Hz tone and 4 seconds of no tone. The FUA unit converts this tone to 2 seconds of negative voltage which activates the ringing detector circuit and the receiver logic circuit. The output of the receiver logic circuit is simplexed over the T and R leads to the D1, D3, or D4 tandem channel unit controlling the transmission of ringing signal to the FXS unit located at the station end of trunk. The FXS unit controls the ringing supply at the station end. When the station answers by going off-hook, loop closure is applied to the input of the ground detector and cut control circuit. The output of the ground detector and cut control circuit removes the voice path cut and activates the tone control circuit which removes 2600-Hz tone that is being transmitted to the central office. Removal of 2600-Hz tone to the central office results in loop closure and ring trip. Removal of the cut establishes voice path from the station to the central office.

GS Mode

2.59 To place the FRD unit in the GS mode, the LS/GS switch must be operated to the GS position. In the GS mode, tone is transmitted and received in the idle state.

2.60 When the PBX originates the call, ring is grounded seizing the trunk. Ring ground is simplexed over the T1 and R1 leads and applied to the input of the ground detector and cut control circuit. The output of the ground detector circuit activates the tone control circuit stopping transmission of 2600-Hz toward central office.

2.61 When central office answers, tip is grounded toward the PBX. Tip ground at the FRD unit activates the GS control circuit and receiver logic circuit transmitting tip ground to the D1, D3, or D4 tandem channel unit. The output of the GS control circuit turns off the ground detector removing the previously established ring ground. Tip ground at the PBX end FXS unit causes loop closure to be transmitted back to the FRD unit. The ring ground removal is delayed 40 ms to allow loop closure to occur first. The 40-ms delay allows time for the tip ground signal to travel the distance of three tandem T1 carriers to the PBX or station and back to the FRD unit as loop closure with approximately a 19-ms guardband.

2.62 When the central office originates a call in the GS mode, tip is grounded removing 2600-Hz tone to the FRD unit. The GS control circuit responds to the removal of 2600-Hz tone after a delay by grounding the tip to the D1, D3, or D4 tandem unit and FXS unit which transmits tip ground to the PBX trunk circuit. The GS control circuit also deactivates the ground detector circuit eliminating the possibility of the PBX grounding the ring circuit and seizing the trunk. With tip grounded, the central office transmits 2600-Hz tone that is modulated at 20-Hz rate for 2 seconds on and 4 seconds off which is converted by the FUA unit to a negative voltage — open 20-Hz pulse train. This 20-Hz pulse train activates the ringing detector circuit and receiver logic circuit. The output of the receiver logic circuit is simplexed over the T and R leads to the D1, D3, or D4 tandem channel unit controlling the transmission of the ringing signal to the FXS unit located at the PBX end of the trunk. The FXS unit controls the ringing supply at the PBX end. When the PBX answers by going off hook, loop closure activates the ground detector and cut control circuit which removes voice path cut and activates the tone control circuit. When the tone control circuit is activated, the 2600-Hz that was being transmitted to the central office is removed resulting in loop closure and ring trip. Removal of the cut establishes voice path from the PBX to the central office.

3. CARRIER GROUP ALARM (CGA)

3.01 Each of these units is provided with a CGA control feature. The circuit is placed into service by turning down either the ALM or ALO screw switches on the face of these units. ♦The FLC-L2 unit also has an ALB switch that is mounted on a separate printed wiring board which is attached to the FLC-L2 printed wiring board.♦ The FPD and FRD units have rocker switches located on the printed wiring board instead of screw switches to activate the CGA circuits. Circuit release is the only condition the CGA can provide in these units except for the FPD, FRD, ♦and FLC-L2♦ units which also have an ALB circuit. The ALM switch is used when normal alarms are desired and the ALO switch is used when alarm override is desired. The ALB circuit makes the trunk busy 2 seconds after the trunk is released.

A. FL_ and FPA Units

3.02 Ground applied to the ALM (or ALO) lead following a carrier failure causes the R relay to release. The released R relay removes the ground from E lead and opens the A and B loop. ▶In the FLC-L2 unit, when the ALB switch is closed, a carrier failure applies a -48V to the CGA circuit causing the R relay to be operated. Operation of the R relay causes the circuit to go on-hook for 2.5 seconds and then off-hook for the duration of the carrier failure. This makes the trunk appear busy after 2.5 seconds which prevents false seizure of the common equipment.◀

B. FRA and FS_ Units

3.03 Ground applied to the ALM (or ALO) lead following a carrier failure operates the CGA relay. Make contacts of the CGA relay ground the E lead to prevent ringing from being applied to the customer and open the A and B leads.

C. FPD and FRD Units

3.04 When ground is applied to the ALO or ALM input and 2 seconds later a negative voltage is applied to the ALB input of the receiver logic circuit, the CGA (ALO and ALM) and ALB operational amplifiers, gating, and optical isolators are activated creating three conditions. First, the tip ground lead is opened, simulating trunk release. Second, the ringing lead is opened, preventing ringing from being applied to the PBX or station. Third, the ALB option is enabled making the trunk busy.

4. TRANSMISSION CIRCUITS

4.01 The FPA and FRA units incorporate a 4-wire extension circuit for use with 4-wire cable extensions. This circuit allows impedance matching and frequency equalization. Impedance matching is obtained by selecting the transformer impedance ratio by the use of screw-type switches. Equalization is obtained by taps on the transformer in the transmit and receive paths (also selected by screw switches). When the 1200-ohm tap is used, independently controlled low- and high-frequency equalization sections can be used. This circuit also has a transformer center tap on the cable side for simplex circuits. A and B screw switches are used to incorporate the simplex arrangement.

4.02 The FL_ and FS_ units allow conversion from 2-wire (900 ohm—FLA, FLC, FSA, and FSC; 600 ohm—FLB, FLD, FSB, and FSD) operation to the 4-wire (600-ohm) interface with the FUA or FUD unit (Fig. 9, 10, 14, 15, 18, 19, 21, or 22). The conversion is obtained by a 2-transformer hybrid in the auxiliary unit. The NBOC may be varied from 0.0 to 0.127 μF in 0.002 μF steps when the auxiliary is used with an FUA unit. This permits balancing against office cabling. When the auxiliary unit is used with an FUD unit the NBOC switches must be operated to the open positions. These units also have a compromise network (COMP NET) of 900 or 600 ohms (R1) plus 2.15 μF (C1). ▶The FLC-L2 unit has an additional compromise network of 1100-ohm resistor in parallel with a 100-ohm resistor and 0.0301 μF capacitor. This additional compromise network provides a better impedance match when the FLC-L2 is interfacing with an ESS office that is associated with an RSS application. This network is cut into the circuit with slide switch S2.◀ When the auxiliary unit is used with the FUD unit, the compromise network switches must be operated to the open position. The FUD provides a precision balanced network which is adjusted when cable is required between the auxiliary unit and the load.

4.03 The FPD and FRD tandem auxiliary units are 4-wire units that incorporate two voice frequency transformers with center tapped primaries for simplexing. The FPD is simplexed toward the central office and the FRD is simplexed toward the PBX or station. The secondary windings have resistors that match the internal transformer ac resistance to 600 ohms in each direction. There is also a capacitor across the secondary windings to tune the transformer inductance to improve the return loss. The SRL-LO is approximately 30 dB, ERL is approximately 33 dB, and SRL-HI is 35 dB. There is an electrostatic shield which is grounded to improve the logitudinal/metallic conversion loss.

5. PULSING CHARACTERISTICS

A. Transmitting for FRA and FS( ) Units

5.01 The FRA and FS_ units will accept dial pulses on the M lead or the A and B loop as follows:

PULSES-PER-SECOND	PERCENT BREAK
7.5	15-90

10.0	20-90
12.5	25-90

Note: The tone pulse output of the shaper is limited to a minimum of 47 ms and a maximum of 57 ms.

B. Receiving for FL( ) and FPA Units

5.02 The FL( ) and FPA units are limited to receiving dial pulses in the range of 7.5 to 12.5 pps. A minimum pulse of 29 ms is required to operate the receiver and a minimum interval of 15 ms between dial pulses is required for the pulse corrector to recycle completely. The output of the receiver is a constant 56 percent break independent of the input percent break within the range from 29 to 90 percent break at 7.5 pps, to 48 to 85 percent break at 12.5 pps.

C. FPD and FRD Transmitting and Receiving

5.03 The FPD tandem office unit receives dial pulses of a minimum of 52 ms wide on the E-1 lead from the PBX or station. The pulse corrector converts the 52 ms dial pulses to 56 percent break, which is constant over the frequency range of 7.5 pps to 12.5 pps. The 56 percent break is transmitted from the FPD unit on the E lead toward the central office.

5.04 The FRD tandem station unit receives dial pulses from the PBX or station on the M lead in the form of break intervals. The AM pulse shaper circuit will accept a minimum break interval of 16 ms duration and guarantees a break interval output of 52 ms minimum. If the break interval or dial pulse is greater than 52 ms at the M lead, the AM pulse shaper transmits the pulse compressed 5 ms. Dial pulses are transmitted toward the central office in the form of corrected 52-ms break intervals of 2600-Hz tone bursts.

6. TRANSMISSION CHARACTERISTICS FOR FL( ), FPA, FRA, AND FS( ) UNITS

6.01 The transmission section of the FPA and FRA units contains equalizer circuitry. The prescription settings for the circuitry are shown in Tables G through K. The equalization circuitry is in the transmitting speech path of these two units. Therefore, in both cases it is at the receiving end of the metallic extension facility where equalization is normally required. See Fig. 6.

6.02 The following assumes that the temperature is approximately 70°F, and the dc power converter is within -24 ±1.2 volts dc.

A. 2-Wire Operation

6.03 The envelope delay distortion present in the transmit and receive circuits can be seen in Fig. 23. In the FL_ and FS_ units, the delay is about 15 microseconds for frequencies of 3000 Hz and above for either the transmit or receive portions. The rise in distortion is quite rapid below 2000 Hz. The delay increases from 18 microseconds at 2000 Hz to 160 microseconds at 500 Hz as shown by the transmit and receive circuit curves in Fig. 23.

6.04 The transmit path in the FUA unit has a negligible amount of loss but is preceded by a P-pad with up to 16.5-dB loss. This pad must be adjusted to obtain -16 dBm0 at the LINE TRMT PORT of the FUA unit. The FUD has 13- to 3-dB loss and must be adjusted to obtain -16 dBm0 at the LINE TRMT PORT of the FUD unit. The loss of the transmit circuit transmission path of the auxiliary unit can be seen in Fig. 24 and 25.

6.05 The output level of the receiving circuit transmission path for the FUA unit is within 0.4 dB of the input signal level between 300 and 3000 Hz. The output level of the receiving circuit transmission path for the FUD unit can be varied over a 10-dB range (-6 to +4 dB) with respect to the input level between 300 and 3000 Hz. The combined variation due to the FUA or FUD unit plus the auxiliary unit between the input and output level in the voice frequency range with and without the band-elimination filter in the circuit is demonstrated in Fig. 26 through 29. The high loss between 2200 and 2800 Hz, shown in Fig. 26 and 27, is due to the presence of the band-elimination filter.

6.06 The longitudinal balance is shown in Fig. 30. The return loss and transhybrid loss curves are shown in Fig. 31 through 33 for COMP NET settings of the auxiliary units. These conditions exist only when the auxiliary unit is connected to loads that are equal to the COMP NET values. When the FUD unit is used with auxiliary units, the return loss and transhybrid loss will depend on the balance achieved by the precision balance networks in the FUD for a particular cable configuration.

B. 4-Wire Operation

6.07 Equalization values suitable for the connecting line facilities are selected by means of the screw-type switches located on the face of the FPA and FRA units. Equalization for long lengths (Table L) of nonloaded cable is obtained by using the 150-ohm taps on the transformer in the transmit and receive paths (selected by screw switches located on printed wiring board). The 150-ohm impedance faces the cable. The resulting deliberate impedance mismatch between the network and cable is larger at low frequencies and thus produces reflection loss that tends to complement cable loss and flatten the overall loss-frequency response. Some equalization for short lengths (Table L) of nonloaded cable is obtained by using the 600:600-ohm taps on the network. The small amount of equalization required is provided by the low-frequency loss in the transformers. The 1200-ohm taps on the transformers are used to match the cable impedance when loaded H88 cable is used.

6.08 For loaded H88 cable, independently adjustable low- and high-frequency equalization sections (Tables G through K) provide the necessary equalization to obtain a substantially flat frequency response over the range of 250 to 3000 Hz. The 1000-Hz insertion loss before equalization is adjusted is 3.3 ±0.3 dB between the AUX TRMT IN and AUX TRMT OUT ports. Between the AUX RCV IN and AUX RCV OUT ports the 1000-Hz insertion loss is 0.3 ±0.3 dB. These 1000-Hz insertion loss values apply to 600-ohm impedance operation (R600 screws down).

6.09 Figures 34 through 39 are curves that illustrate the effect of varying the values of the components of the equalizer sections of the network. These curves do not include any variance in the transformers. All curves have been normalized to zero loss at 1 kHz. The compensation loss at 1 kHz is greater than the amount of HF compensation at 3 kHz.

6.10 The series arm (low-frequency) components (R_{LF} and C_{LF}) provide compensation for amplitude distortion in the 4-wire line facilities at frequencies up to approximately 1000 Hz. Figures 34 through 36 illustrate typical equalization losses which can be obtained by various combinations of C_{LF} and R_{LF}. Figure 34 shows the results of keeping C_{LF} constant at 0.25 μF and varying R_{LF} with the HF section out of the circuit. Figure 35 shows the results of keeping R_{LF} constant at 1500 ohms and varying C_{LF} with the HF section out of the circuit.

6.11 The shunt arm (high-frequency) components provide amplitude equalization for H88 loaded, high-capacitance cable where the nominal cutoff is 3500 Hz. Capacitor C_{HF} and inductor L_{HF} form a parallel resonant circuit tuned to 3000 Hz which is in series with the adjustable resistor R_{HF}. Varying resistor R_{HF} adjusts the amount of high-frequency equalization for various lengths and gauges of facilities. Figure 36 illustrates the typical corrective losses which may be obtained by various settings of R_{HF}.

6.12 While the low-frequency components (R_{LF} and C_{LF}) provide compensation for amplitude distortion, they introduce delay distortion at the same time. Figures 37 through 39 illustrate typical delay-frequency characteristics obtained by various combinations of C_{LF} and R_{LF}. Figure 37 illustrates results of keeping C_{LF} constant at 0.25 μF and varying R_{LF} with the HF section out of the circuit. Figure 38 shows the results of keeping R_{LF} constant at 1500 ohms and varying C_{LF} with the HF section out of the circuit.

6.13 While the high-frequency components provide compensation for amplitude distortion, they also introduce delay distortion. Figure 39 illustrates typical delay-frequency characteristics obtained by varying R_{HF}.

7. MAINTENANCE

7.01 No field maintenance adjustments are provided on the FL_, FPA, FRA, FS_, FPD, and FRD. Units not meeting circuit requirements should be sent to Western Electric Company for repair. Defective units should be replaced with spare units.

7.02 The Type F Test Extender SD-1C241-02 is provided to gain access to the transmission and signaling ports. Use of the test extender will necessitate the removal of the SF units from the bay. The test extender provides jack access to all transmission and signaling ports of the SF units.

7.03 Descriptive or test practices on other related components within the Type F Signaling System can be found under individual component headings in the Bell System Practices Index 179-000-000.

