DX AUXILIARY UNITS

DESCRIPTION

TYPE F SIGNALING SYSTEM

CONTENTS PAGE

1. GENERAL

1.01 This section describes the FGA and FHA single frequency (SF) auxiliary signaling units (SD-1C373-01), a component part of the Type F Signaling System. The FGA and FHA units provide a DX interface and are intended for use on trunks requiring metallic extensions with DX signaling.

1.02 This section is being reissued to include the FUD unit and to make corrections in Fig. 9 and Table E. Revision arrows are used to indicate significant changes.

A. System and Unit Description

1.03 The FGA or FHA unit must be used in conjunction with a Type F converter unit to obtain a complete SF signaling circuit. ➧The FGA unit may be used with the FUA or FUD unit whereas the FHA unit can only be used with the FUA unit. The FUA and FUD units are described in Section 179-363-101. The FGA unit is mounted adjacent to the FUA or FUD unit and the FHA unit is mounted adjacent to the FUA unit➧ in the Type F signaling bay.

1.04 The FGA or FHA unit can be placed in its in-service position by inserting it into the guides of the appropriate shelf position and sliding it towards 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 has been made. To remove the unit, release the locking device and withdraw the unit.

1.05 The identification label on the face of the FGA and FHA units has a cream colored background and the lettering is federal gray.

1.06 On the face of the FGA and FHA units are screw switches which provide: line build-out resistance, carrier group alarm features, balancing network, compensating network, and gain-frequency equalization. The compensating network and balancing network screw positions are provided on the FGA unit, and the gain-frequency equalization screws are provided on the FHA units. Both FGA and FHA units have screw positions for line build-out resistance and carrier group alarm features.

1.07 All circuit components of the FGA and FHA units are mounted on a printed wiring board. The board is attached to a die cast aluminum frame which is approximately 10-1/2 inches deep by 1-1/2 inches wide by 7 inches high . All interconnections between the bay and the unit are via a 40-pin connector which is part of the printed wiring board.

1.08 Figure 1 is a photograph showing an FHA unit (left) and an FGA unit. Some of the circuit components which are used in unit construction can be seen in the photograph. Figure 2 shows the details of the faceplates of the FGA and FHA units.

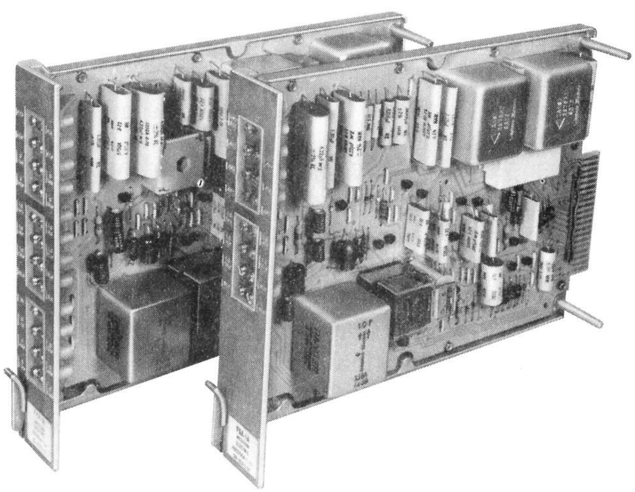


Fig. 1—FHA and FGA Units

B. Application and Compatibility

1.09 The FGA and FHA units are interfaced with an ▶FU( )◀ converter unit on one side and a DX signaling link on the other side. Therefore, an FGA or FHA unit will usually be at an intermediate point of the overall circuit. Figures 3 through 5 are typical circuits showing trunk circuits employing FGA and FHA units.

1.10 The FGA unit has a built-in, 900-ohm 4-wire terminating set for 2-wire extensions. The 4-wire side of the terminating set faces the FUA ▶or FUD◀ unit and the 2-wire side faces the DX signaling link (Fig. 3). The FHA unit has a built-in 4-wire line matching circuit. Simplex leads are provided for access to the DX interface. The line matching circuit provides frequency equalization and impedance matching.

1.11 The line balancing resistors (LR_) are selected to match the value of the total loop (DX) resistance. For FGA loops, the total resistance is equal to the loop resistance of the cable pair (see Fig. 6A). For FHA loops, the total resistance is equal to one-half of the loop resistance of either cable pair (assuming they have the same make-up). (See Fig. 6B.) Once the total resistance value has been obtained, refer to Table A to determine which LR_ screw to turn down to match the line resistance. Select the LR_ screw combination which covers the range in which the loop resistance value lies. The DX signaling circuit must be balanced to the resistance of the facility within 10 percent or it will not function properly.

1.12 The FGA and FHA units are compatible with most of the other Type F signaling units and some of the later vintage E-type units. Table B provides a list of compatible units which can be used at the other end of the carrier facility. If a Type F auxiliary unit is being used at the distant office, an FU( ) converter unit will always be associated with it.

2. OPERATION

2.01 For the purpose of this section (and manufacturing testing) the DX signaling leads (within the FGA or FHA unit) associated with transmitting and receiving signals shall be referred to as the Test E and M leads. The Test E lead monitors the condition of the R relay (which is controlled by the distant SF unit) and the Test M lead monitors the condition of the D relay (which is controlled by the distant DX unit). (See Fig. 7, 8, and 9.)

2.02 For the discussion that follows, the following table and figures are provided for clarification:

(1) Table C—gives the condition of the E and M leads, test E and M leads, and 2600-Hz tone for various circuit conditions.

(2) Figures 7, 8, and 9—illustrate a simplified schematic of the FGA (Fig. 7 and 8) and FHA (Fig. 9) units. The test E and M leads are shown in each of these figures.

2.03 The operation of the FGA and FHA units can best be described by considering two types of calls: (1) A call originated at the distant DX signaling end, and (2) a call originated at the distant SF unit end. Refer to Table C and Fig. 7, 8, and 9 to determine the state of the FGA or FHA unit when in the idle condition. In the idle condition the M relay is operated, which supplies 2600-Hz tone towards the distant SF unit. The D and R relays are both released. Referring to Fig. 7, 8, or 9, if there is no difference in dc earth potential between the ends of the DX signaling link, there is no current flow in the upper two windings of the D relay. However, the D relay is held released through its lower winding.

A. Call Originated at Distant DX Office

2.04 When the customer at the distant DX end goes off-hook, battery via the A lead is placed on the T lead (FGA unit) or T1 and R1 leads (FHA unit). The battery causes the D relay to operate (via the A lead) in the FGA or FHA unit. The operated D relay applies battery to the M lead interface circuit causing the M relay to release (after an 18.5 ± 1.5 ms delay). The released M relay removes tone towards the distant SF unit as an indication of a seizure.

2.05 With the D relay operated, ground is applied to the CT lead toward the FUA unit causing the CT relay in the FUA to release and remove the transmission cut applied when the CT relay is operated. ♦The FUD unit does not have a CT relay, but the same command that operates the CT relay in the FUA unit controls a transistorized cut circuit in the FUD unit. When the customer at the distant DX end dials, ground and battery signals are alternately applied toward the FGA or FHA unit causing the D relay to follow the battery pulses. The M relay, in turn, pulses and alternately applies and removes 2600-Hz tone toward the distant SF unit. A minimum pulse of 49.5 ± 3.5 ms is guaranteed by the FGA or FHA unit for the pulsing of 2600-Hz tone. During pulsing, the CT relay in the FUA (transistorized cut circuit in the FUD) is held operated so that noise and speech signals do not interfere with the 2600-Hz tone pulses. A guaranteed minimum break of tone of 26 ± 4 ms is provided by the M relay timing circuit. At the end of each digit pulsed, the CT relay in the FUA unit (transistorized cut circuit in the FUD)♦ releases (after a delay of approximately 625 ms).