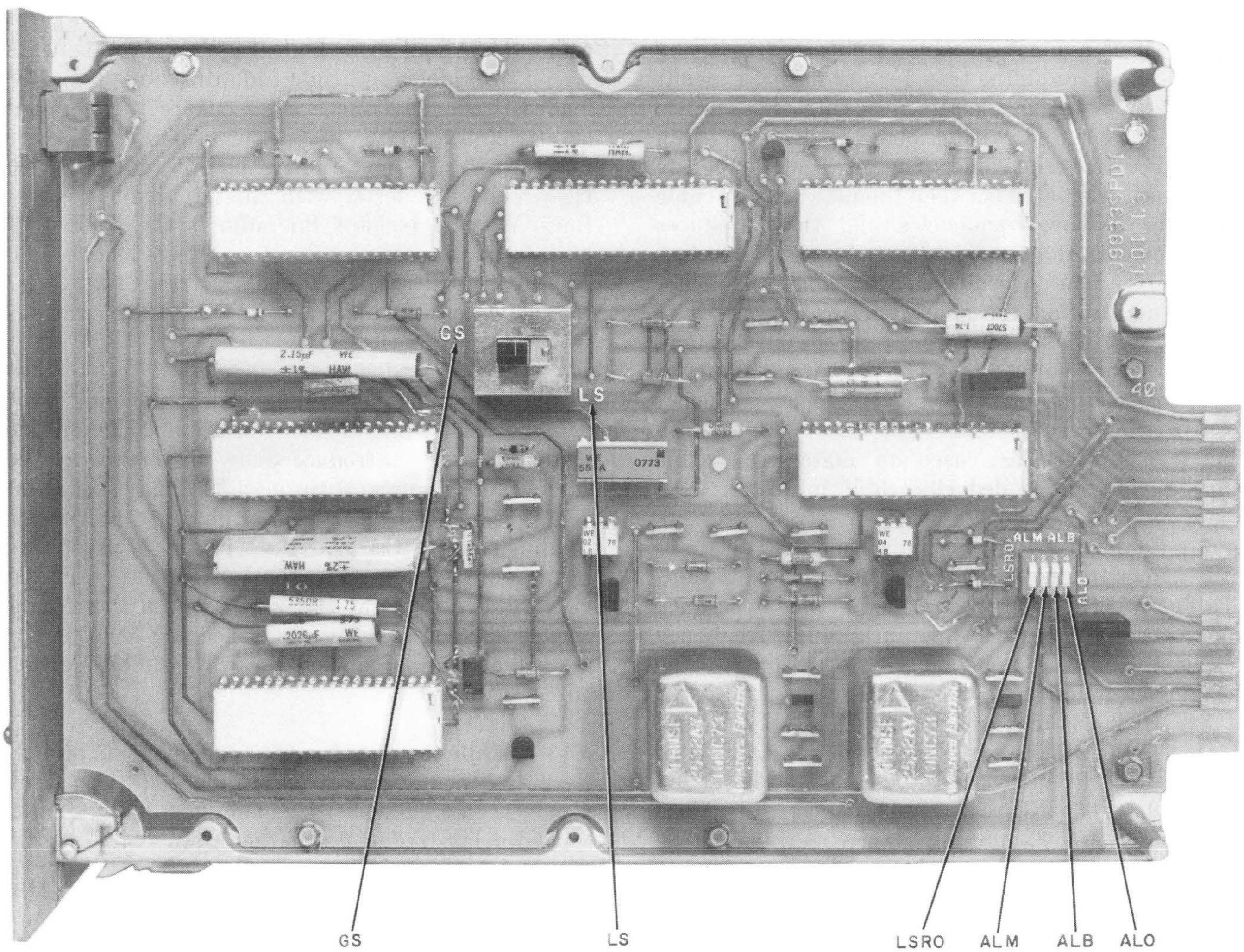


Fig. 1—Illustration Showing Location of Switches on FPD Unit

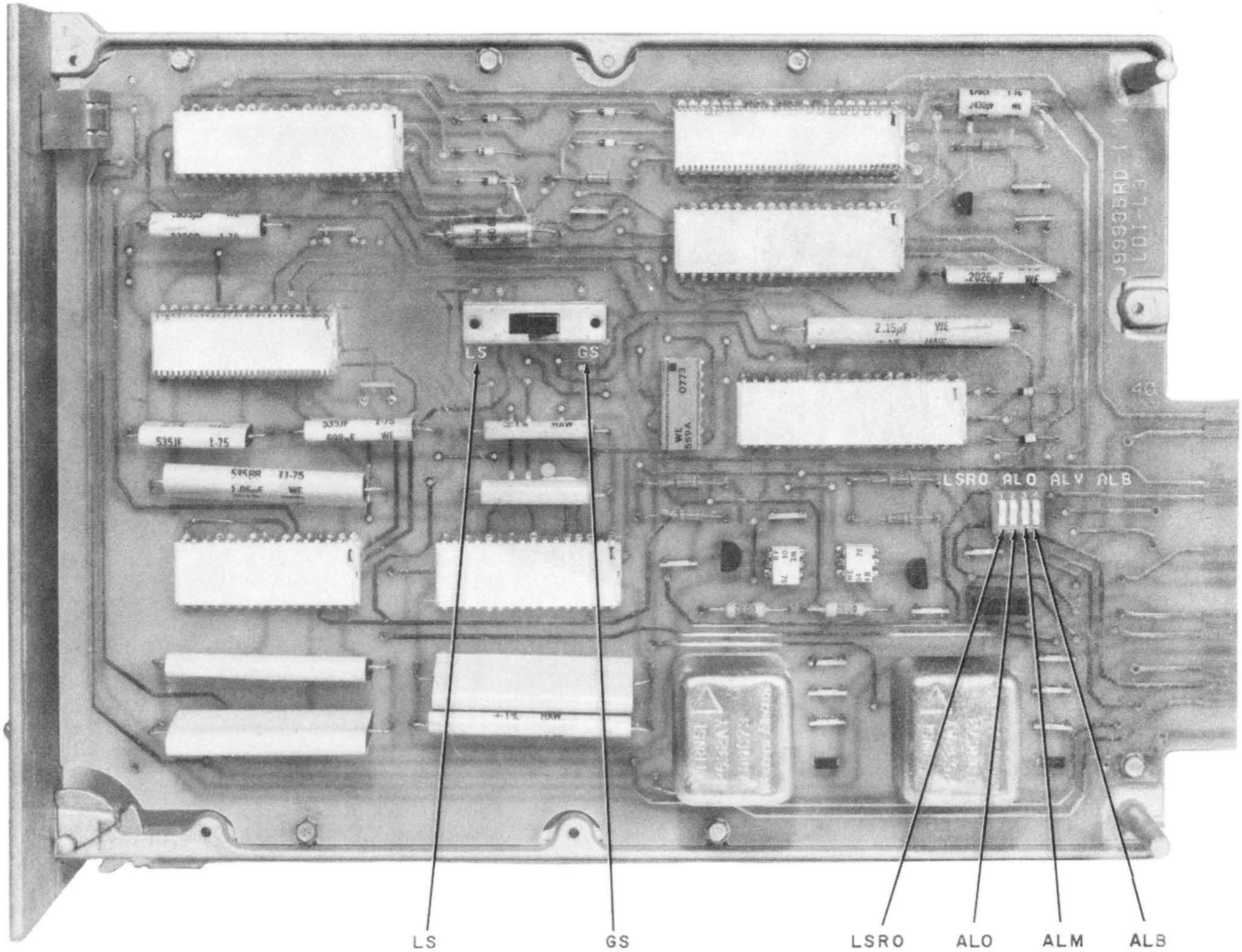


Fig. 2—Illustration Showing Location of Switches on FRD Unit

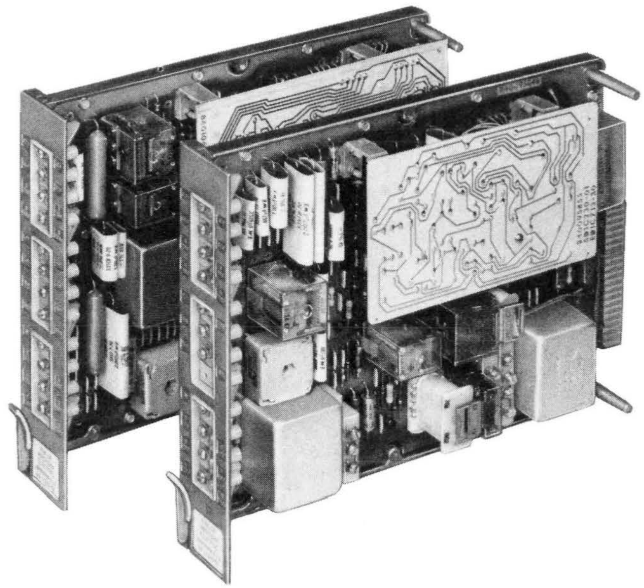


Fig. 3—FPA and FRA Units

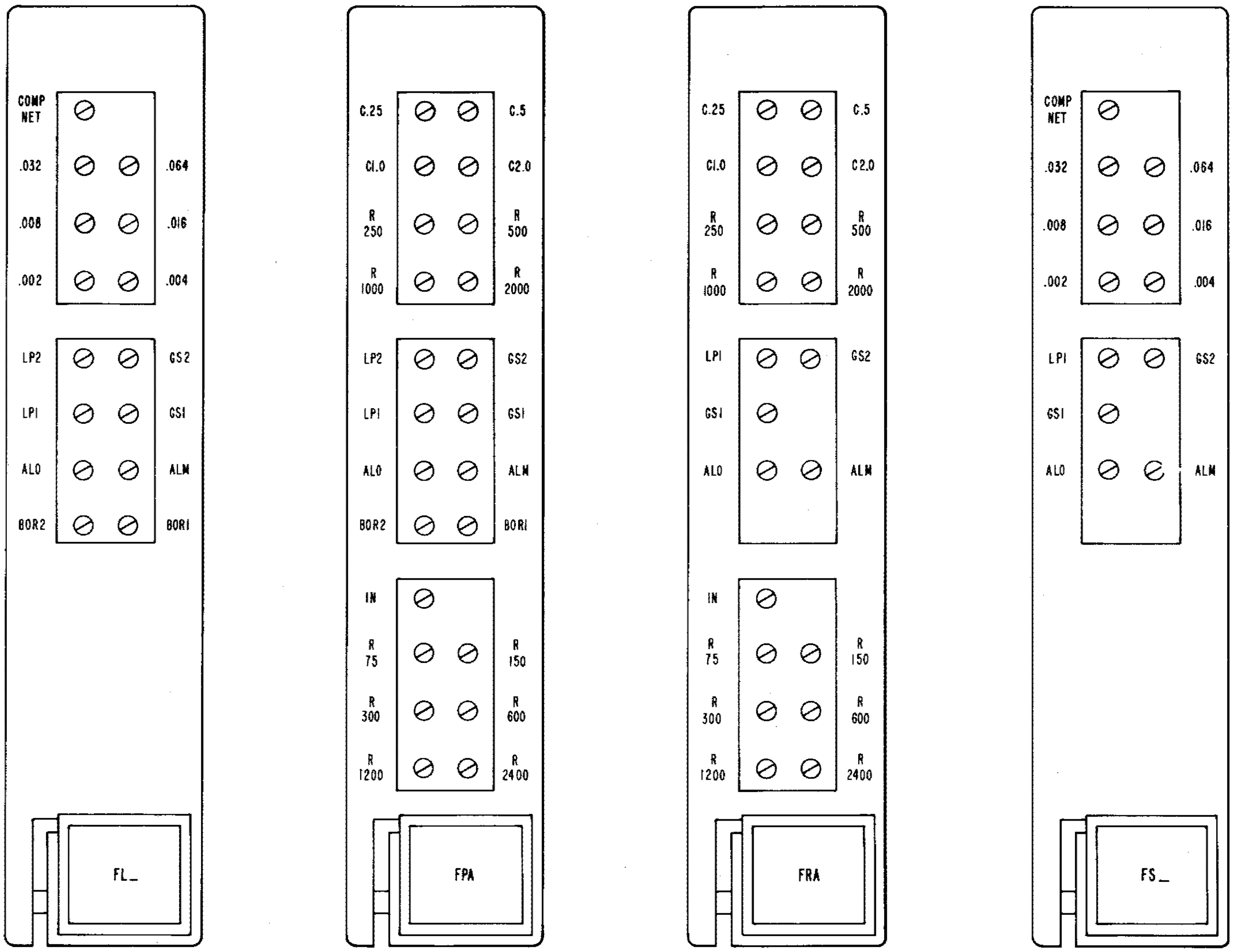


Fig. 4—FL_, FPA, FRA, and FS_ Unit Faceplates

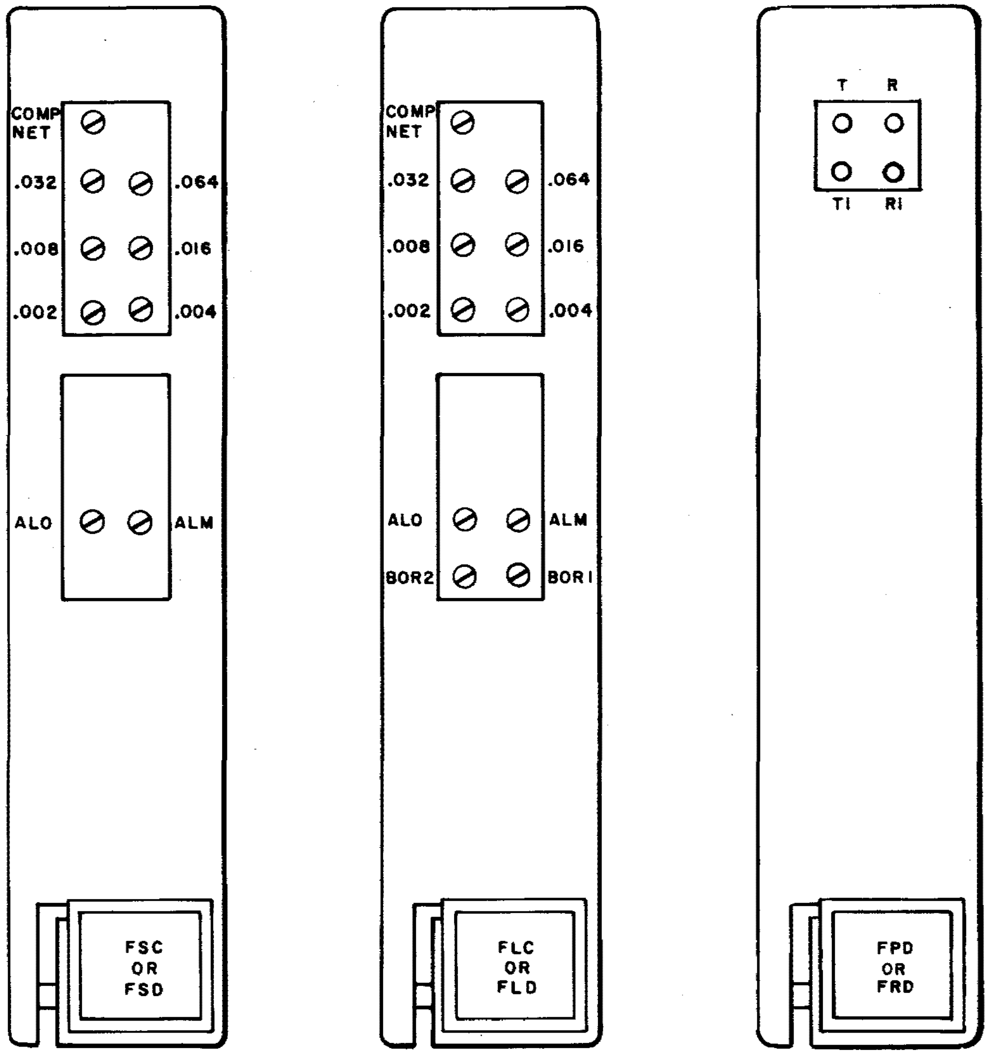


Fig. 5—FSC, FSD, FLC, FLD, FPD, and FRD Unit Faceplates

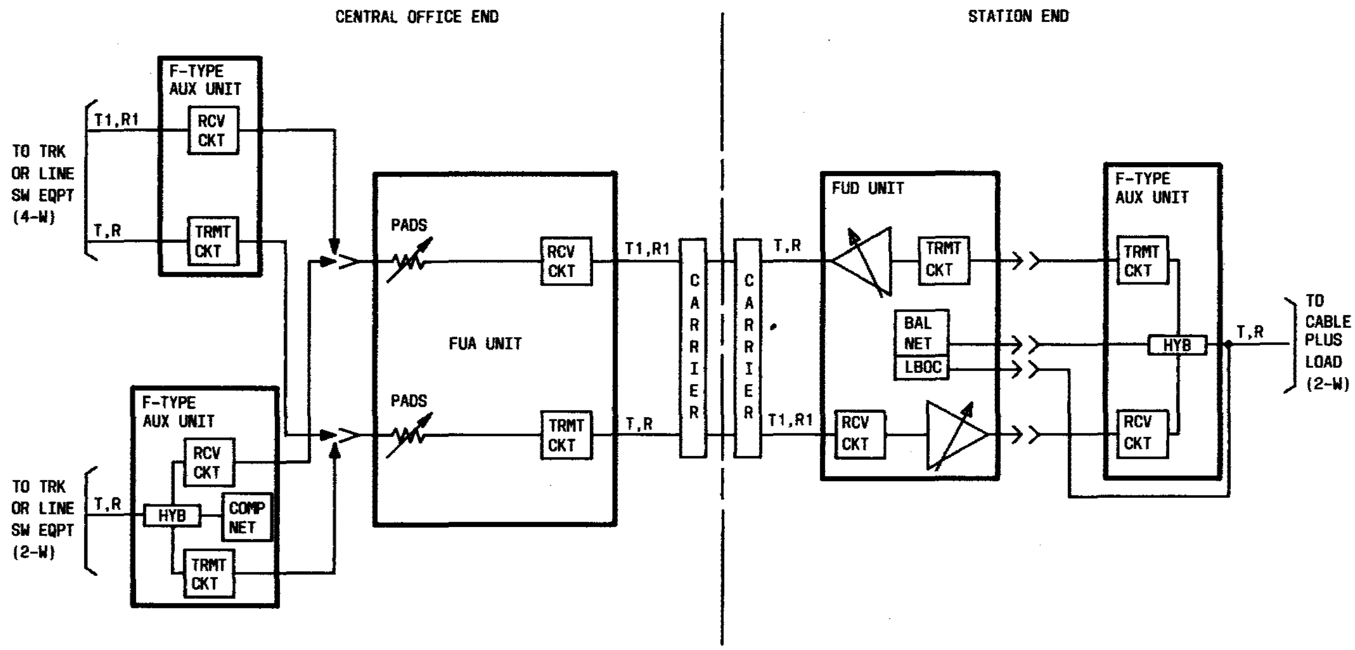
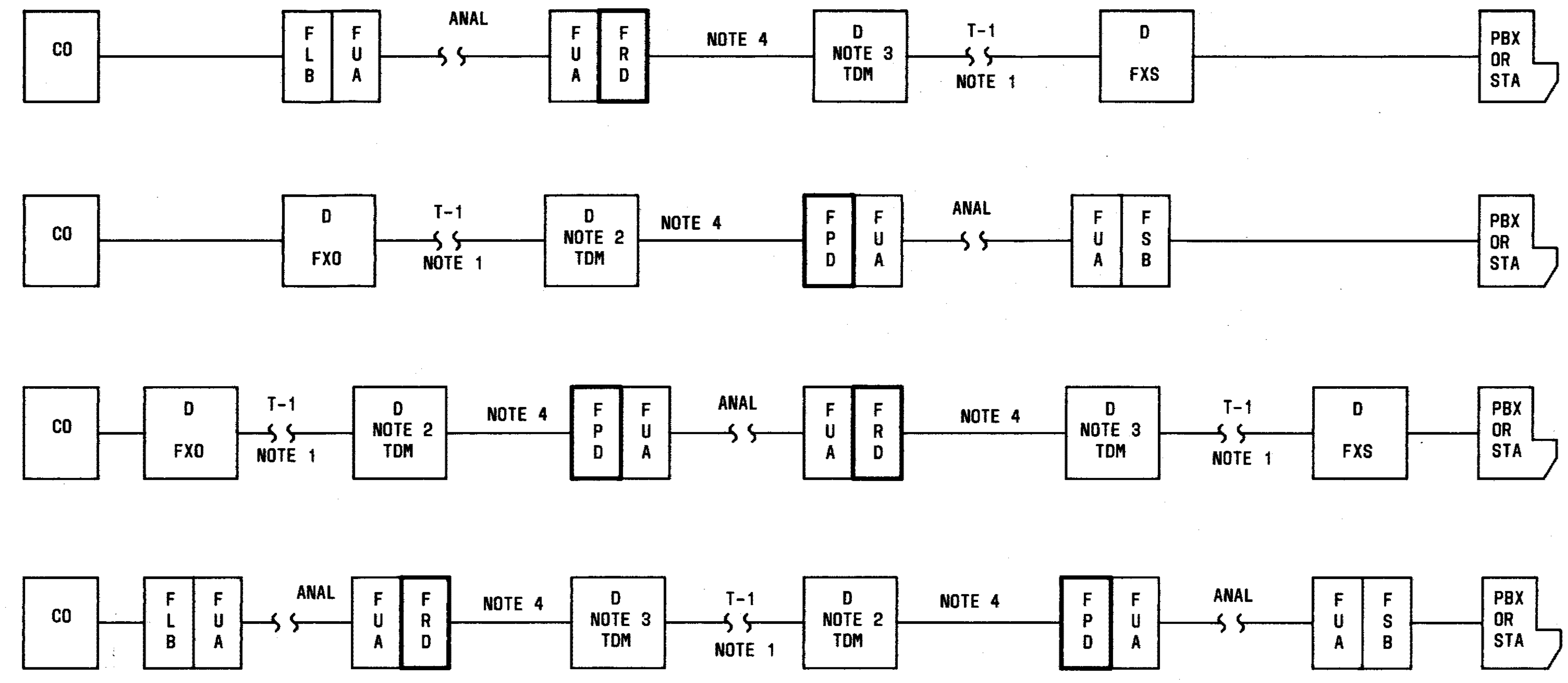


Fig. 6—Simplified Application Schematic of the FUA and FUD Units Plus the Auxiliary Unit



NOTES:
1. T-1 CARRIER MAY BE UP TO 3 LINKS (6-TDM INTERFACES)
2. D1, D3, OR D4 TANDEM CHANNEL UNIT MUST BE SET PER TABLE D WHEN USED IN THIS CONFIGURATION (SEE NOTE 1 OF TABLE D)
3. D1, D3, OR D4 TANDEM CHANNEL UNIT MUST BE SET PER TABLE E WHEN USED IN THIS CONFIGURATION (SEE NOTE 1 OF TABLE E)
4. DISTANCE BETWEEN FPD AND/OR FRD TANDEM AUXILIARY UNIT AND D1, D3, OR D4 TANDEM CHANNEL UNIT MUST BE NO GREATER THAN 2000 FEET

Fig. 7—Illustration Showing Different Configurations of T1 and Analog Carriers Using FPD and/or FRD Tandem Auxiliary Units

TABLE A

TYPE F AUXILIARY SIGNALING UNITS GENERAL INFORMATION AND APPLICATION

CODE	FUNCTIONAL DESCRIPTION	GENERAL APPLICATION	SPECIFIC USE	TYPE E SF UNITS REPLACED
FLA	Special Access CO End	Special Access LS or GS	2W-900 ohm	E2L-E2LA E1P + Term. Set
FLB	Special Access CO End	Special Access LS or GS	2W-600 ohm	E1P + Term. Set
FLC	Special Access CO End	Special Access LS	2W-900 ohm	E2L E1P + Term. Set
FLD	Special Access CO End	Special Access LS	2W-600 ohm	—
FPA	Special Access CO End	Special Access LS or GS	4-wire extension	E1P + Type 4182 network
FPD	Special Access at CO End of Tandem Analog and T-1 Carrier	Special Access LS or GS	4W-600 ohm	—
FRA	Special Access Station End	Special Access LS or GS	4-wire extension	E1R + Type 4182 network
FRD	Special Access at Station/PBX End of Tandem Analog and T-1 Carrier	Special Access LS or GS	4W-600 ohm	—
FSA	Special Access Station End	Special Access LS or GS	2W-900 ohm	E2S-E2SA E1R + Term. Set
FSB	Special Access Station End	Special Access LS or GS	2W-600 ohm	E1R + Term. Set
FSC	Special Access Station End	Special Access LS	2W-900 ohm	E2S E1R + Term. Set
FSD	Special Access Station End	Special Access LS	2W-600 ohm	E1R + Term. Set

TABLE B

COMPATIBILITY OF AUXILIARY UNITS WITH E- AND F- TYPE UNITS

AT OR TOWARD CENTRAL OFFICE END	MODE OF OPERATION	AT OR TOWARD CUSTOMER END								
		FRA	FRD	FSA FSB	FA- FB- FWA	E2BK, E2BKA, E3BK, E3BKA, OR E4B	E2S	E2SA	E1R	FSC FSD
FLA & FLB	LS	√	√	√	1, 3	1	√	No	√	√
	GS	√	√	√	No	No	√	√	√	No
FPA	LS	√	√	√	1, 3	1	√	No	√	√
	GS	√	√	√	No	No	√	√	√	No
FPD	LS	√	√	√	No	No	√	No	√	√
	GS	√	√	√	No	No	√	√	√	√
FLC & FLD	LS	√	√	√			√	No	√	√
FA-, FB-, FWA	LS	2, 3	No	2, 3						
	GS	No	No	No						
E2L	LS	√	√	√			√	No	√	√
	GS	√	√	√			√	√	√	No
E2LA	LS	No	No	No						No
	GS	√	√	√						No
E1P	LS	√	√	√			√	No		√
	GS	√	√	√			√	√		No

Note 1: When used with SD-96252-01 DLL Circuit

Note 2: When used with SD-96251-01 DLL Circuit

Note 3: Not a desirable arrangement

TABLE C

MODE OF OPERATION	CONDITION OF TRUNK	FP – AND FL – UNITS †					FR – AND FS – UNITS †				
		CONDITION OF SIG & TRMSN LEADS					CONDITION OF SIG & TRMSN LEADS				
		M LEAD	E LEAD	A & B LOOP	2600-HZ TONE		M LEAD	E LEAD	A & B LOOP	2600-HZ TONE	
					TRMT	RCV				TRMT	RCV
LOOP-START CALL ORIGINATED AT STATION END	Idle	BATT	Open	Open	OFF	ON	GRD	GRD	Open	ON	OFF
	Seizure	BATT	GRD	Closed	OFF	OFF	BATT	GRD	Closed	OFF	OFF
	Pulsing	BATT	Open-GRD	Open-Closed	OFF	ON-OFF	BATT-GRD	GRD	Open-Closed	ON-OFF	OFF
	Talking	BATT	GRD	Closed	OFF	OFF	BATT	GRD	Closed	OFF	OFF
LOOP-START CALL ORIGINATED AT CENTRAL OFFICE END	Idle	BATT	Open	Open	OFF	ON	GRD	GRD	Open	ON	OFF
	Seizure	GRD	Open	Ready for Ringing	ON	ON	GRD	Open	Open	ON	ON
	Ringing	GRD	Open	Open	ON	ON	GRD	Open	Open	ON	ON
	Talking	BATT	GRD	Closed	OFF	OFF	BATT	GRD	Closed	OFF	OFF
GROUND-START CALL ORIGINATED AT STATION END	Idle	—	—	Open	ON	ON	—	—	Open	ON	ON
	Seizure	—	—	B Lead Grounded	ON	OFF	—	—	B Lead Grounded	OFF	ON
	Pulsing	—	—	Open-Closed	ON	ON-OFF	—	—	Open-Closed	ON-OFF	ON
	Talking	—	—	Closed	OFF	OFF	—	—	Closed	OFF	OFF
GROUND-START CALL ORIGINATED AT CENTRAL OFFICE END	Idle	—	—	Open	ON	ON	—	—	Open	ON	ON
	Seizure	—	—	A Lead Grounded	OFF	ON	—	—	Open	ON	OFF
	Ringing	—	—	Open	ON*	ON	—	—	Open	ON	ON*
	Talking	—	—	Closed	OFF	OFF	—	—	Closed	OFF	OFF

* In the GROUND-START mode, during the ringing interval, 2600-Hz tone is interrupted at a 20-pps rate.
† The FLC, FLD, FSC, and FSD units do not have ground-start capabilities.

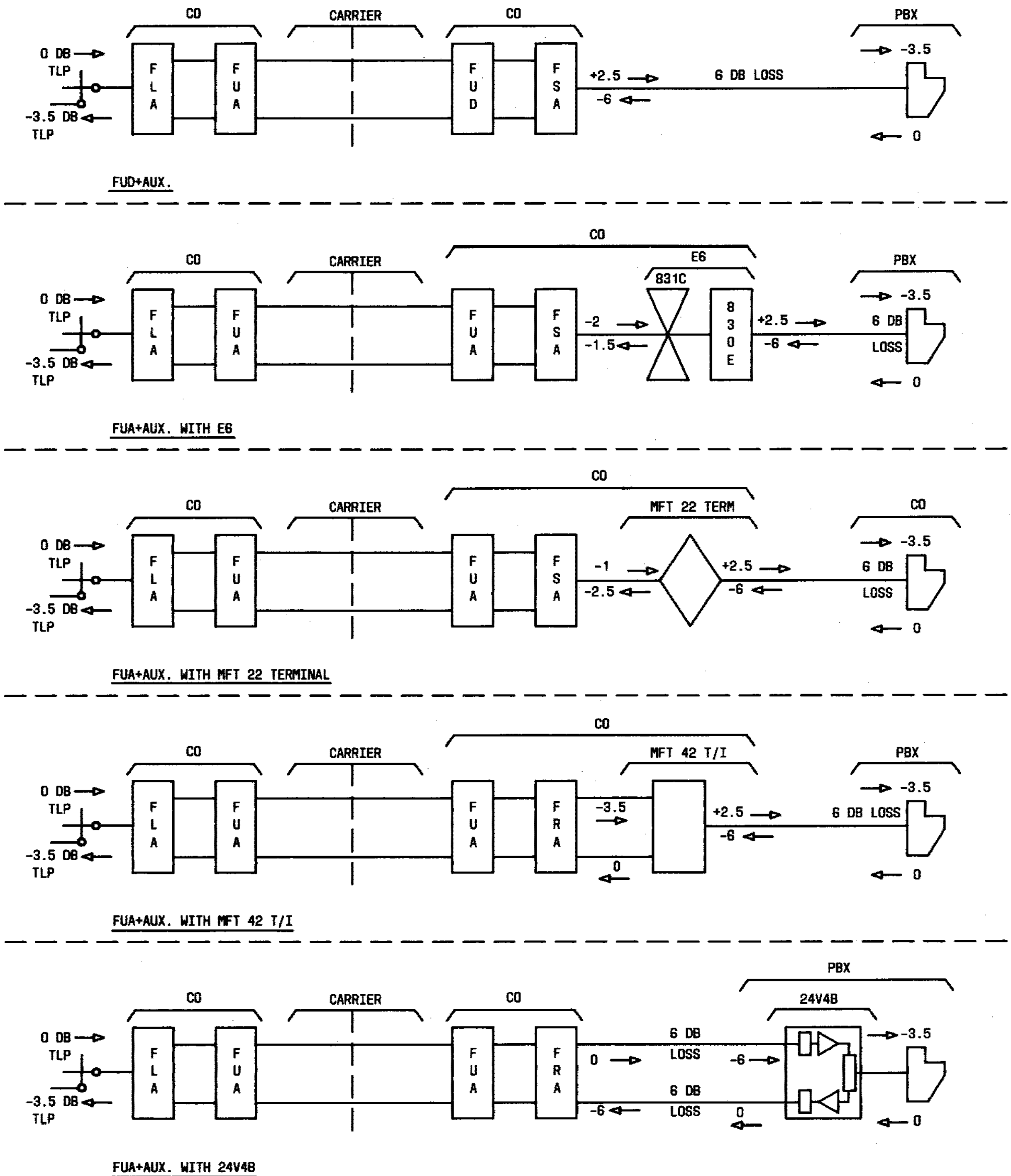


Fig. 8—Typical Circuits Illustrating FUD Plus Auxiliary Versus FUA Plus Auxiliary With External Equipment