2.06 After completion of pulsing, and after the customer at the distant SF end answers the call, 2600-Hz tone is removed toward the FGA or FHA unit. The removal of tone causes the R relay (after a 33 ± 1.5 ms delay) to operate. Operation of the R relay connects battery to the upper D relay winding, and thus to the A lead. This causes the DX signaling relay at the distant DX office to operate, indicating answer supervision. The D relay in the FGA or FHA remains operated through its lower winding (Fig. 7, 8, or 9). The FGA or FHA unit is now in the talking condition.

2.07 When the customer at the distant DX signaling office goes on-hook, battery via the A lead is removed from the T lead (FGA unit) or T1 and R1 leads (FHA unit) and the D relay releases. The M relay operates and tone is again applied toward the distant SF unit. When the customer at the distant SF unit end goes on-hook, tone is reapplied toward the FGA or FHA unit and causes the release of the R relay. The R relay removes battery via the A lead from the T lead (FGA unit), or T1 and R1 leads (FHA unit), and the DX signaling relay in the distant DX office releases.

B. Call Originated at Distant SF Unit

2.08 On calls that are originated at the distant SF unit end, the FGA or FHA unit is informed of a request for service when the idle 2600-Hz tone is removed from its receive port. After a delay of 33 ± 1.5 ms, the R relay operates and applies battery via the A lead to the T lead (FGA unit) or T1 and R1 leads (FHA unit) toward the distant DX signaling unit. The DX signaling relay at the DX office operates, seizing the associated trunk circuit by grounding the E lead.

2.09 During dialing, the R relay alternately releases and operates in response to the 2600-Hz tone pulses being received from the SF unit at the distant office. The tone signals are timed to insure minimum make and break intervals of the R relay. A minimum make interval of 30 ± 1 ms and a minimum break interval of 50 ± 3 ms is guaranteed. The pulsing R relay alternately applies ground and battery toward the distant DX signaling relay.

2.10 When the customer at the distant DX signaling office answers the call, battery is applied to the T lead (for FGA unit) or T1 and R1 leads (for FHA unit). The battery cancels the battery applied at the distant DX end causing the D relay in the FGA or FHA to operate. When operated, the D relay releases the M relay and thus removes 2600-Hz tone towards the distant SF unit. This causes a supervisory relay in the distant SF unit to change state, thus giving answer supervision. The FGA or FHA unit is now in the talking condition.

2.11 Disconnect is the same as previously described in 2.07.

3. CARRIER GROUP ALARM

3.01 The FGA and FHA units have carrier group alarm (CGA) options which may be inserted into the circuit by turning down appropriate screws on the face of the unit. The ALM or ALO screws turned down (with the ALB screw backed off) provides circuit release functions. The ALB screw turned down (with either ALM or ALO screw turned down) provides the make-busy function.

3.02 The circuit release and make-busy functions are activated when the carrier system associated with the FGA or FHA unit have encountered a trouble condition. For controlling circuit release, a ground is extended to the FGA or FHA unit from the carrier group alarm control circuit. The ground releases the R relay (if operated) and keeps it in the released condition until the carrier system failure has been restored. When make-busy features are to be applied, the R relay is operated (or reoperated, if applicable) which causes the circuit to be made busy.

3.03 The ALB, ALM, and ALO screws shall be turned down or backed off as determined by Table D.

4. TRANSMISSION CIRCUITS

4.01 The FGA unit contains a built-in terminating set. It provides conversion from 2-wire 900-ohm (DX signaling side) to 4-wire 600-ohm (FUA ➧or FUD➧ converter side) operation. The conversion is obtained by a 2-transformer hybrid. Build-out capacitance permits balancing against office cabling on the 2-wire side. Capacitance from 0.0 to 0.127μF in .002 steps can be added into the circuit by turning the associated screws down on the face of the FGA unit. A compromise 900-ohm 2μF network can be used if desired by turning down the COMP NET screw. Access is also provided for connecting to an external precision balancing network if desired. ➧When the FGA unit is used in conjunction with the FUD unit, the internal compromise network and network build-out capacitor (NBOC) screw switches of the terminating set must be in the open position (screwed out). The FUD supplies the precision balancing network and LBOC as required.➧