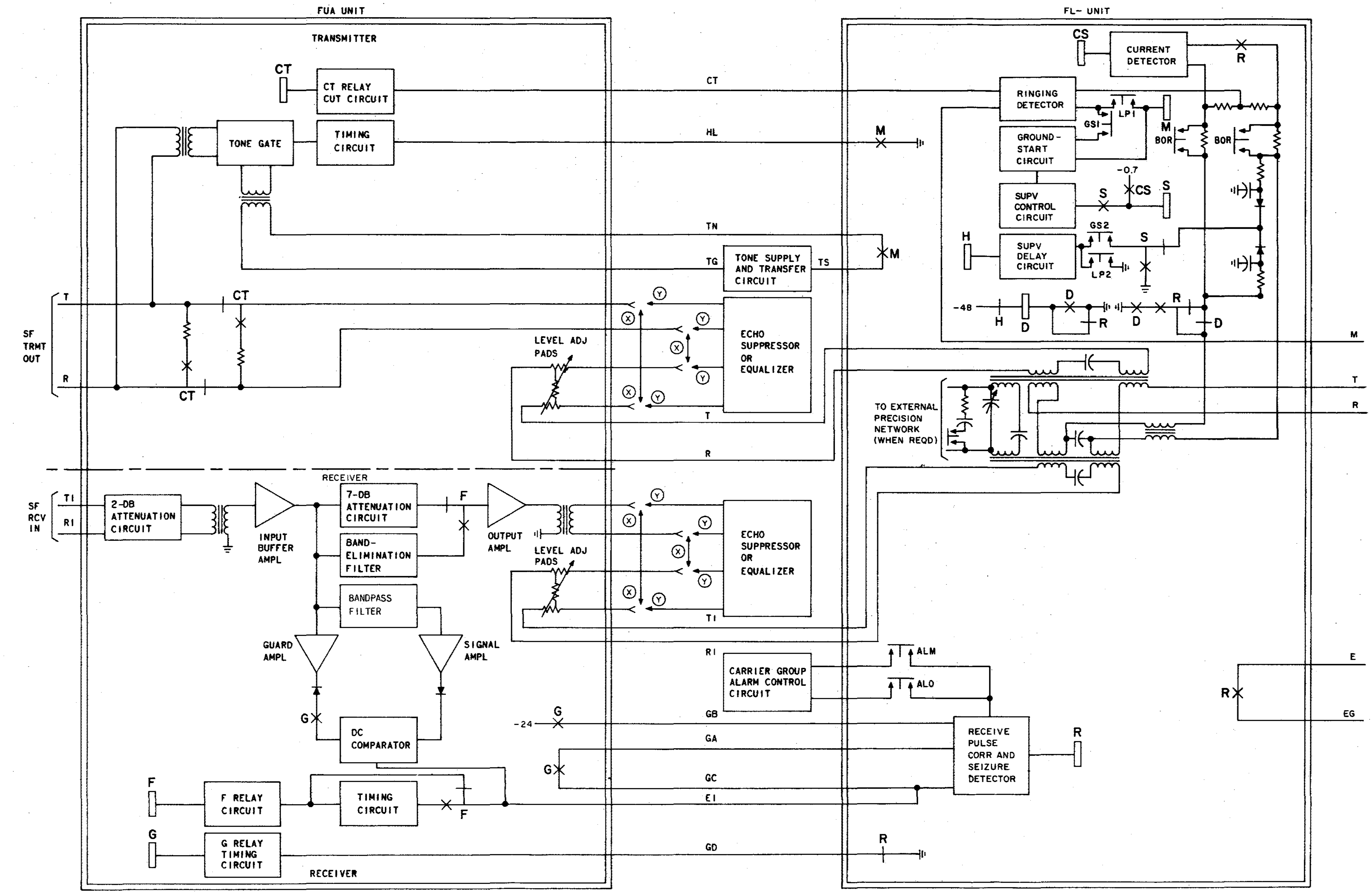


Fig. 9—FUA Plus FL_ Units

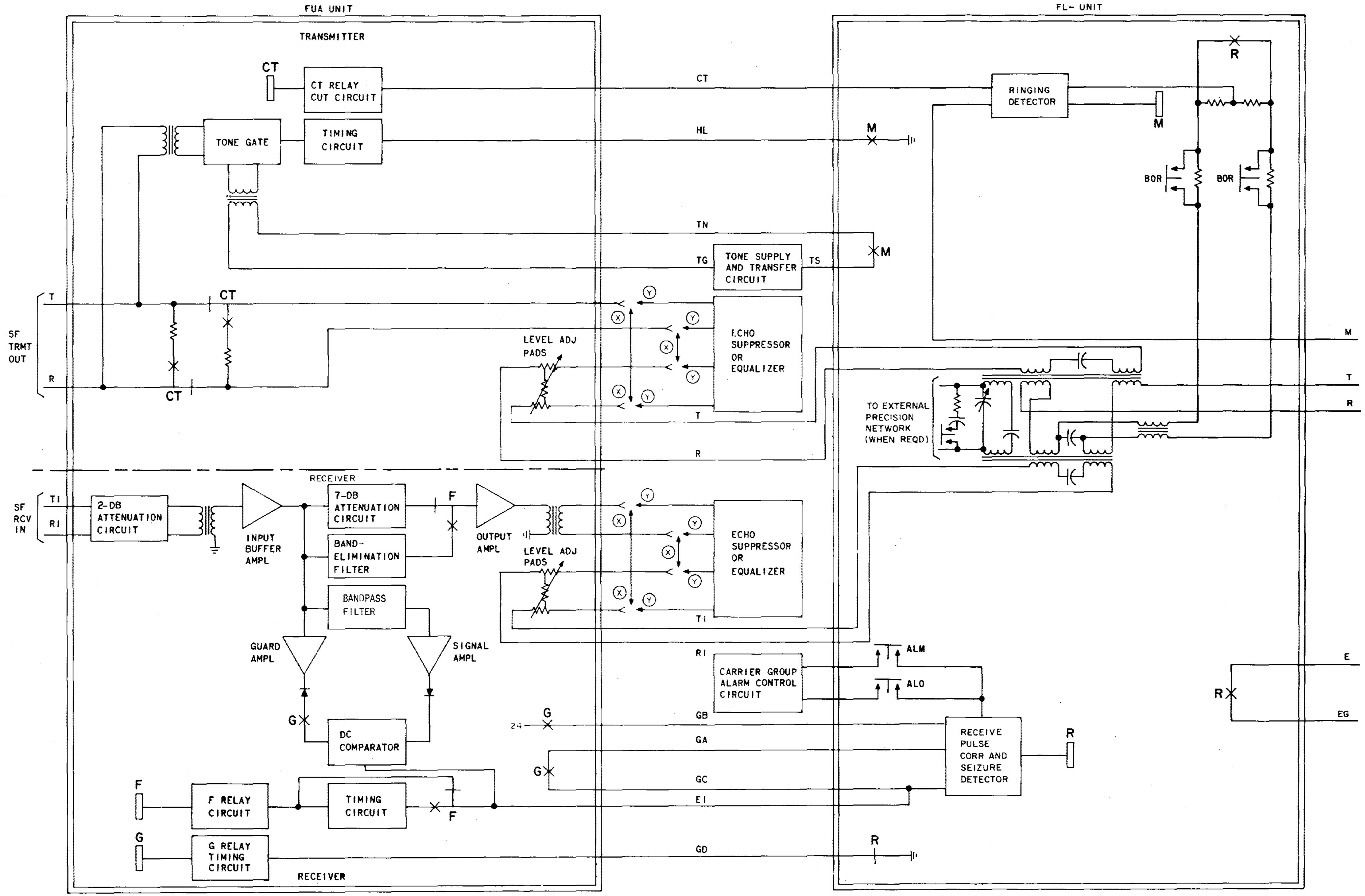


Fig. 10—FUA Plus FLC (or FLD) Units

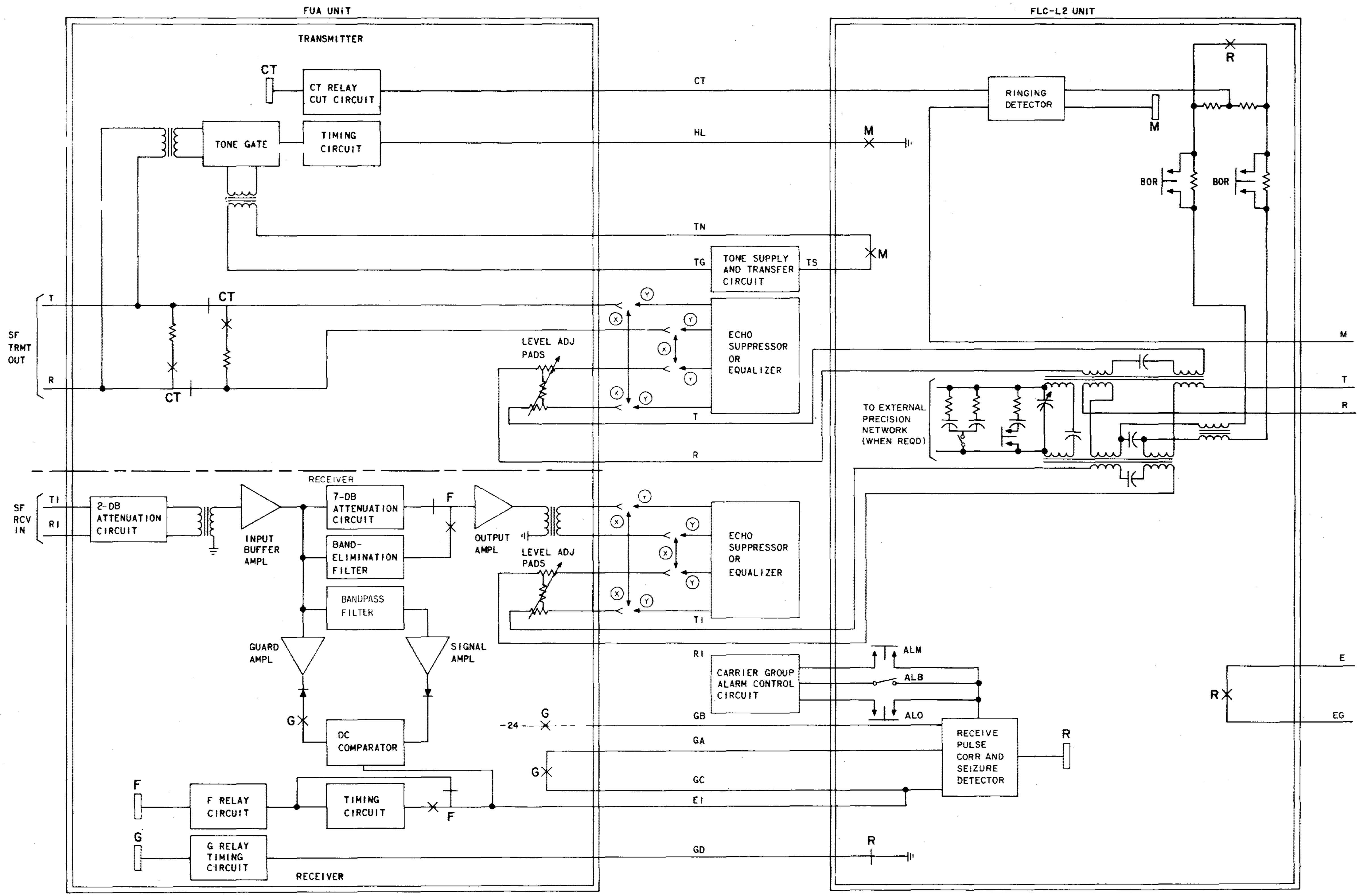


Fig. 11—FUA Plus FLC-L2 Units

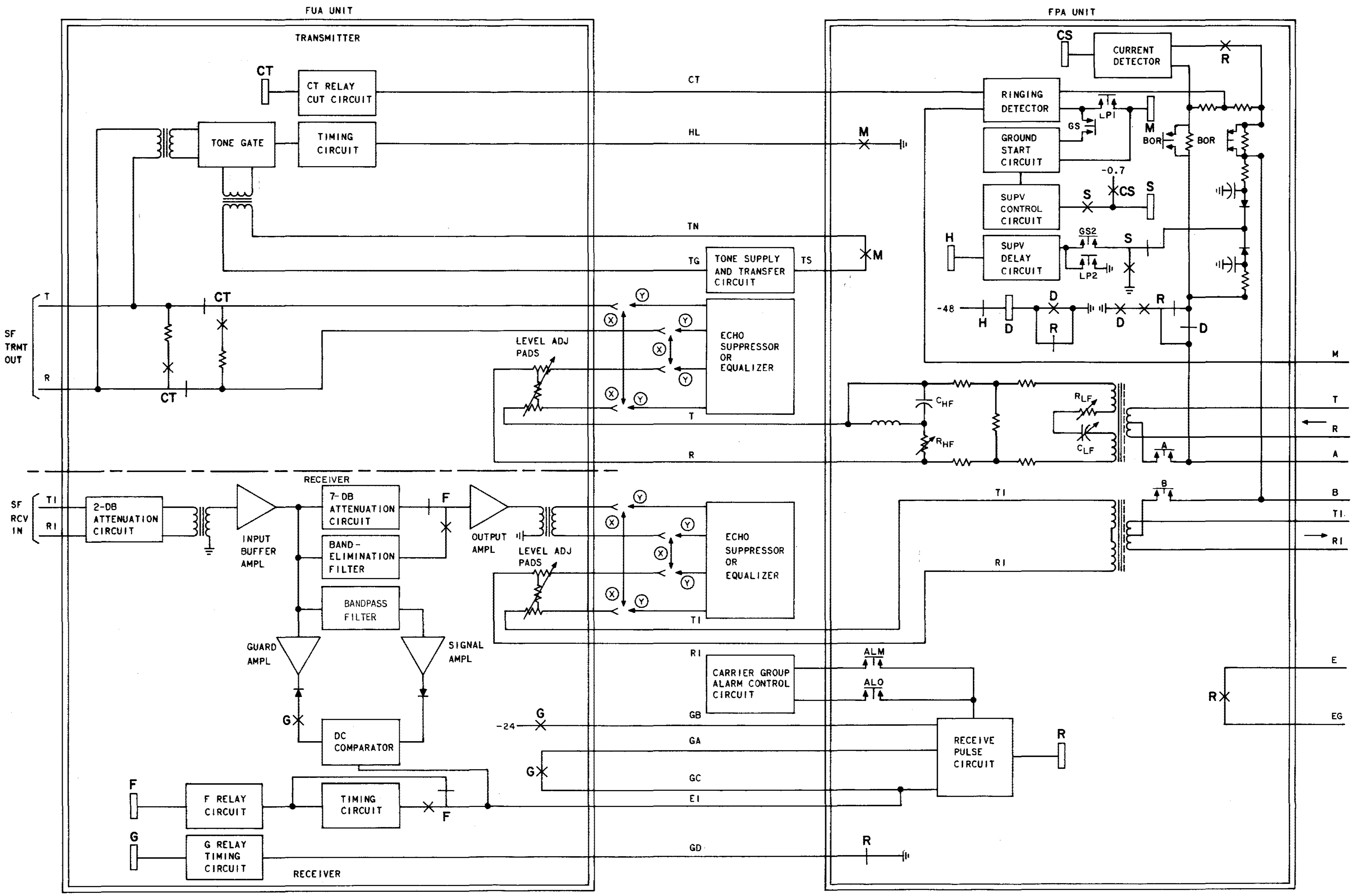


Fig. 12—FUA Plus FPA Units

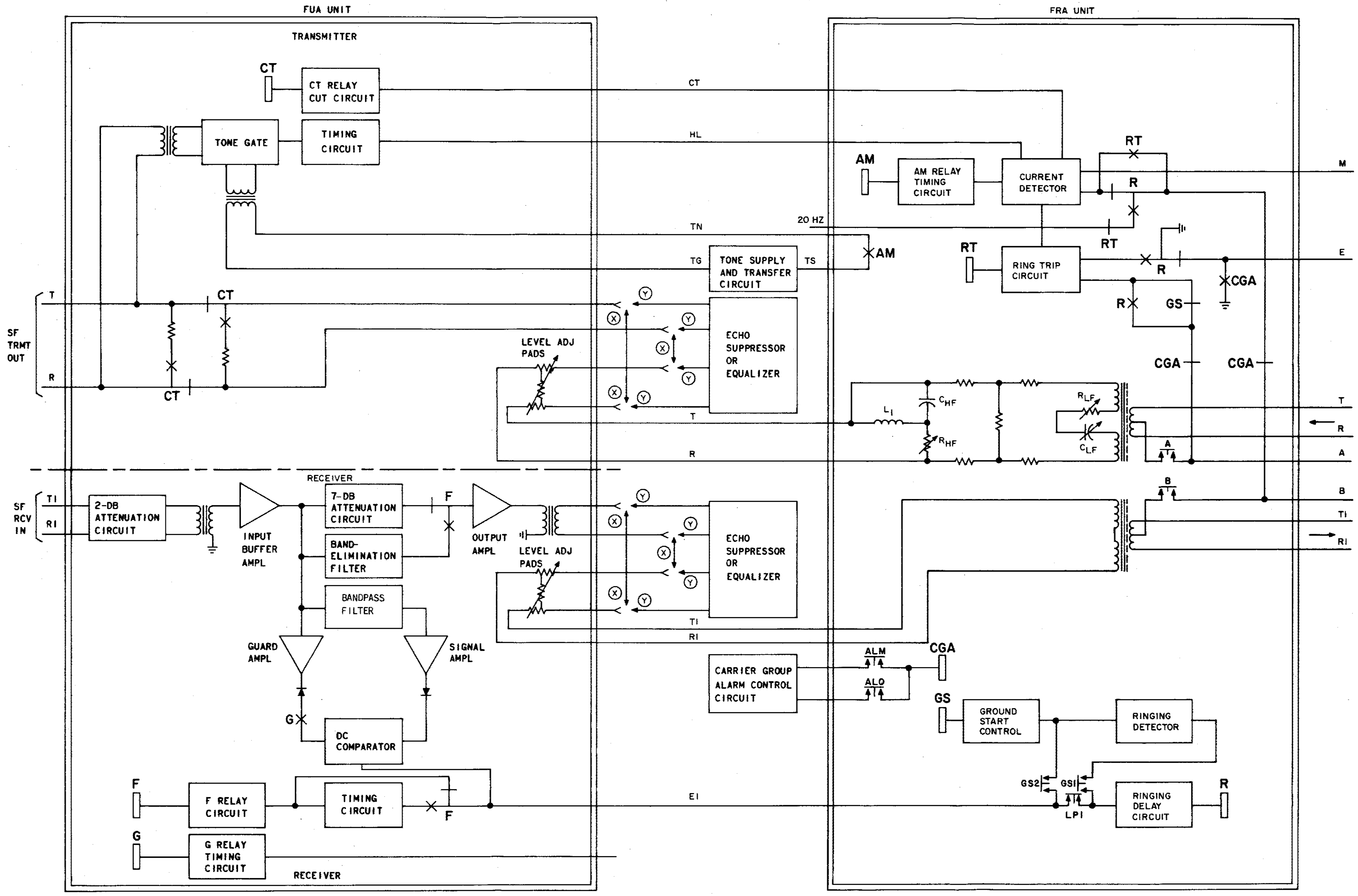


Fig. 13—FUA Plus FRA Units

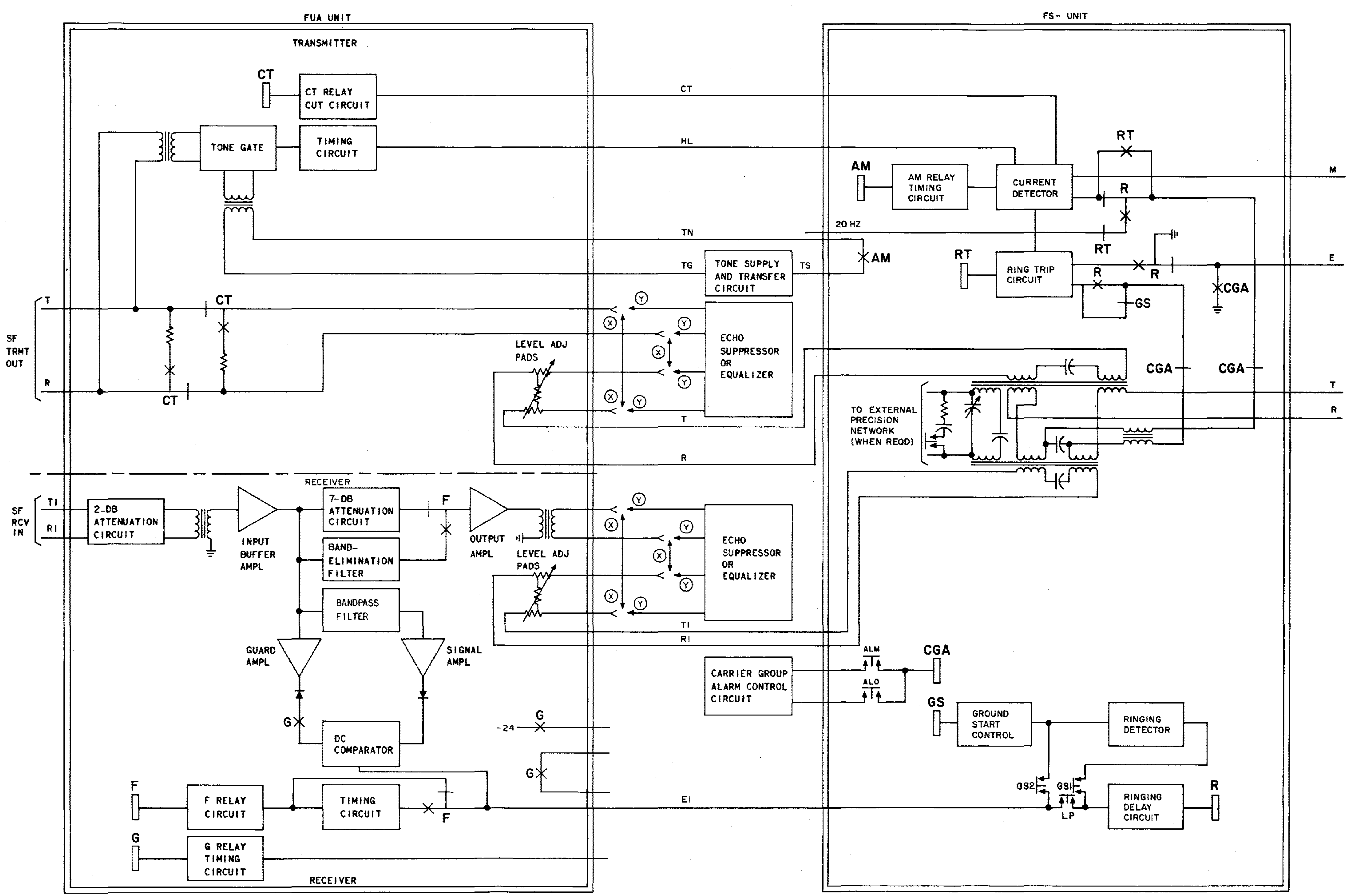


Fig. 14—FUA Plus FS_ Units

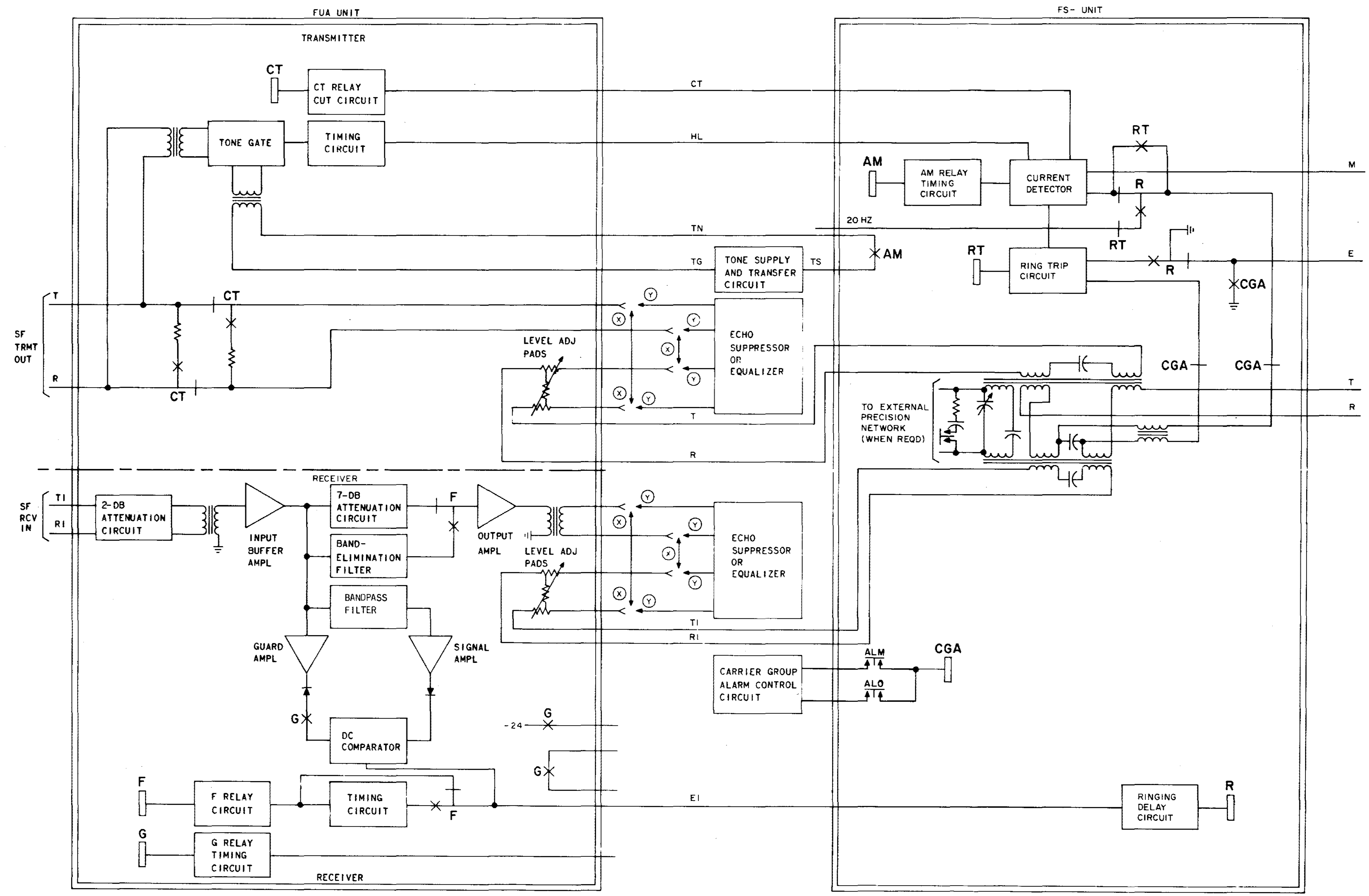


Fig. 15—FUA Plus FSC (or FSD) Units

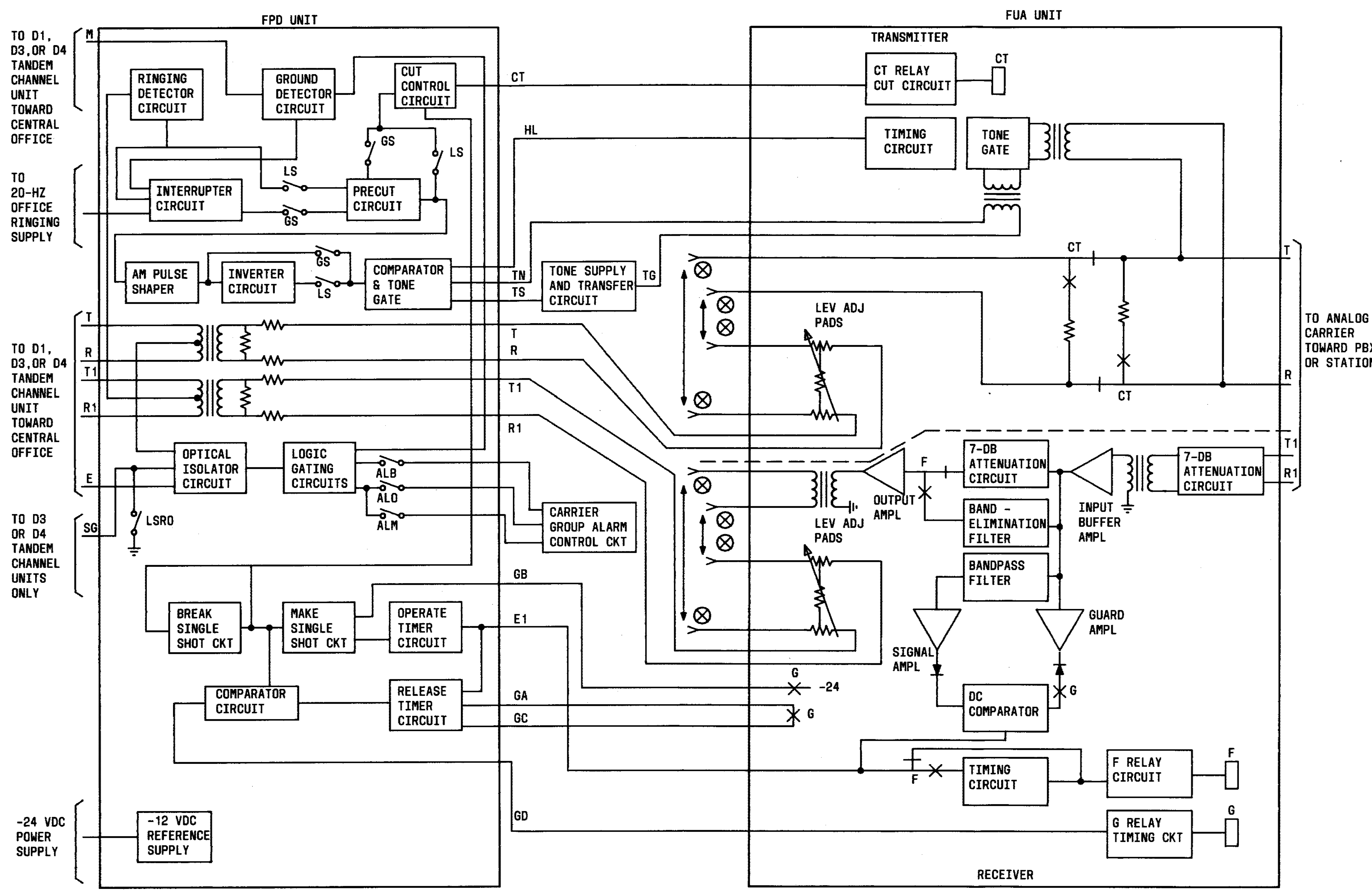


Fig. 16—FUA Plus FPD Units

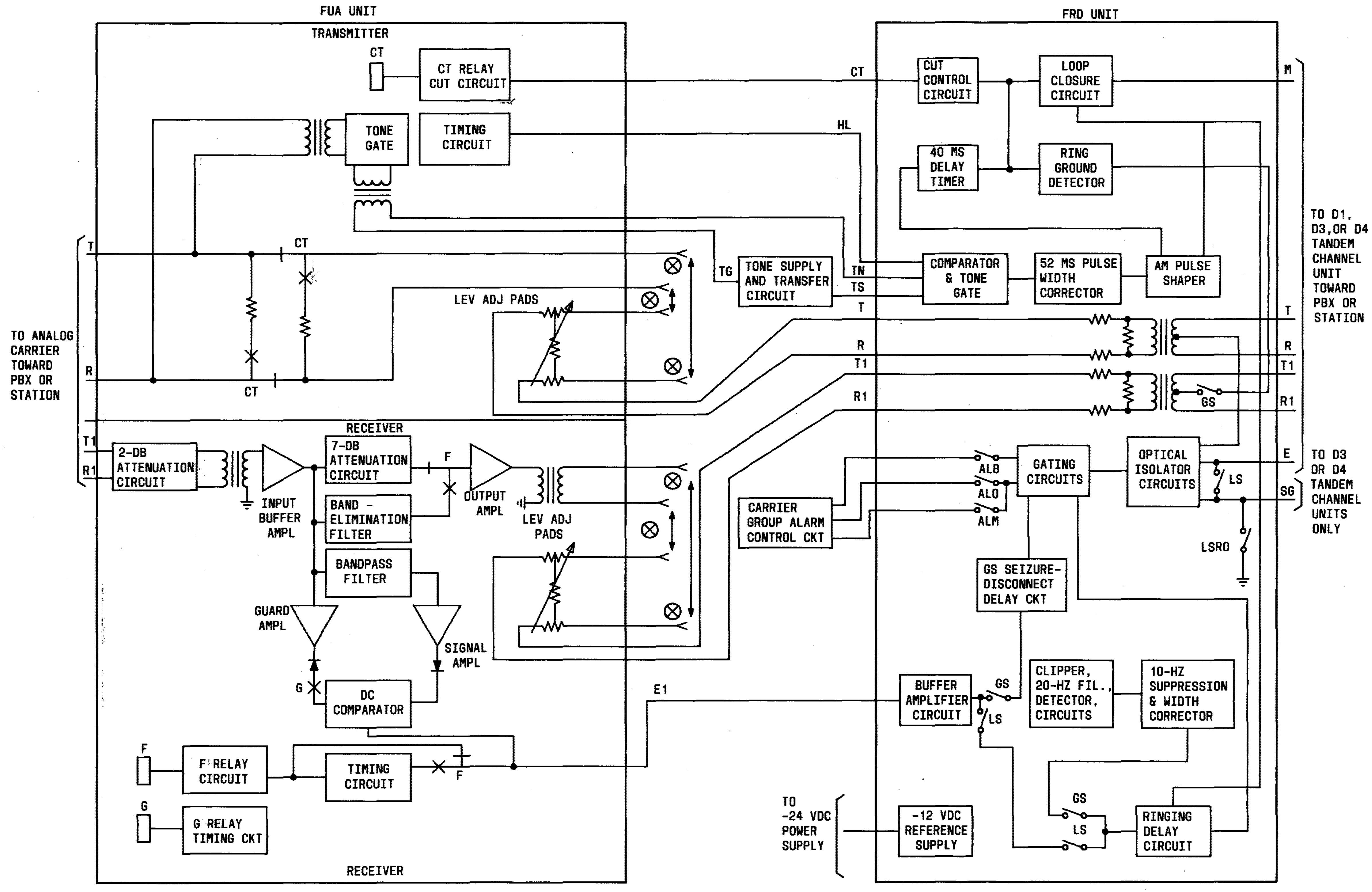


Fig. 17—FUA Plus FRD Units

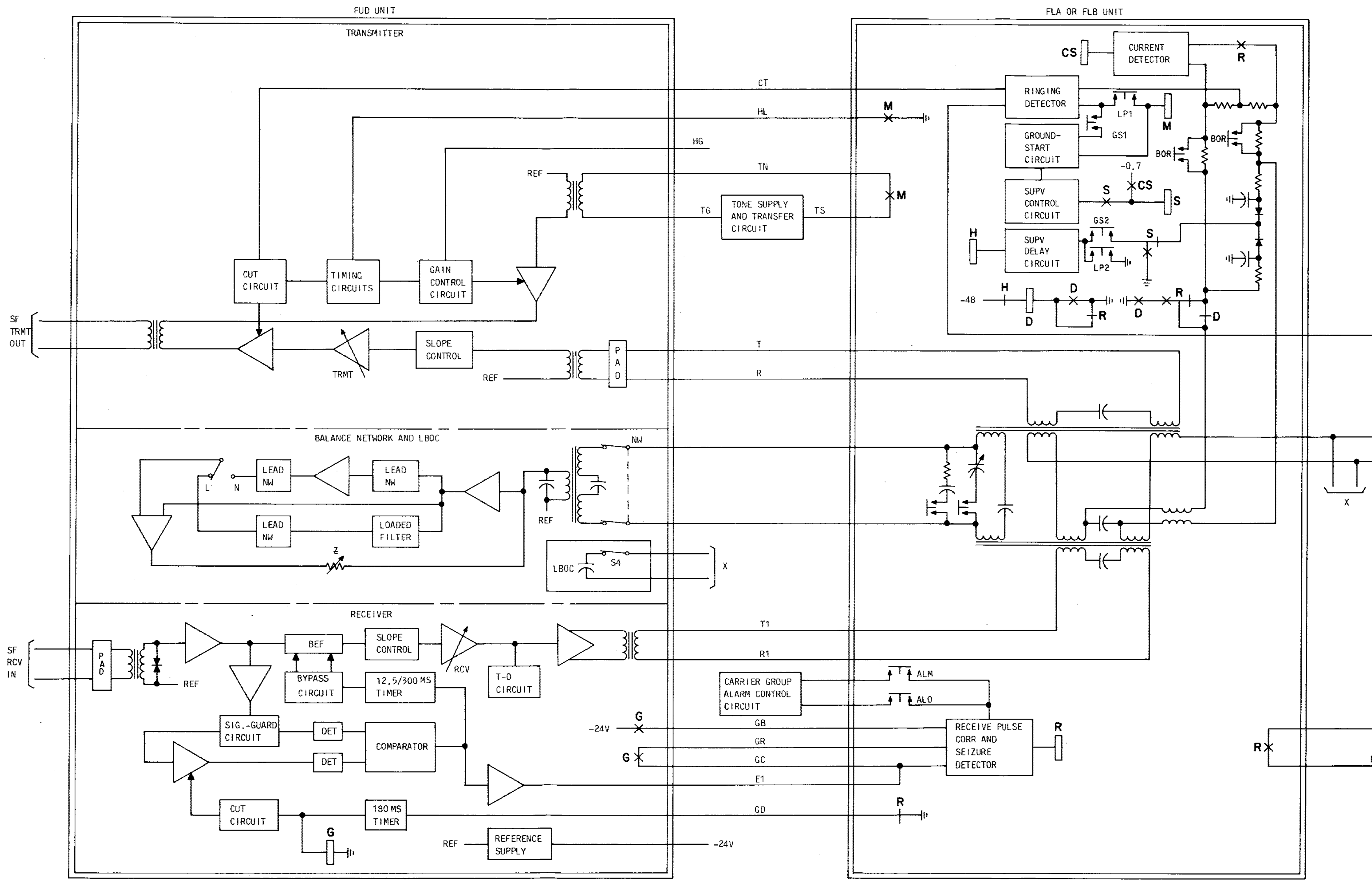


Fig. 18—FUD Plus FLA (or FLB) Units

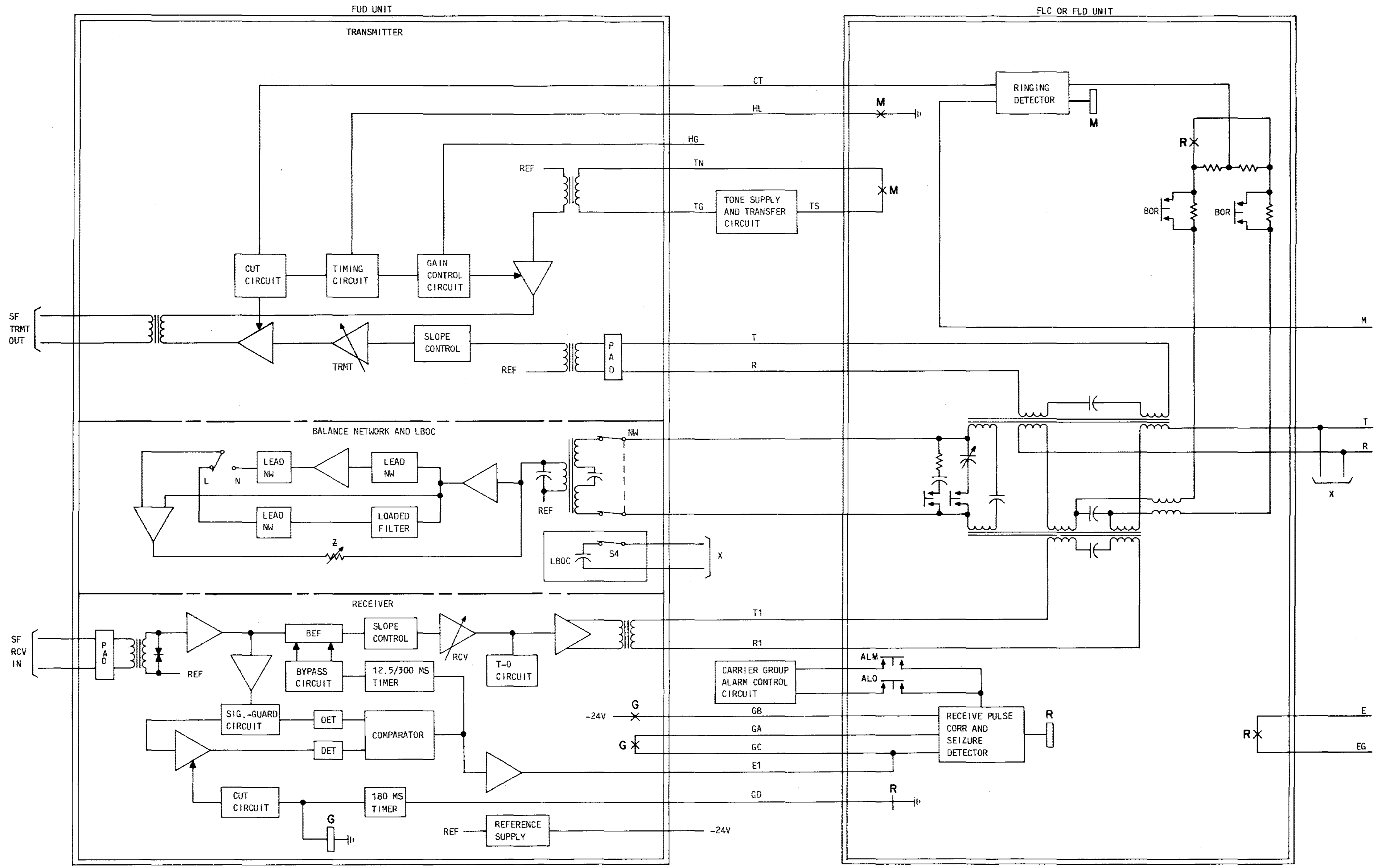


Fig. 19—FUD Plus FLC (or FLD) Units

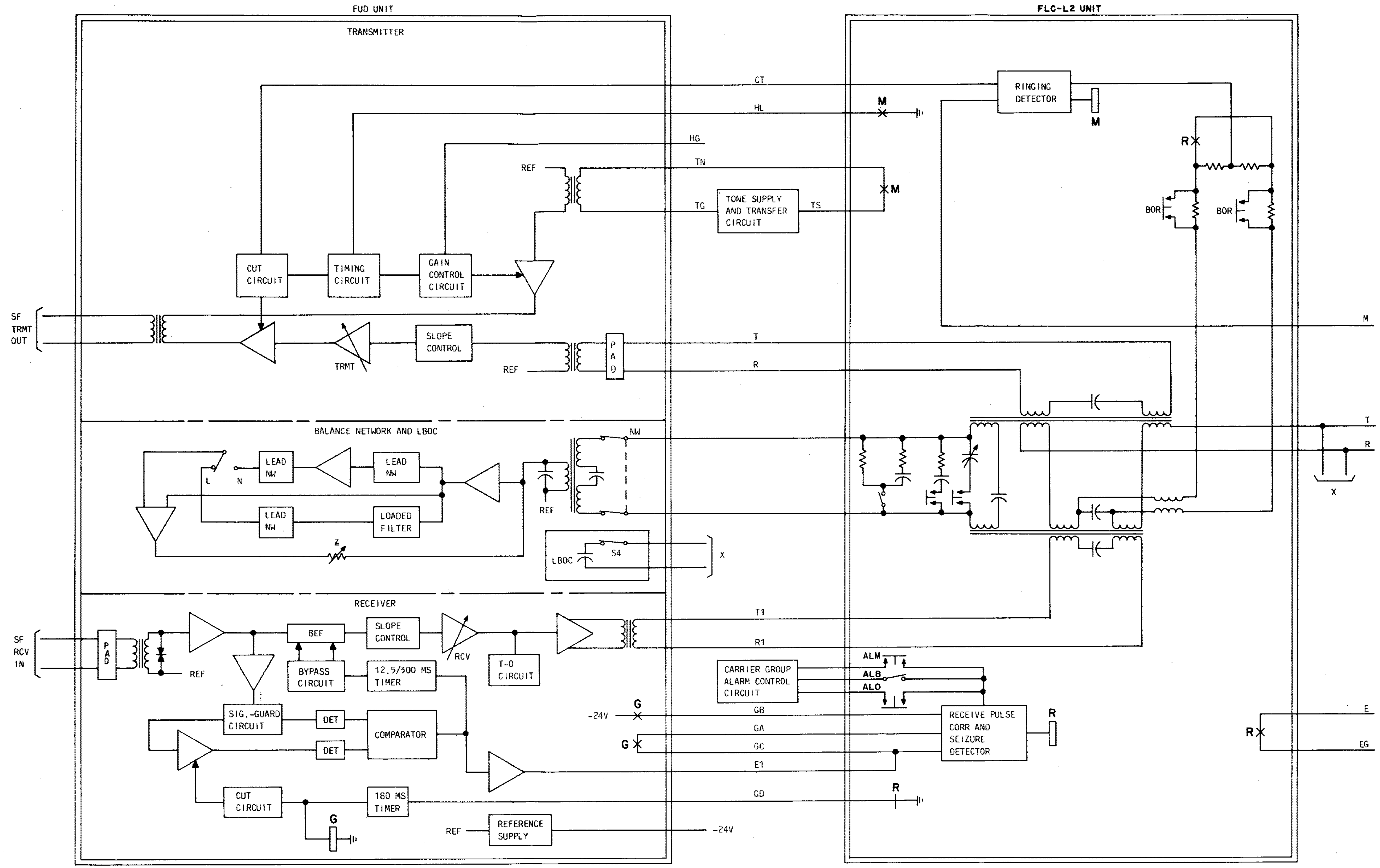


Fig. 20—FUD Plus FLC-L2 Units

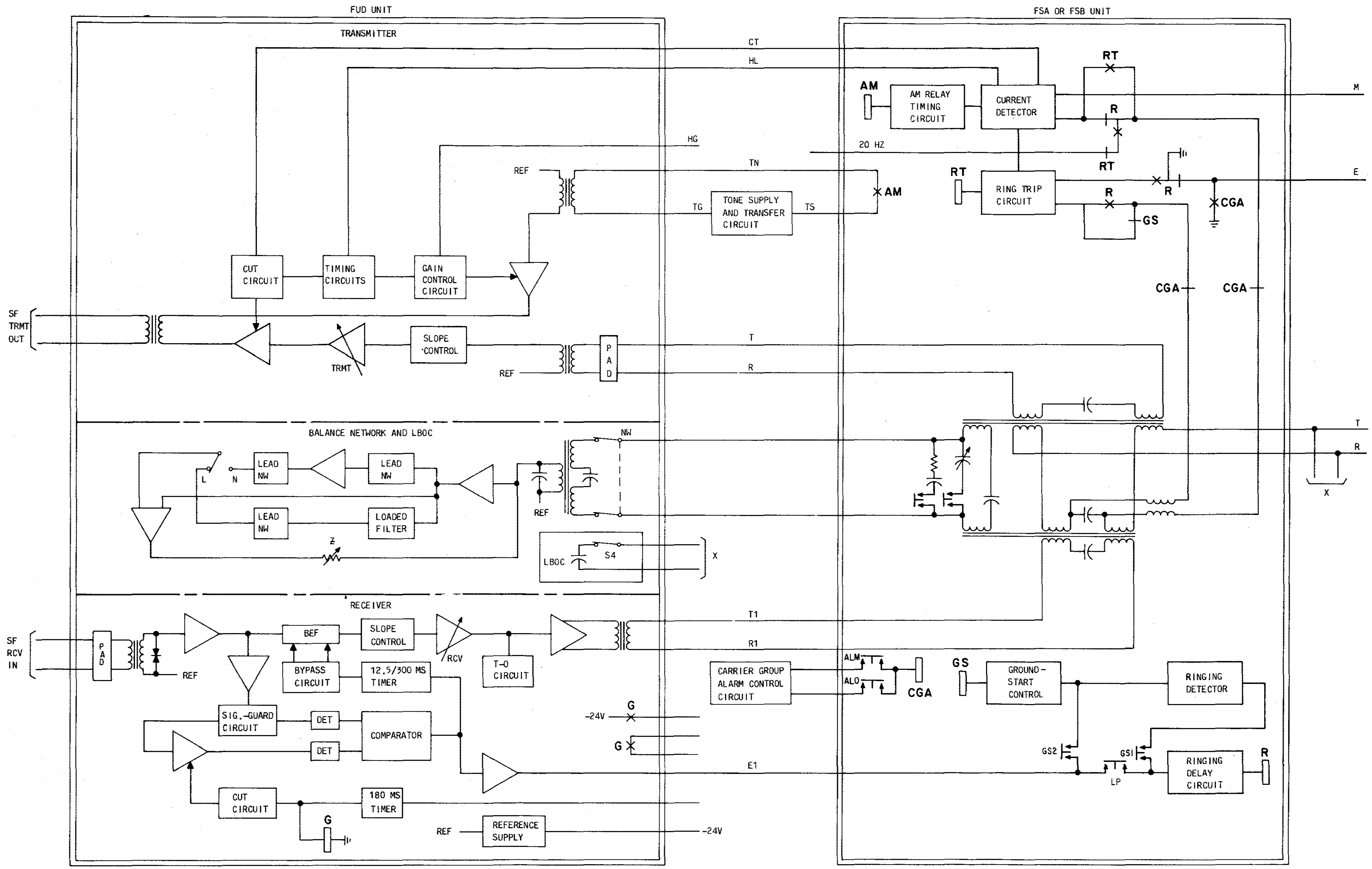


Fig. 21—FUD Plus FSA (or FSB) Units

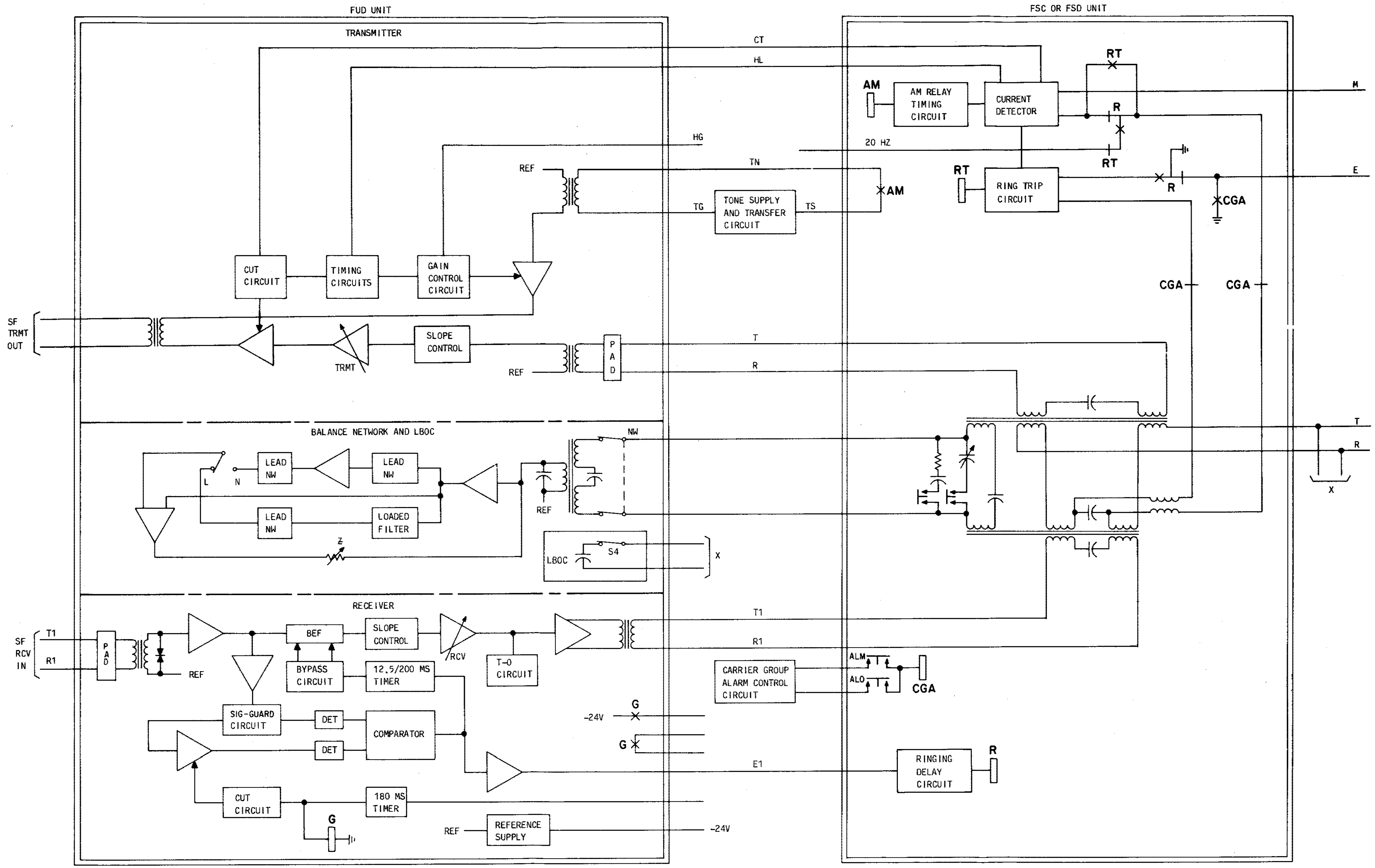


Fig. 22—FUD Plus FSC (or FSD) Units

TABLE D

NOTE 1

OPTION SWITCH	D1 TANDEM		D3 TANDEM		D4 TANDEM	
	OPEN	CLOSED	OPEN	CLOSED	OPEN	CLOSED
Q	√		NA	NA	NA	NA
R	Note 2	Note 2	√		√	
S		√		√		√
T	√		√		√	
V	√			√		√
W	√			√		√
X		√	NA	NA	NA	NA
Y		√		√		√
Z		√	√		√	
E	NA	NA		√		√
EG	NA	NA	NA	NA	(CGA OPTION)	

Note 1: Option switch settings for D tandem units looking through the T-1 carrier toward the serving central office (see Fig. 7, Note 2).

Note 2: Close for D1A — open for D1B and D1D.

TABLE E

NOTE 1

OPTION SWITCH	D1 TANDEM		D3 TANDEM		D4 TANDEM	
	OPEN	CLOSED	OPEN	CLOSED	OPEN	CLOSED
Q	√		NA	NA	NA	NA
R	Note 2	Note 2	√		√	
S	√		√		√	
T		√		√		√
V		√		√		√
W		√		√		√
X	√		NA	NA	NA	NA
Y		√	√		√	
Z		√		√		√
E	NA	NA		√		√
EG	NA	NA	NA	NA	(CGA OPTION)	

Note 1: Option switch settings for D tandem units looking through the T-1 carrier toward the PBX or station (see Fig. 7, Note 3).

Note 2: Close for D1A — open for D1B and D1D.

TABLE F

	TLP BETWEEN FPD OR FRD AND TANDEM CHANNEL UNITS			TLP BETWEEN FPD OR FRD AND FUA UNITS FOR TANDEM CHANNEL UNITS		
	D1	D3	D4	D1	D3	D4
T-R	−1.5	−2.1	−2.1	−3.9	−4.5	−4.5
T1-R1	−3.0	−2.85	−2.85	−0.6	−0.45	−0.45

TABLE G

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FPA AND FRA UNITS FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 19H88 HC								
CABLE LENGTH KILOFEET*		12-42	42-60	60-78	78-96	96-108	108-114	114-150
CABLE LENGTH MILES*		2-8.0	8.0-11.4	11.4-14.8	14.8-18.2	18.2-20.5	20.5-21.6	21.6-28.4
SCREW DESIGNATION		SCREW SETTINGS						
HF	IN	○	●	●	●	●	●	●
	75	○	●	●	●	●	●	○
	150	○	●	●	○	●	○	●
	300	○	○	●	○	○	●	●
	600	○	●	●	○	○	○	○
	1200	○	○	○	●	●	●	●
	2400	○	●	●	●	●	●	●
LF	.25	○	○	○	○	○	○	○
	.50	○	○	○	○	○	○	○
	1.00	○	○	○	○	○	○	○
	2.00	○	○	○	○	○	○	○
	250	●	●	●	●	●	●	●
	500	●	●	●	●	●	●	●
	1000	●	●	●	●	●	●	●
	2000	●	●	●	●	●	●	●
HF TOTAL RES. (OHMS)		∞	1500	1200	1050	900	750	675
LF TOTAL CAP. (UF)		0	0	0	0	0	0	0
LF TOTAL RES. (OHMS)		0	0	0	0	0	0	0

* For an exact cable length shown at the top of the table, use the adjustment for the shorter lengths.
Example: For 60 kilofeet, use the adjustment for the range 42–60 kilofeet.

○ Indicates "screw up" (3 full turns).

● Indicates "screw down".

TABLE H

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FPA AND FRA UNITS FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 22H88						
CABLE LENGTH KILOFEET*		12-18	18-24	24-60	60-90	90-108
CABLE LENGTH MILES*		2-3.4	3.4-4.5	4.5-11.4	11.4-17.0	17.0-20.5
SCREW DESIGNATION		SCREW SETTINGS				
HF	IN	○	●	●	●	●
	75	○	●	●	●	●
	150	○	●	●	●	○
	300	○	●	●	○	○
	600	○	●	●	●	○
	1200	○	○	●	○	●
	2400	○	○	○	●	●
LF	.25	○	●	○	○	●
	.50	○	●	●	○	○
	1.00	○	●	●	○	●
	2.00	○	●	●	●	○
	250	●	●	●	●	●
	500	●	●	●	●	●
	1000	●	○	○	○	●
	2000	●	○	○	○	○
HF TOTAL RES. (OHMS)		∞	3600	2400	1500	1050
LF TOTAL CAP. (UF)		○	3.75	3.50	2.0	1.25
LF TOTAL RES. (OHMS)		○	3000	3000	3000	2000

* For an exact cable length shown at the top of the table, use the adjustment for the shorter lengths.

Example: For 60 kilofeet, use the adjustment for the range 24-60 kilofeet.

○ Indicates "screw up" (3 full turns).

● Indicates "screw down".

TABLE I

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FPA AND FRA UNITS FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 24H88						
CABLE LENGTH KILOFEET*		12-18	18-30	30-42	42-60	60-72
CABLE LENGTH MILES*		2-3.4	3.4-5.7	5.7-8.0	8.0-11.4	11.4-13.6
SCREW DESIGNATION		SCREW SETTINGS				
HF	IN	○	●	●	●	●
	75	○	●	●	●	●
	150	○	●	●	●	●
	300	○	●	●	○	●
	600	○	○	●	●	●
	1200	○	○	●	○	○
	2400	○	○	○	●	●
LF	.25	○	○	○	○	●
	.50	○	●	●	○	●
	1.00	○	●	●	●	○
	2.00	○	○	○	○	○
	250	●	○	●	○	●
	500	●	●	○	○	●
	1000	●	●	●	●	○
	2000	●	●	●	●	●
HF TOTAL RES. (OHMS)		∞	4200	2400	1500	1200
LF TOTAL CAP. (UF)		○	1.5	1.5	1.0	0.75
LF TOTAL RES. (OHMS)		○	250	500	750	1000

* For an exact cable length shown at the top of the table, use the adjustment for the shorter lengths.
  Example: For 42 kilofeet, use the adjustment for the range 30—42 kilofeet.