4.02 The FHA unit contains a line matching network which is used with 4-wire cable facilities. Impedance matching is obtained by selecting the proper transformer impedance ratio by the use of screw switches located on the printed wiring board. Both DX signaling cable pairs must be matched. Transformer T401 is associated with the T and R leads and transformer T402 is associated with the T1 and R1 leads. The L(150), M(600), and H(1200) screws associated with each transformer are to be turned down as determined by the following:

SCREW POSITION	SPECIFIC USE
H(1200)	To be used when associated DX signaling link uses loaded H88- or H44-type cable
M(600)	To be used when associated DX signaling link uses nonloaded, short length cable (see Column 1, Table E)
L(150)	To be used when associated DX signaling link uses nonloaded, long length cable (see Column 3, Table E).

4.03 When the associated DX signaling link utilizes H88 loaded cable, additional screw controlled resistance and capacitance of the receiving H88 cable pair can be added for equalization. The additional resistance and capacitance is independently controlled for low and high frequency equalization. For frequencies between 250 and 3000 Hz, the insertion loss of the FHA unit toward the transmitting H88 cable pair is 0.3 dB from the receiving H88 cable pair and the loss will vary from 3.3 to 6.3 dB when the equalizing controls are being adjusted. The high-frequency section is controlled by the IN, R75, R150, R300, R600, R1200, and R2400 screws and the low-frequency section is controlled by C.25, C.50, C1.0, C2.0, R250, R500, R1000, and R2000 screws. Turning down capacitance screws adds capacitance whereas turning down resistance screws removes resistance. Prescription settings for various gauges of H88-type cable are given in Tables F through J.

5. PULSING CHARACTERISTICS

A. Transmitting

5.01 The FGA and FHA units will accept pulses from the distant DX signaling office within the following limits:

PULSES-PER-SECOND	PERCENT BREAK
7.5	15-90
10.0	20-90
12.5	25-90

For inputs of less than 50 milliseconds the output tone pulse to the FUA unit ➧(or FUD unit for the FGA unit)➧ will be 49.5 ± 3.5 ms. For inputs with a make interval of less than 30 ms but greater than 4 ms, the output break tone interval will be 26 ± 4 ms. At 10 pulses-per-second the output tone pulse will track with the input DX pulse between 46 and 78 percent break.

B. Receiving

5.02 The FGA and FHA units are limited to reproducing pulses within the 7.5 to 12.5 pulses-per-second range. A minimum 2600-Hz tone pulse of 38 milliseconds is required to operate the receiver. The acceptance range for the input tone pulses are as follows:

PULSES-PER-SECOND	PERCENT BREAK
7.5	28-90
10.0	38-85
12.5	47-80

Input tone pulses less than 50 milliseconds will produce a dc output to the DX circuit of 50 ± 3 ms. Pulses greater than 60 ms will produce an output within 3 ms of the input. Pulses between 50 and 60 milliseconds will produce an output between ±3 ms of the input pulse.

5.03 The cut in the transmit path, which is introduced by the CT relay in the FUA unit ➧(transistorized cut circuit in the FUD unit)➧ will not exceed 125 milliseconds following an off-hook transition or 750 milliseconds following an on-hook transition. The path is cut and terminated whenever the circuit is idle.

6. TRANSMISSION CHARACTERISTICS

6.01 The stability of the transmit and receive circuits is dependent upon certain environmental conditions, such as impedance, temperature, aging, and operating voltage. For the discussion that follows in the remaining part of this section it is assumed that the ambient temperature is 70°F and the dc power converter supply voltage is 24V ±5%.