○ Indicates "screw up" (3 full turns).

● Indicates "screw down".

TABLE J

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FPA AND FRA UNITS FOR CABLE END SECTIONS 1500 TO 4500 FEET

		CABLE GAUGE: 25H88 MAT				
CABLE LENGTH KILOFEET*		10-12	12-18	18-24	24-42	42-60
CABLE LENGTH MILES*		2-2.3	2.3-3.4	3.4-4.5	4.5-8.0	8.0-11.4
SCREW DESIGNATION		SCREW SETTINGS				
HF	IN	○	○	○	○	○
	75	○	○	○	○	○
	150	○	○	○	○	○
	300	○	○	○	○	○
	600	○	○	○	○	○
	1200	○	○	○	○	○
	2400	○	○	○	○	○
LF	.25	○	○	○	●	○
	.50	○	●	○	●	●
	1.00	○	●	●	○	○
	2.00	○	○	○	○	○
	250	●	○	●	●	●
	500	●	●	○	○	○
	1000	●	●	●	●	○
	2000	●	●	●	●	○
HF TOTAL RES. (OHMS)		∞	∞	∞	∞	∞
LF TOTAL CAP. (UF)		○	1.5	1.0	.75	.5
LF TOTAL RES. (OHMS)		○	250	500	1500	3500

* For an exact cable length shown at the top of the table, use the adjustment for the shorter lengths.

Example: For 60 kilofeet, use the adjustment for the range 42-60 kilofeet.

○ Indicates "screw up" (3 full turns).

● Indicates "screw down."

Note: No HF equalization is required for MAT cable.

TABLE K

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FPA AND FRA UNITS FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 26H88							
CABLE LENGTH KILOFEET*		10-12	12-18	18-24	24-30	30-36	36-42
CABLE LENGTH MILES*		2-2.3	2.3-3.4	3.4-4.5	4.5-5.7	5.7-6.8	6.8-8.0
SCREW DESIGNATION		SCREW SETTINGS					
HF	IN	○	●	●	●	●	●
	75	○	○	○	○	○	○
	150	○	○	○	○	○	○
	300	○	○	○	○	○	○
	600	○	○	○	○	○	○
	1200	○	○	○	○	○	○
	2400	○	○	○	○	○	○
LF	.25	○	●	●	●	○	○
	.50	○	●	●	●	●	●
	1.00	○	○	○	○	○	○
	2.00	○	○	○	○	○	○
	250	●	○	●	○	○	●
	500	●	●	○	○	●	●
	1000	●	●	●	●	○	●
	2000	●	●	●	●	●	○
HF TOTAL RES. (OHMS)		∞	4725	4725	4725	4725	4725
LF TOTAL CAP. (UF)		○	0.75	0.75	0.75	0.50	0.50
LF TOTAL RES. (OHMS)		○	250	500	750	1250	2000

* For an exact cable length shown at the top of the table, use the adjustment for the shorter lengths.

Example: For 30 kilofeet, use the adjustment for the range 24--30 kilofeet.

○ Indicates "screw up" (3 full turns).

● Indicates "screw down."

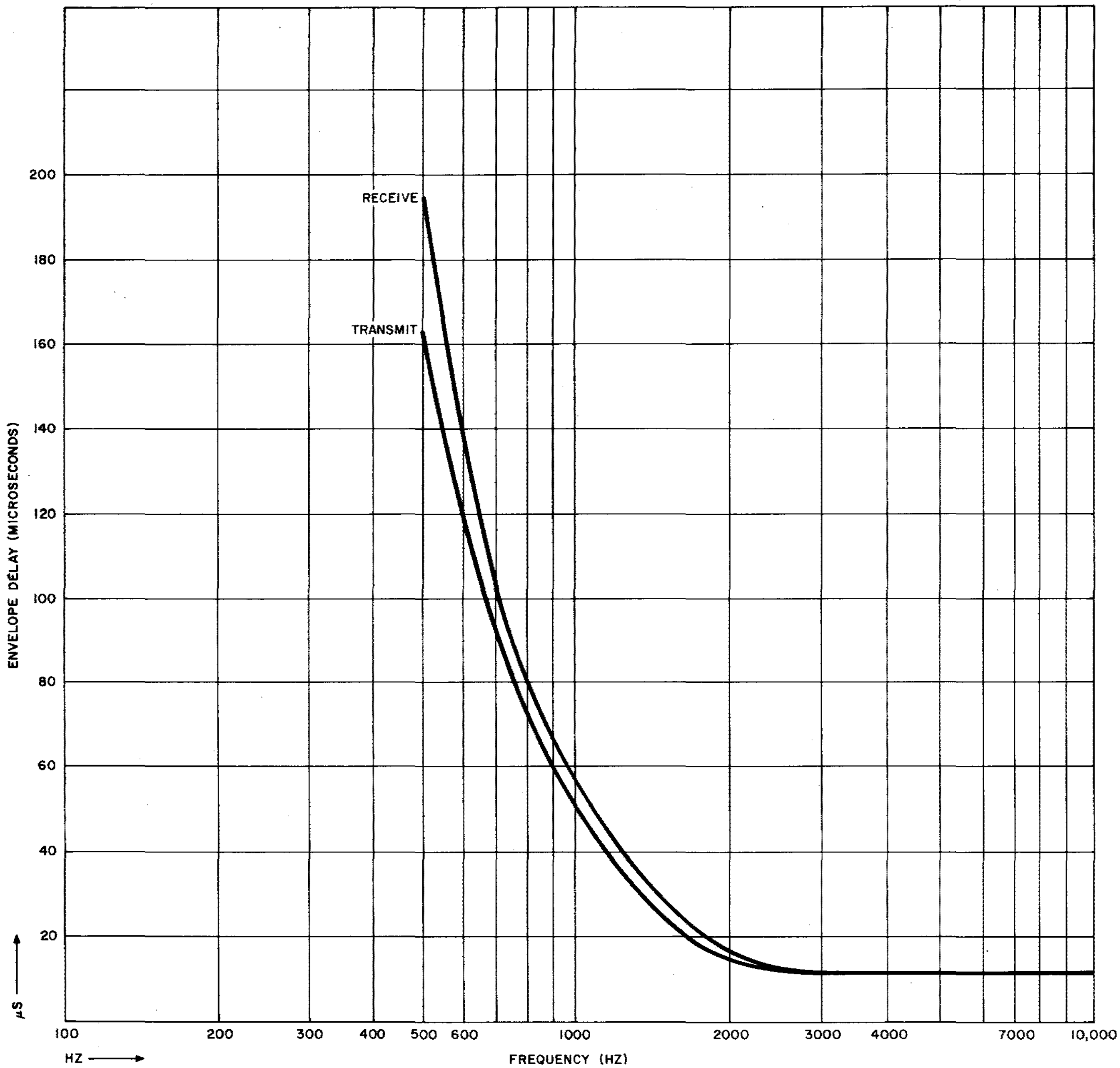


Fig. 23—Nominal Envelope Delay Distortion for the FL_ and FS_ Units

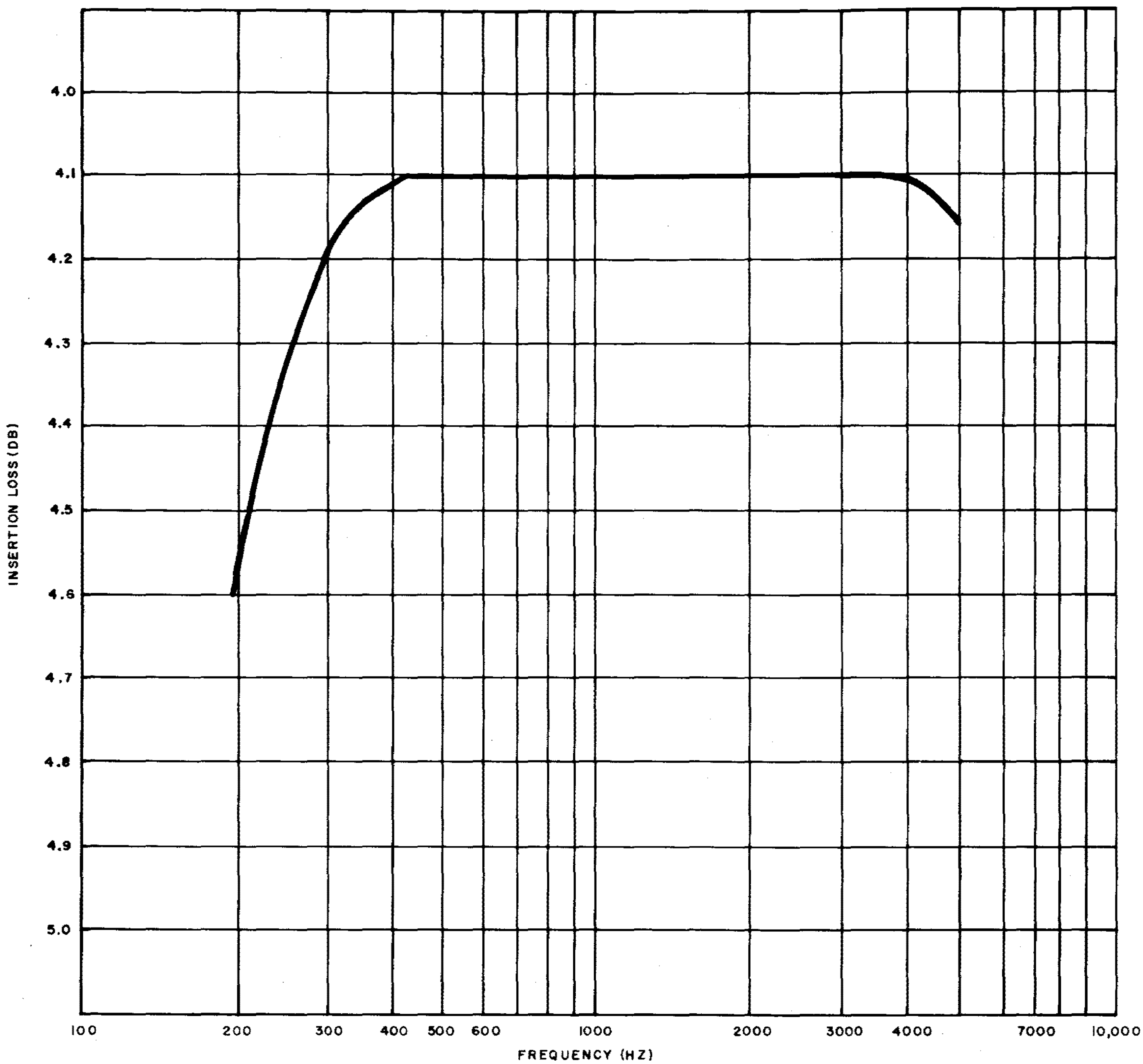


Fig. 24—Nominal Transmit Circuit Insertion Loss for the FLA, FLC, FSA, and FSC Units

Fig. 25—Nominal Transmit Circuit Insertion Loss for the FLB, FLD, FSB, and FSD Units

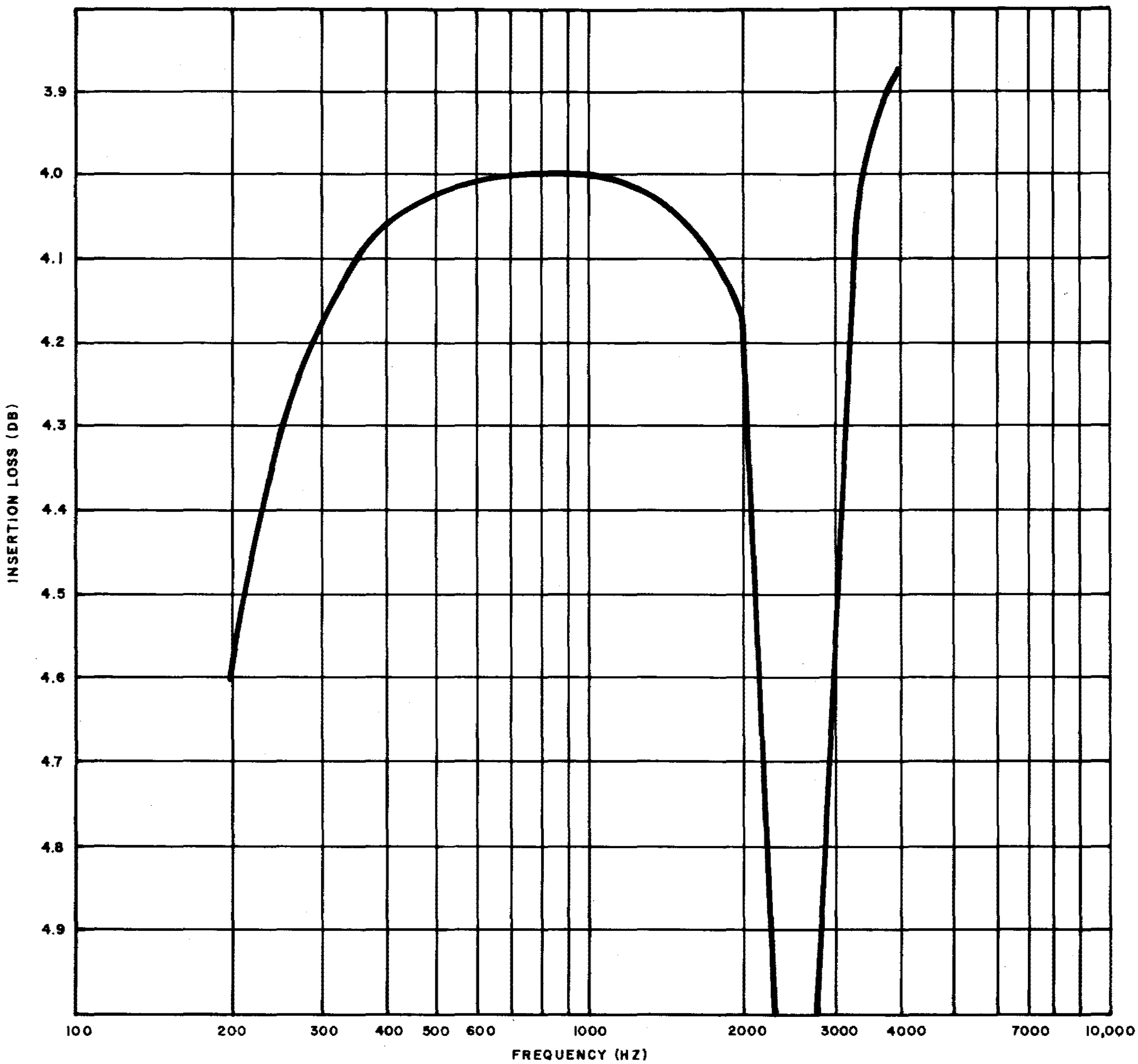


Fig. 26—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter In for the FLA, FLC, FSA, and FSC Units With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz

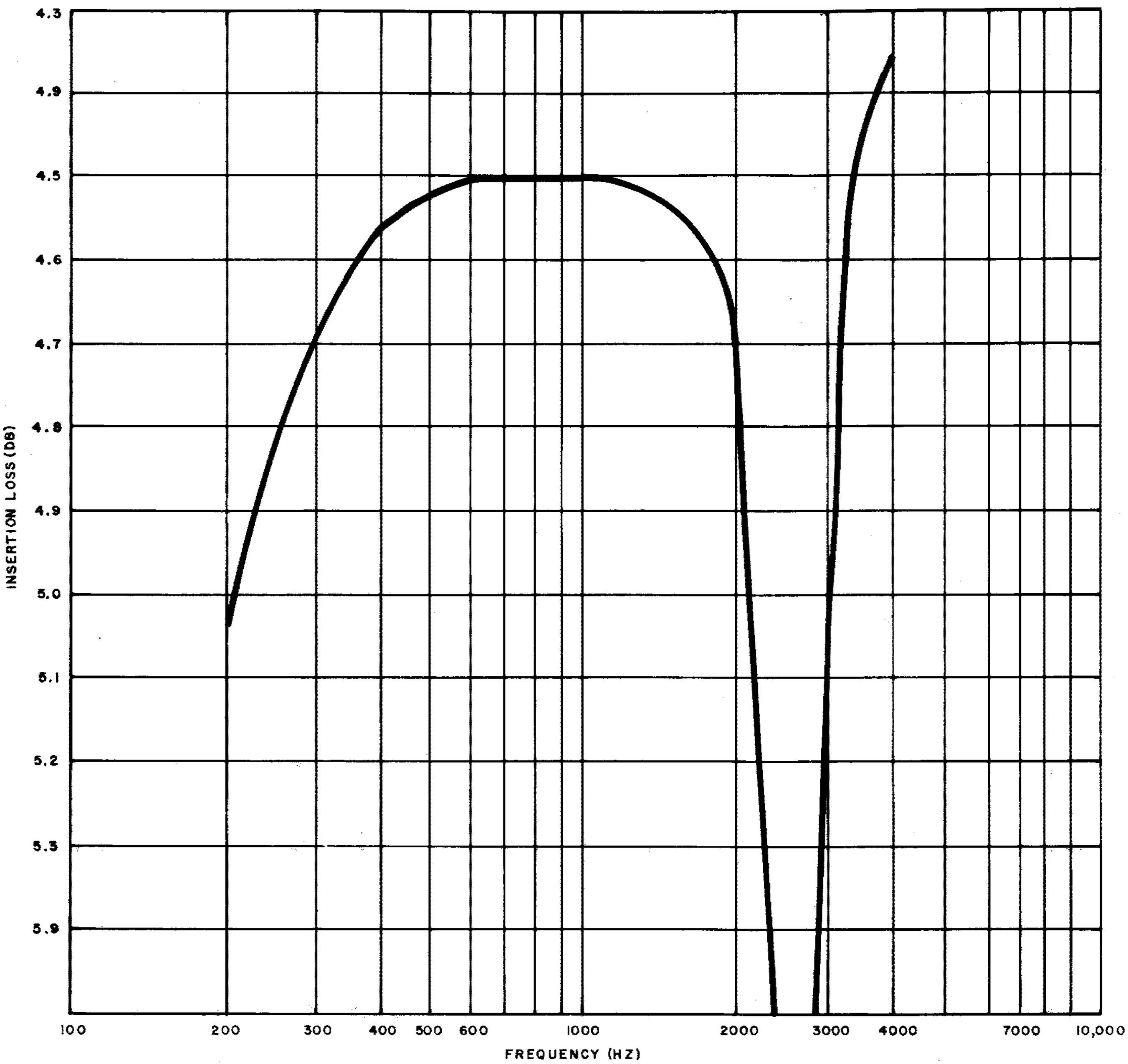


Fig. 27—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter In for the FLB, FLD, FSB, and FSD Units With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz

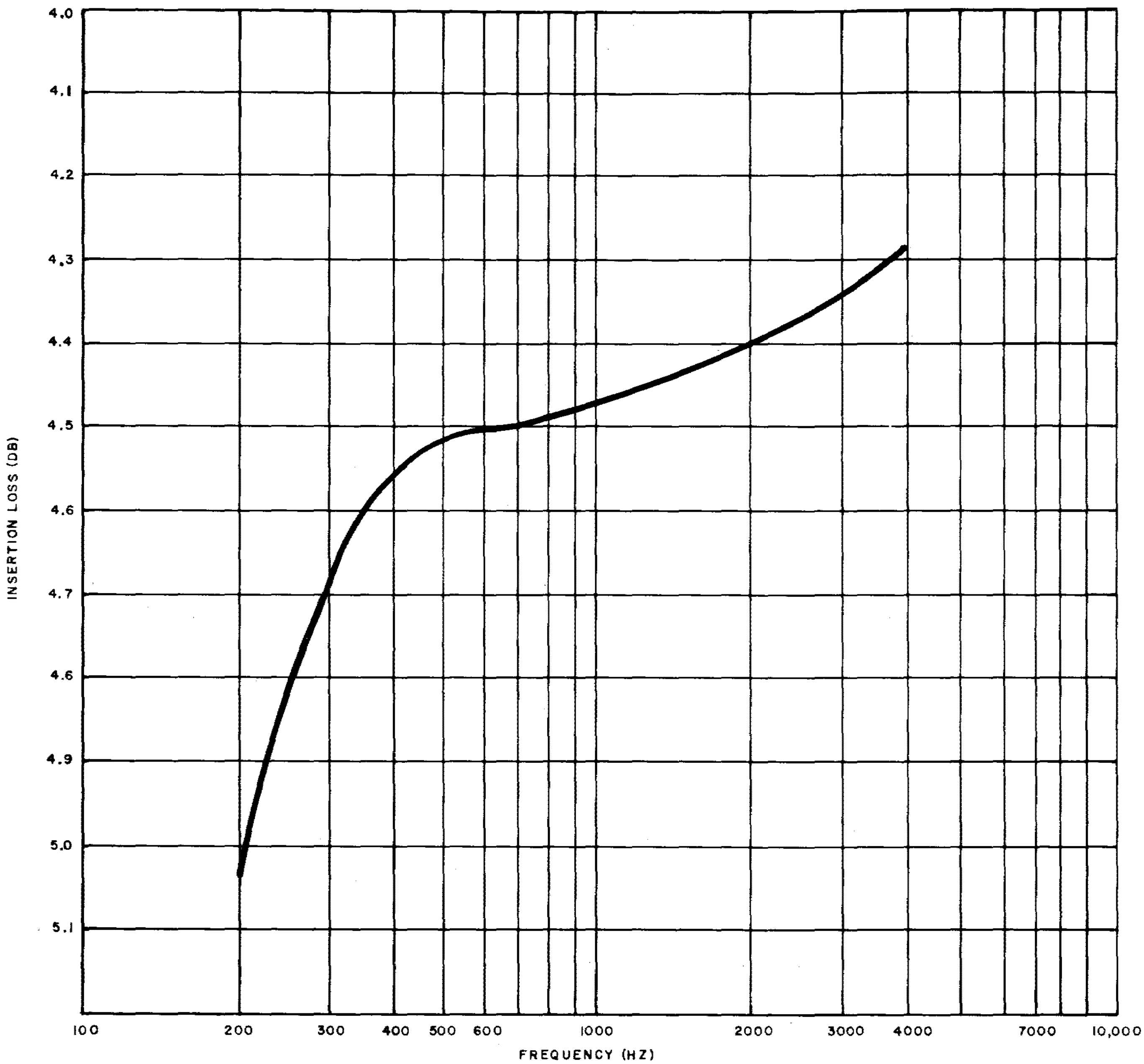


Fig. 28—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter Out for the FLA, FLC, FSA, and FSC Units With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz

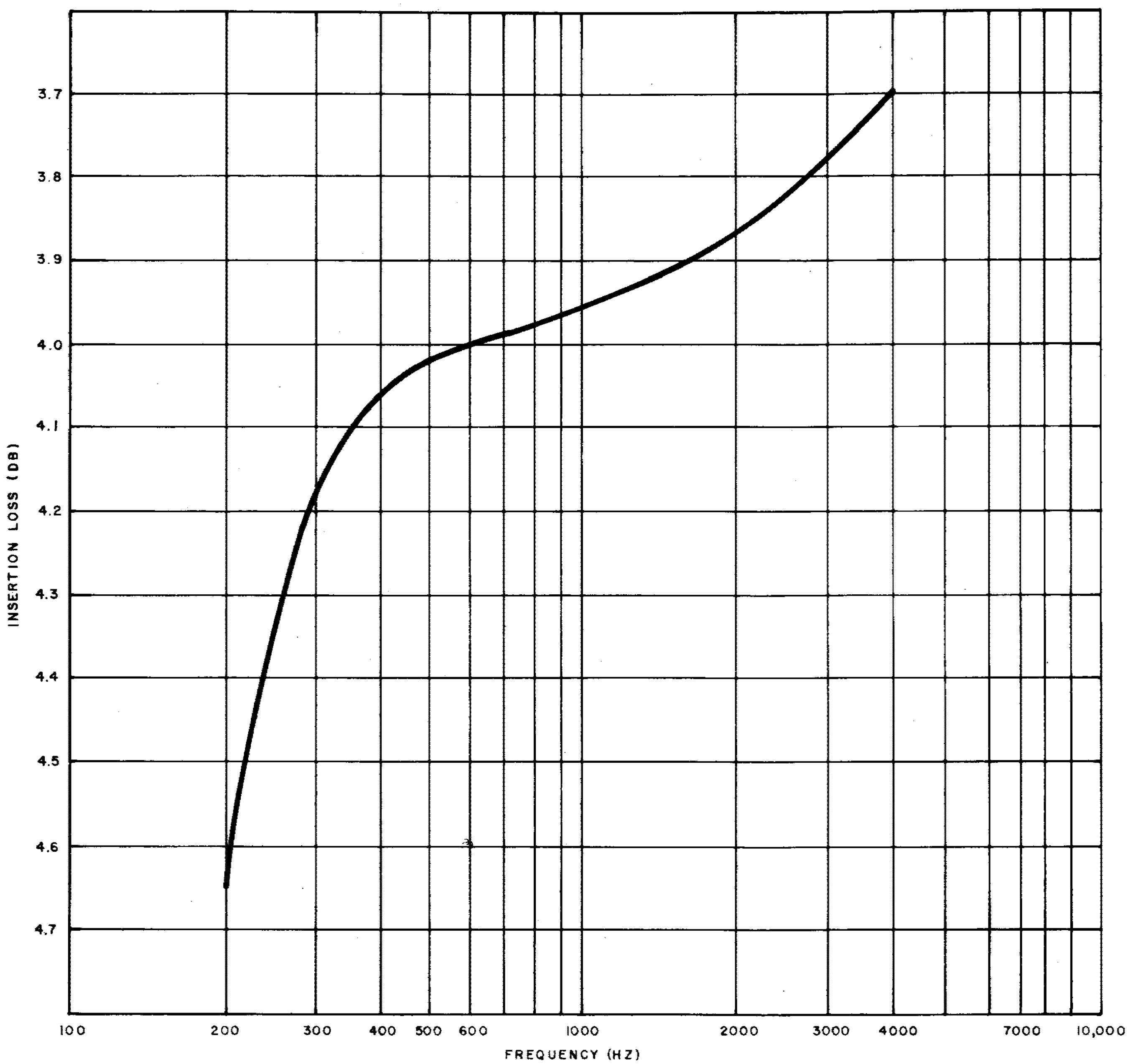


Fig. 29—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter Out for the FLB, FLD, FSB, and FSD Units With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz

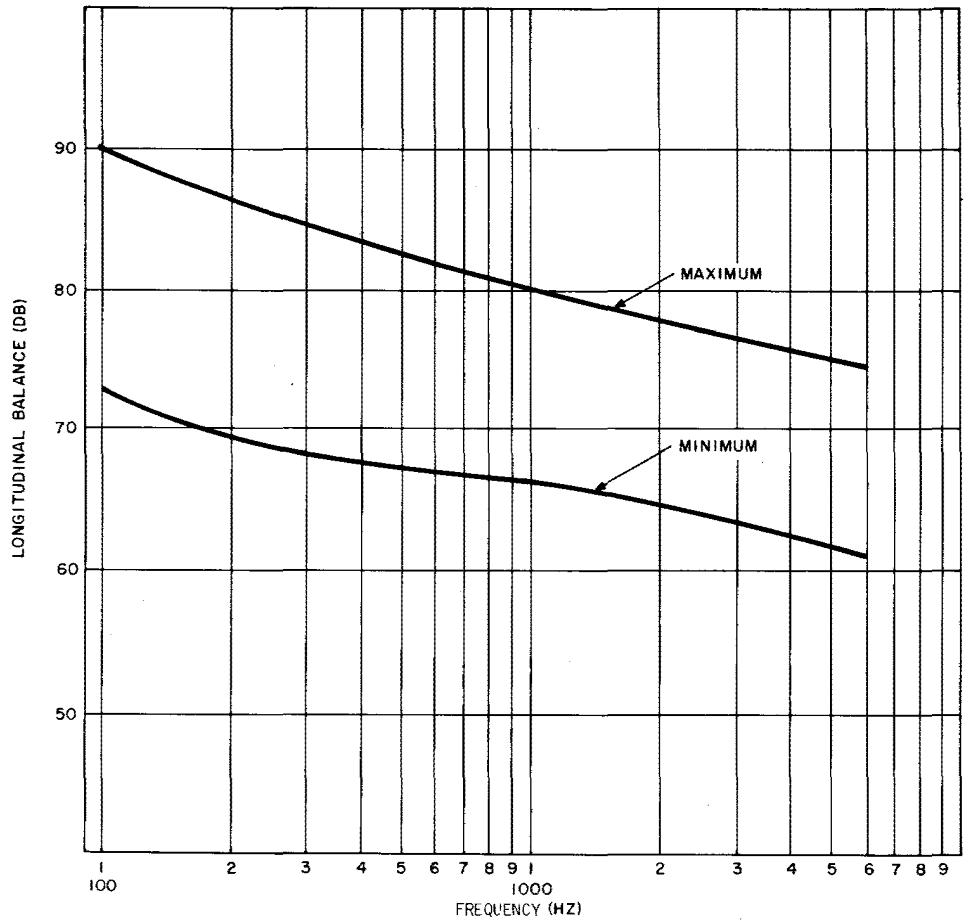


Fig. 30—FLA, FLC, FSA, and FSC Units—Longitudinal Balance Characteristics—2-Wire Side Against 900 Ohms Plus 2.15 μF

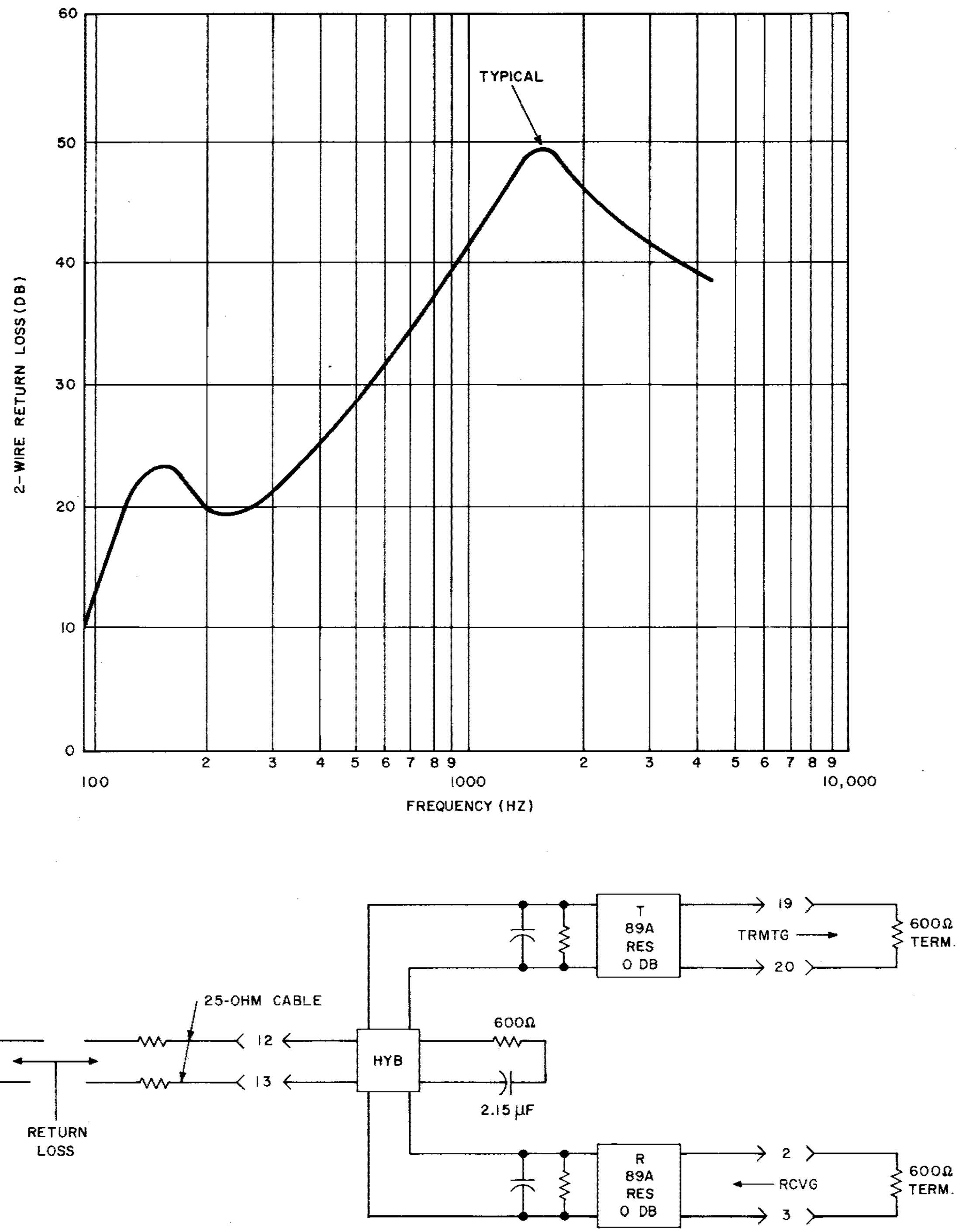


Fig. 31—FLB, FLD, FSB, and FSD Units—Nominal Return Loss-Frequency Characteristics—2-Wire Side Against 600 Ohms Plus 2.15 μF—COMP NET Position of Auxiliary Unit

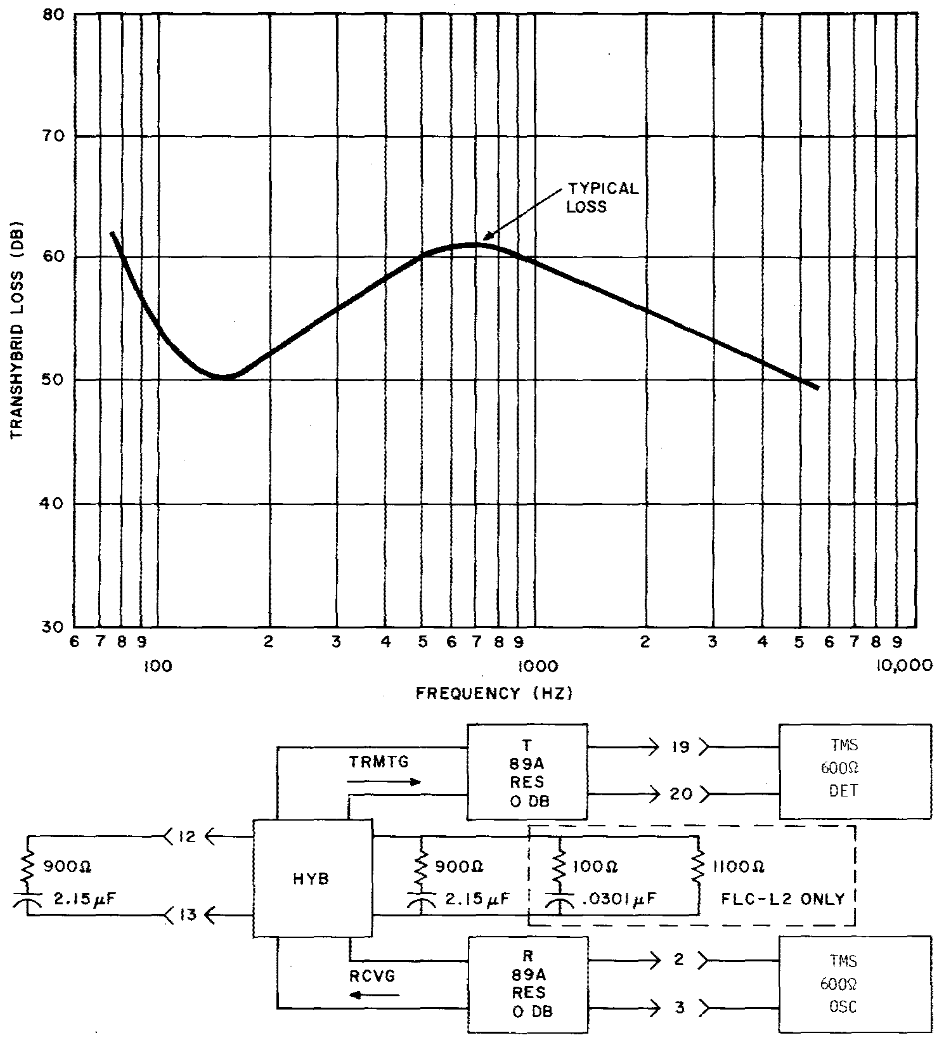


Fig. 32—FLA, FLC, FSA, and FSC Units—Nominal Transhybrid Loss—COMP NET Position of Auxiliary Unit

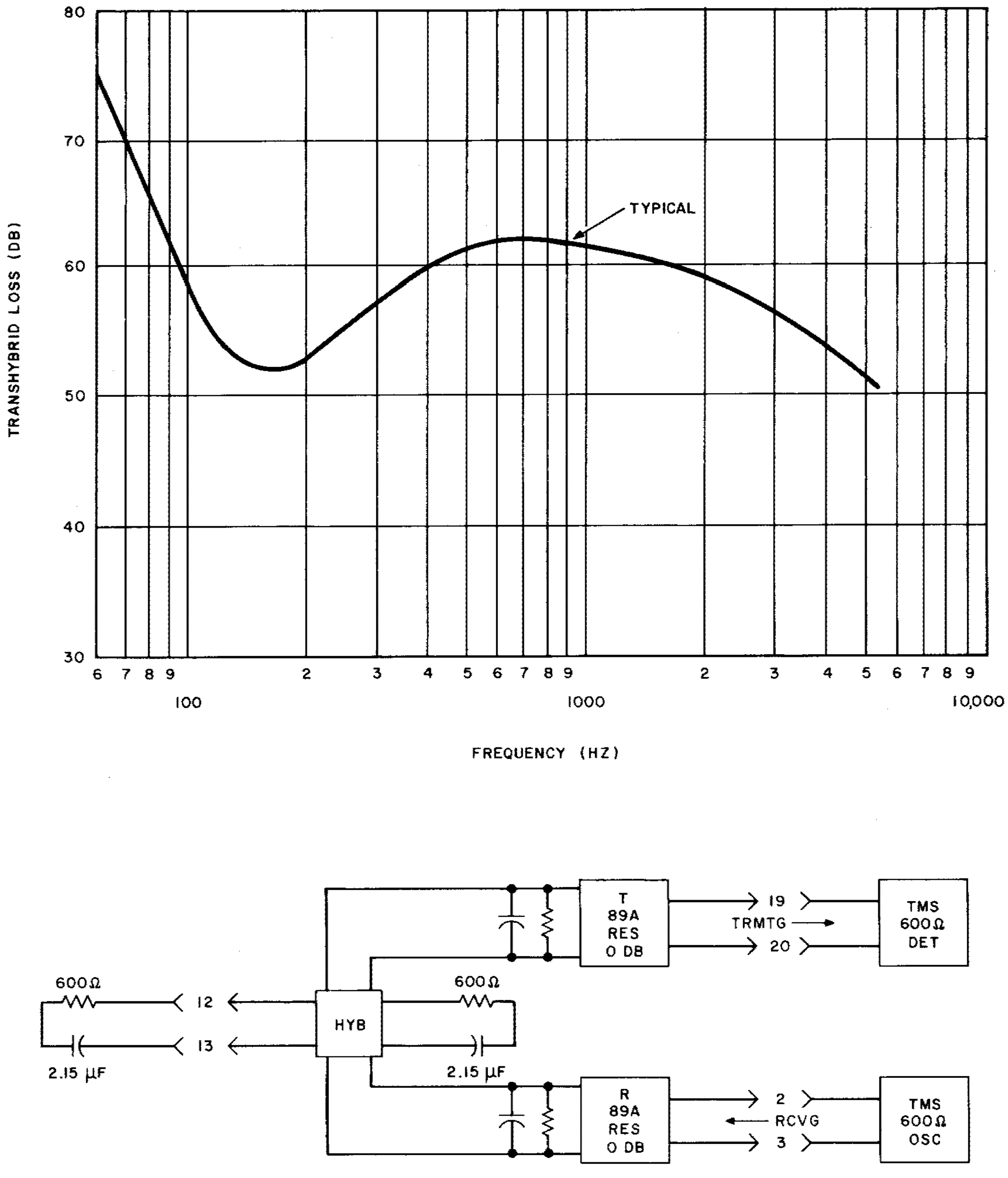


Fig. 33—FLB, FLD, FSB, and FSD Units—Nominal Transhybrid Loss—COMP NET Position of Auxiliary Unit

TABLE L

NONLOADED REPEATER SECTION - 4-WIRE UNITS				
WIRE GAUGE	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4
	(600-600)	(150-600)	(150-150)	(150-150)
	SHORT LENGTH	MEDIUM LENGTH	LONG LENGTH	EXTRA LONG LENGTH
19LC*	8 – 11 Kf	11.1 – 18 Kf	18.1 – 33 Kf	33.1 – 45 Kf
19HC**	7 – 9	9.1 – 16	16.1 – 28	28.1 – 38
22	4 – 8	8.1 – 14	14.1 – 22	22.1 – 30
24	3 – 7.5	7.6 – 12	12.1 – 17	17.1 – 22
25 MAT	3 – 9.0	9.1 – 15	15.1 – 18	18.1 – 25
26	2 – 7	7.1 – 10	10.1 – 15	15.1 – 20

* Low Capacitance

** High Capacitance

Note 1: In computing the length of a facility, include the length of all bridged taps. Gauge of bridge taps is immaterial.

Note 2: The upper lengths in columns 1 thru 3 have been chosen to limit the loss at 3 Kc to about 1.0 dB more than at 1 Kc.

Note 3: The ranges of lengths in column 4 confine the 3 Kc roll-off to the range 1.0 to 3.0 dB.

Note 4: The impedance values (600-600), (150-600), and (150-150) shown above indicate the impedance values at the F-signaling unit and at the far end equipment.