6.02 ➧The envelope delay present in the transmit and receive circuits of the FGA and FHA units can be seen in Fig. 10. The delay for the FGA unit is about 15 microseconds for frequencies of 3000 Hz and above for either the transmit or receive circuits. The rise in delay 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. 10. The delay for the FHA unit is approximately zero for frequencies of 2000 Hz and above for the transmit circuit and 4000 Hz and above for the receive circuit. The delay of the FHA unit does not rise as rapidly as it does in the FGA unit. As can be seen in Fig. 10, the delay in the transmit circuit rises from 2 microseconds at 1000 Hz to 18 microseconds at 300 Hz. The delay for the receive circuit rises from 5 microseconds at 2000 Hz to 100 microseconds at 300 Hz.➧

A. FGA Unit

6.03 ➧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 unit has -13 to -3 dB loss and must be adjusted to obtain -16 dBm0 at the LINE TRMT PORT of the FUD unit. The combined loss of the transmit circuit transmission path for the FUA or FUD➧ unit and the FGA auxiliary unit can be seen in Fig. 11.

6.04 The output level of the receiving circuits 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 from the input level at 1000 Hz. The combined variation due to the FUA or FUD◀ unit plus the FGA 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. 12 and 13. The high loss between 2200 and 2800 Hz shown in Fig. 13 is caused by the band-elimination filter.

6.05 The 2-wire return loss and transhybrid loss characteristics are demonstrated in the curves shown in Fig. 14 and 15, respectively. At 1000 Hz the return loss is approximately 21 dB. The transhybrid loss is greater than 47 dB at 1000 Hz. ▶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. FHA Unit

6.06 Equalization for long and short lengths of nonloaded cable sections (Table E) is provided by the 150- and 600-ohm taps (respectively) of transformers T401 and T402 (Fig. 9). If loaded H88 cable is used for the 4-wire extension, additional equalization controls are provided for the receiving H88 cable pair for both the low-frequency and high- frequency sections of the frequencies within the voice range. This added equalization control is provided to maintain a substantially flat frequency response over the range of 300 through 3000 Hz. With no equalization, the 1000-Hz insertion loss between the AUX TRMT IN and AUX TRMT OUT ports is 3.3 ± 0.3 dB. Between the AUX RCV IN and AUX RCV OUT ports the 1000-Hz insertion loss is 0.3 ± 0.3 dB. Refer to Tables E through J to obtain the prescription screw settings for both loaded H88 cable and nonloaded cable.

6.07 The low-frequency (series arm) 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 16 and 17 illustrate typical equalization losses which can be obtained by various combinations of C_{LF} and R_{LF}. Figure 16 shows the results of keeping C_{LF} constant at 0.25 μF and varying R_{LF} and the HF section out of the circuit. Figure 17 shows the results of keeping R_{LF} constant at 1500 ohms and varying C_{LF} with the HF section out of the circuit.

6.08 The high-frequency (shunt arm) components provide amplitude equalization for H88 loaded, high-capacitance cable where the nominal cutoff is 3500 Hz. Capacitor C_{HF} and inductor L_{LF} 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 18 illustrates the typical corrective losses which may be obtained by various settings of R_{HF}.

6.09 While the series arm low-frequency components (R_{LF} and C_{LF}) provide compensation for amplitude distortion, they introduce delay distortion at the same time. Figures 19 and 20 illustrate typical delay-frequency characteristics obtained by various combinations of C_{LF} and R_{LF}. Figure 19 illustrates the results of keeping C_{LF} constant at 0.25 μF and varying R_{LF} with the HF section out of the circuit. Figure 20 shows the results of keeping R_{LF} constant at 1500 ohms and varying C_{LF} with the HF section out of the circuit.

6.10 While the shunt arm high-frequency components provide compensation for amplitude distortion, they also introduce delay distortion. Figure 21 illustrates typical delay-frequency characteristics obtained by varying R_{HF}.

7. MAINTENANCE

7.01 There are no field adjustments provided on the FGA or FHA units. 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. (See Section 179-361-101.)