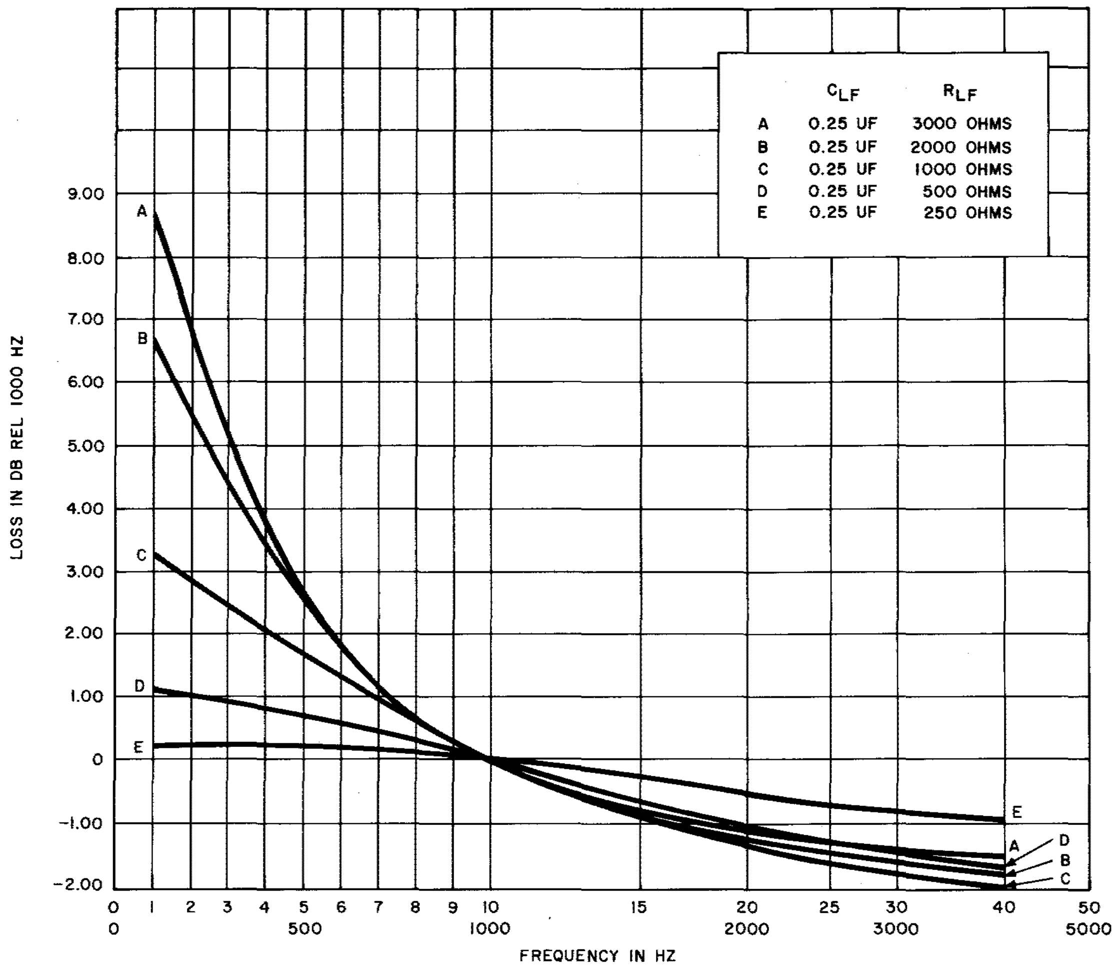


Fig. 34—FPA, FRA Units, Low-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—Varying RLF for CLF Constant at 0.25 μF

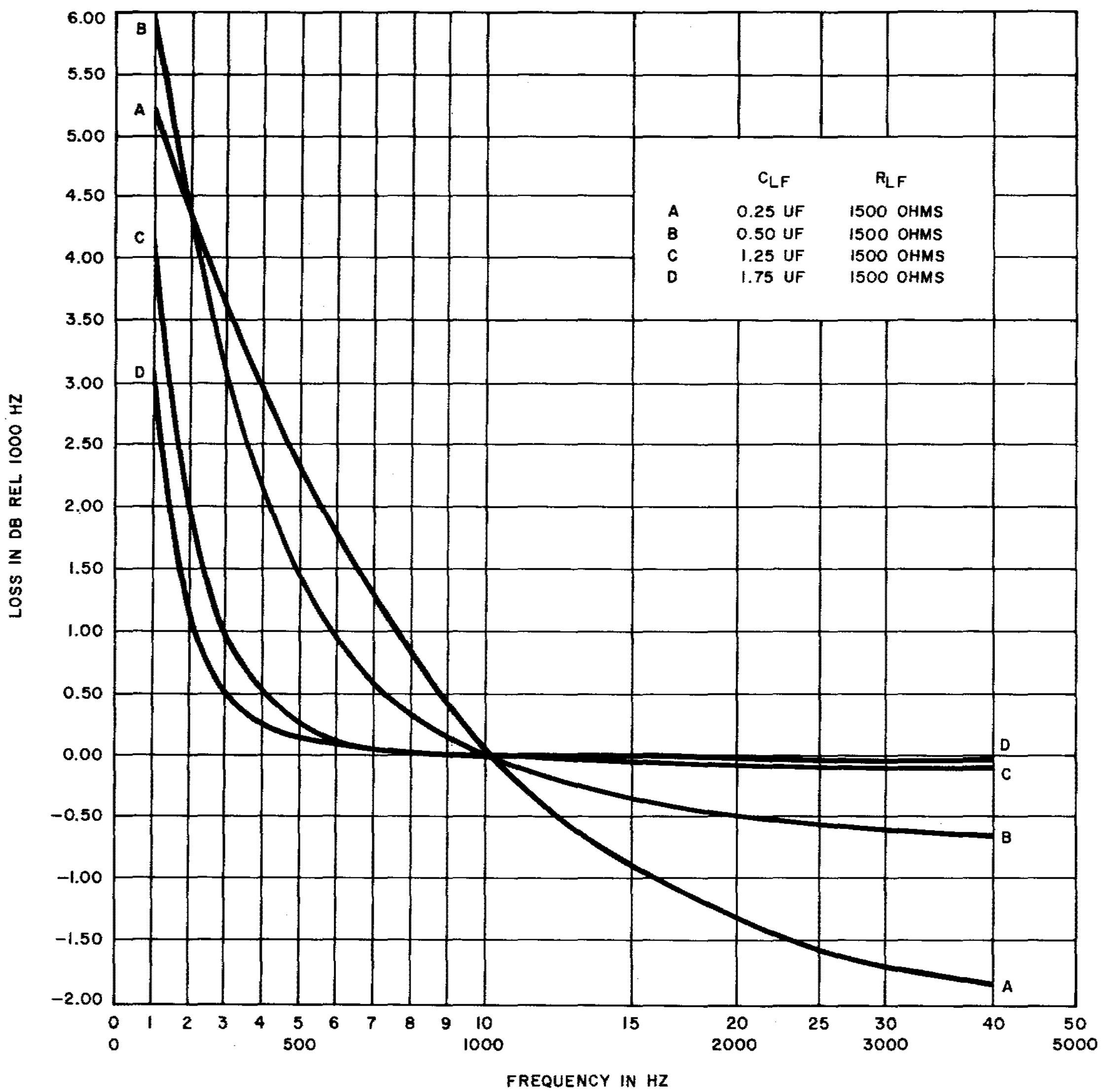


Fig. 35—FPA, FRA Unit, Low-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—Varying CLF for RLF Constant at 1500 Ohms

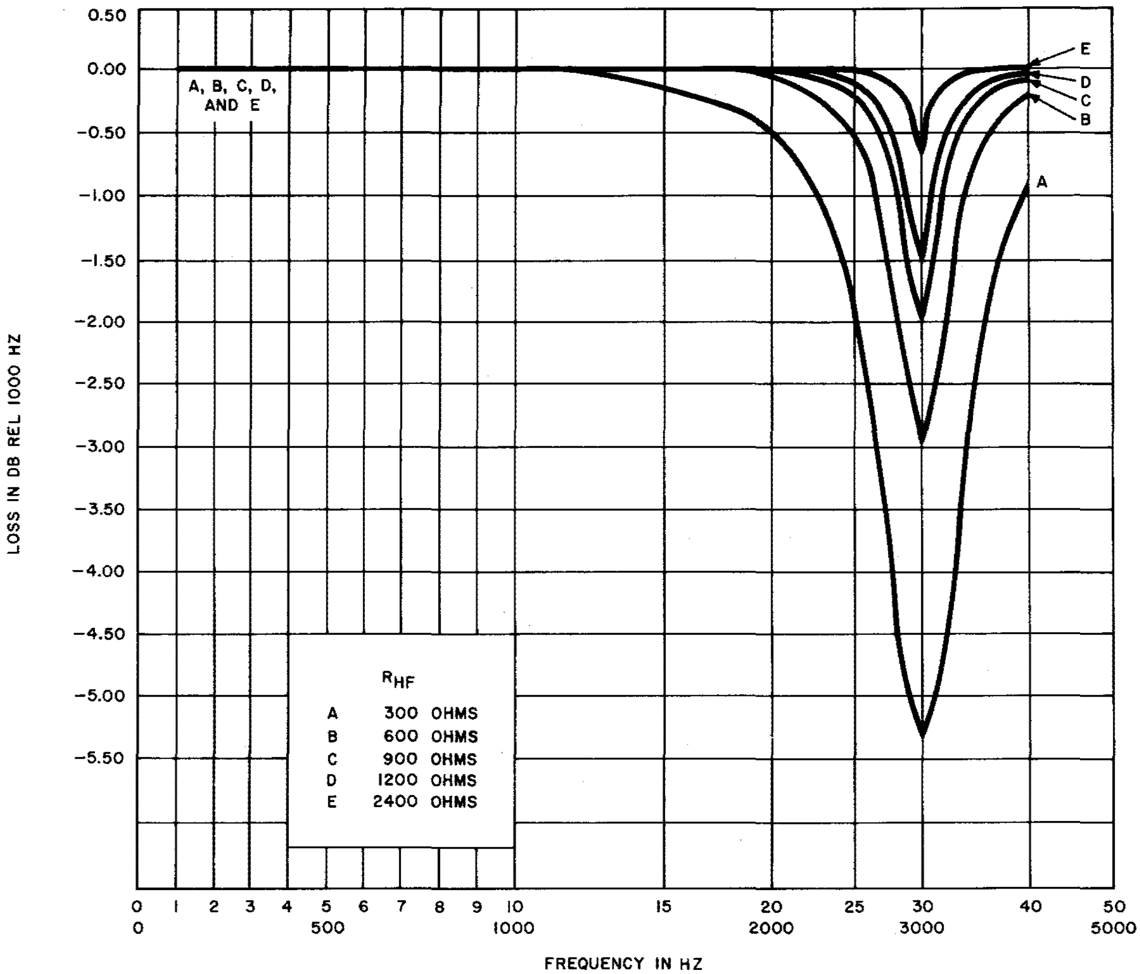


Fig. 36—FPA, FRA Unit, High-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—At Various Settings of RHF

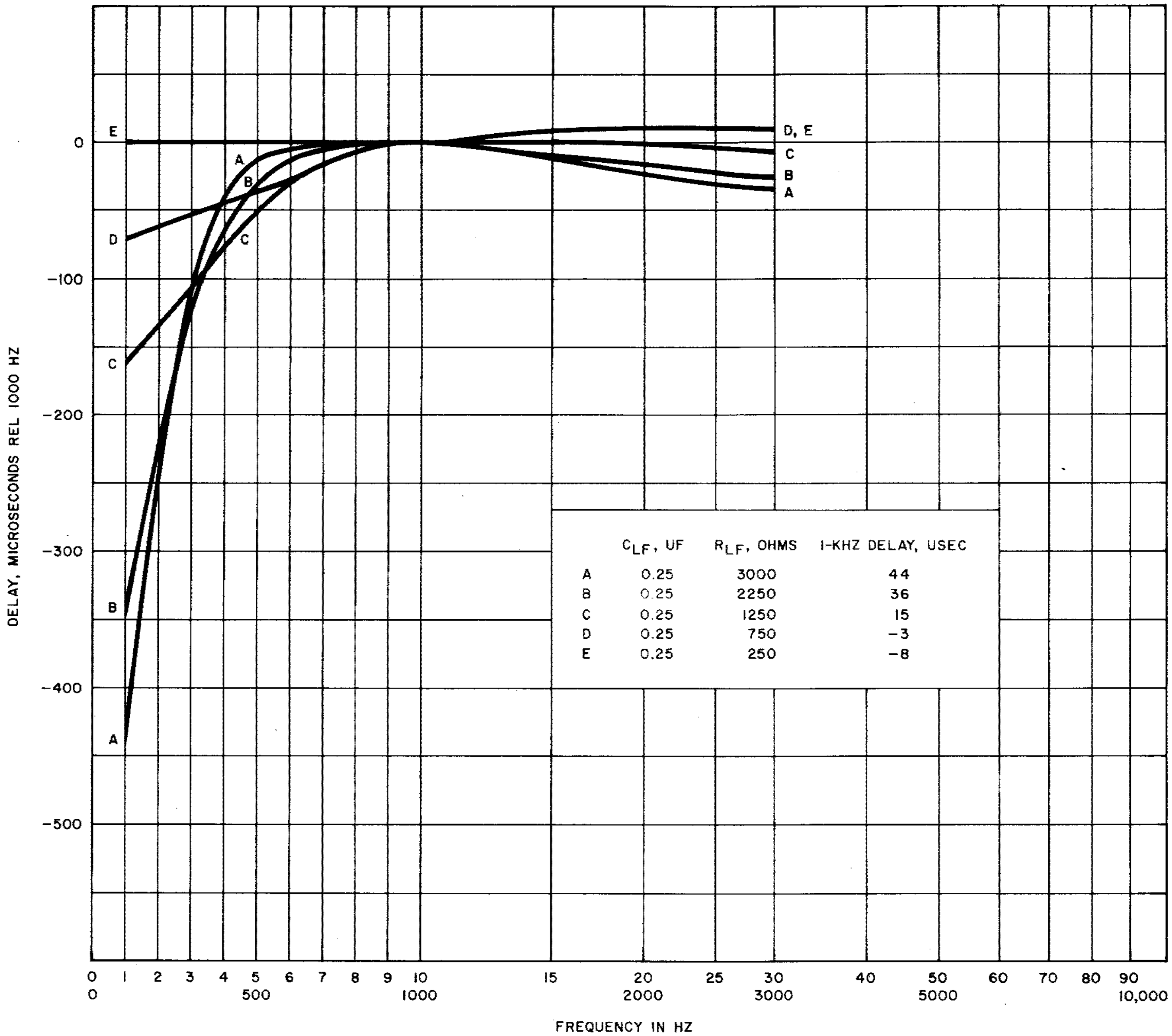


Fig. 37—FPA, FRA Unit, Low-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—Varying RLF for CLF = 0.25 μF

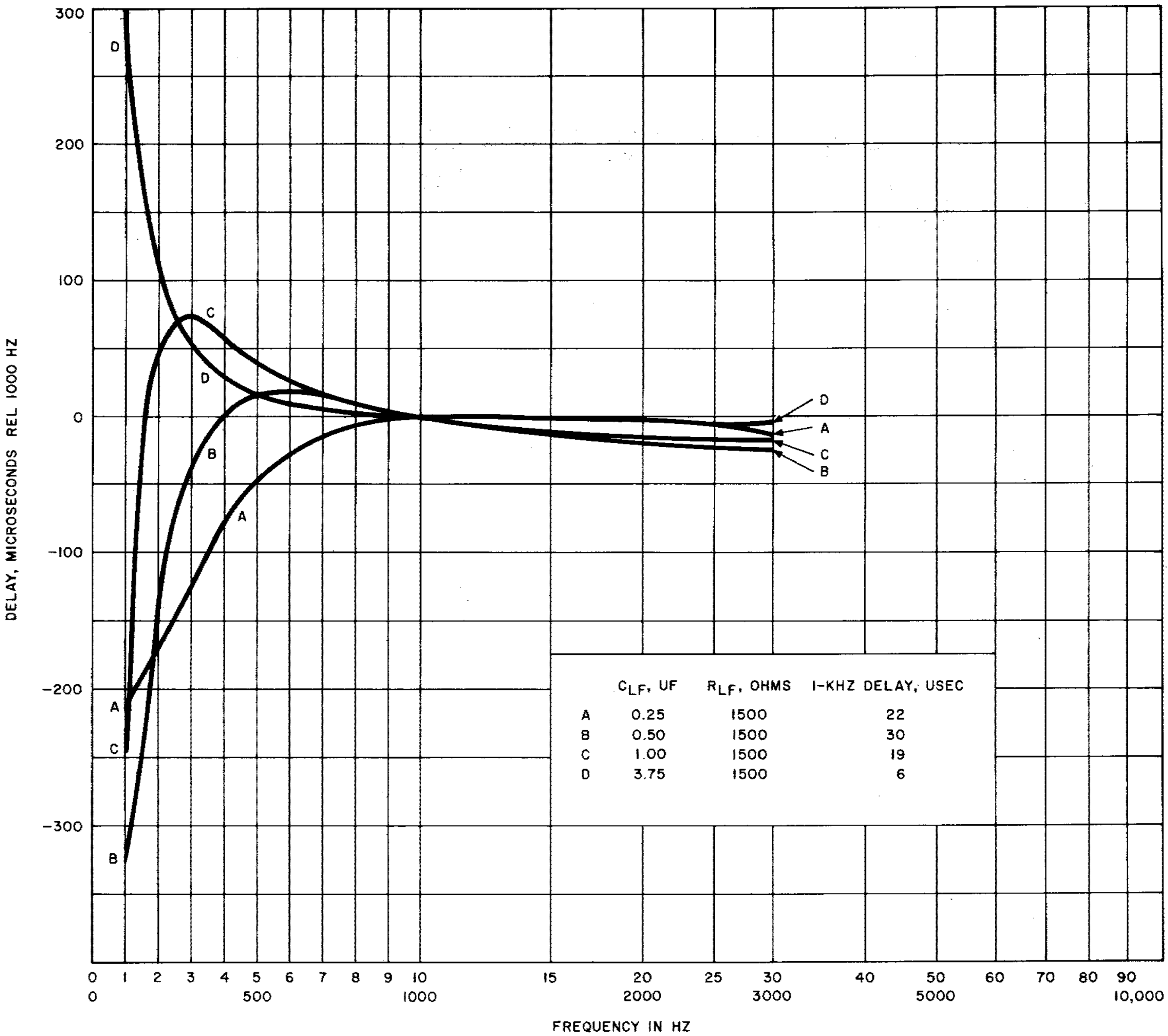


Fig. 38—FPA, FRA Unit, Low-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—Varying CLF for RLF = 1500 Ohms

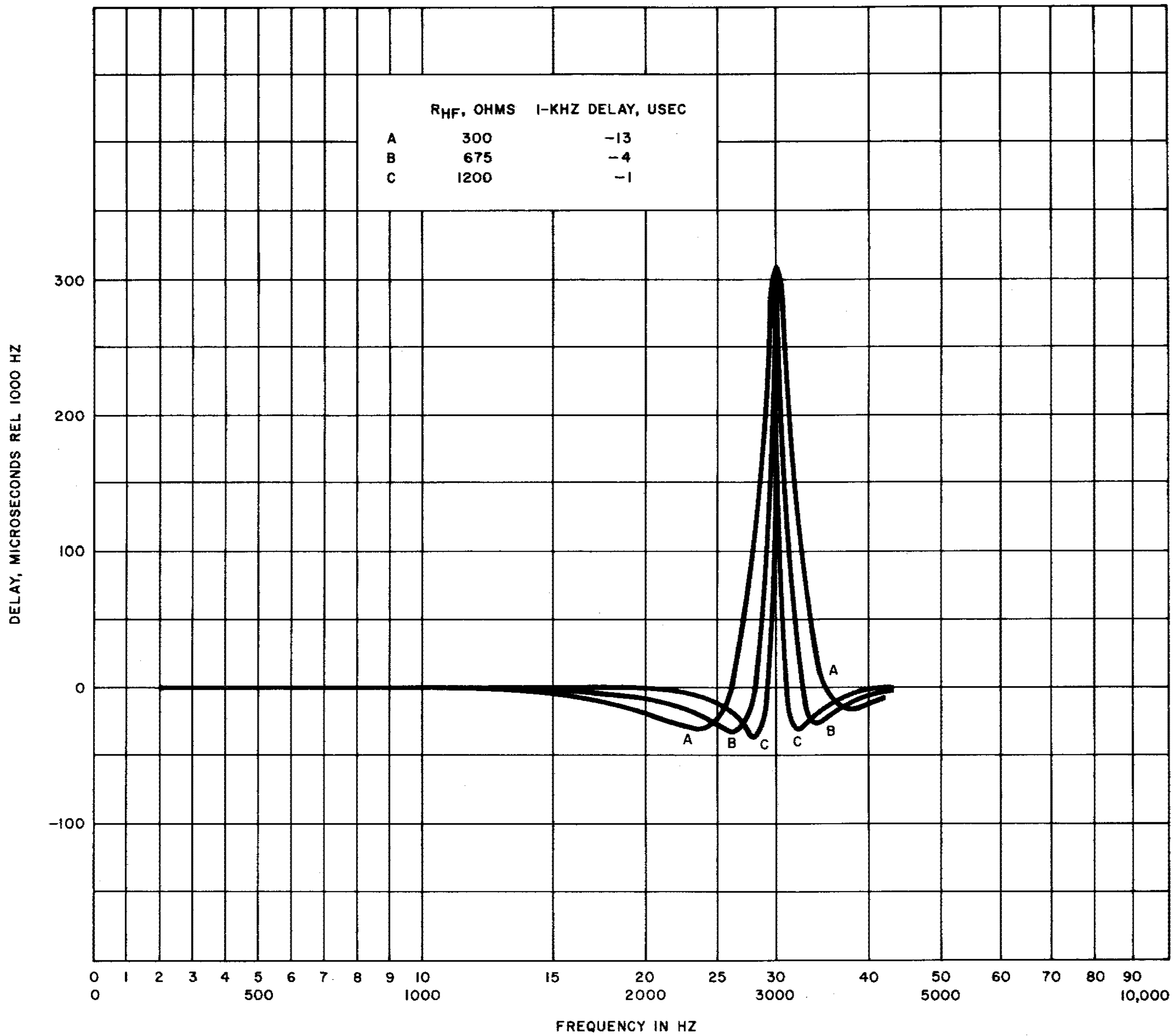


Fig. 39—FPA, FRA Unit, High-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohms Input and 600-Ohms Output Impedance—At Various Settings of RHF