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

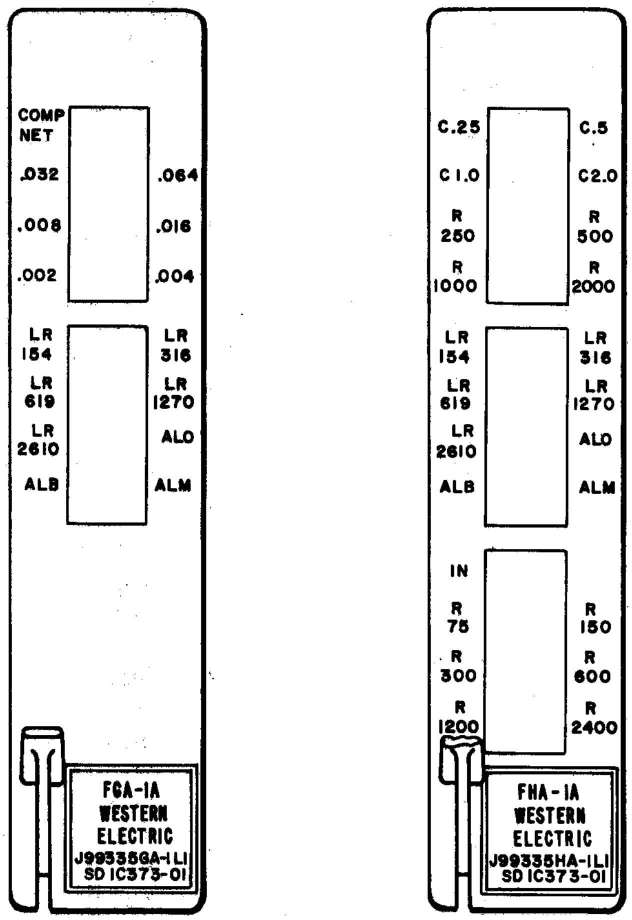


Fig. 2—FGA and FHA Unit Faceplates

TABLE A

RESISTANCE RANGE FOR VARIOUS LR-SCREW COMBINATIONS	LR-SCREW(S) TURNED UP				
	LR-154	LR-316	LR-619	LR-1270	LR-2610
0-77					
78-235	X				
236-393		X			
394-544	X	X			
545-696			X		
697-854	X		X		
855-1012		X	X		
1013-1179	X	X	X		
1180-1347				X	
1348-1505	X			X	
1506-1663		X		X	
1664-1814	X	X		X	
1815-1966			X	X	
1967-2124	X		X	X	
2125-2282		X	X	X	
2283-2484	X	X	X	X	
2485-2687					X
2688-2845	X				X
2846-3003		X			X
3004-3077	X	X			X
3078-3306			X		X
3307-3464	X		X		X
3465-3622		X	X		X
3623-3789	X	X	X		X
3790-3957				X	X
3958-4115	X			X	X
4116-4273		X		X	X
4274-4424	X	X		X	X
4425-4576			X	X	X
4577-4734	X		X	X	X
4735-4892		X	X	X	X
4893-5000	X	X	X	X	X

X Denotes screw turned up

TABLE B

INTERMEDIATE OFFICE SF UNIT	COMPATIBLE SF UNIT IN DISTANT OFFICE
FGA,FHA	FAA,FAC,FAD,FBA,FBB,FCA,FDA,FDB,FWA, E1AK,E1AKD,E1BK,E2B,E3BK,E3BKA,E4B,E2C, E4C,E2D,E4D,E5D

TABLE C

SIGNALS USED FOR SIGNALING BETWEEN OFFICES FOR FGA AND FHA UNITS

DX UNIT IN DISTANT OFFICE			FGA OR FHA UNIT IN INTERMEDIATE OFFICE				COMPATIBLE SF UNIT IN DISTANT OFFICE			
SIGNAL OR STATE	M LEAD	E LEAD	SIGNAL OR STATE	TEST M LEAD	TEST E LEAD	SF TONE OUTPUT	SIGNAL OR STATE	M LEAD	E LEAD	SF TONE OUTPUT
Idle	Ground	Open	Idle	Ground	Open	On	Idle	Ground	Open	On
Seizure at DX End	Battery	Open	Seized	Battery	Open	Off	Seized	Ground	Ground	On
Seizure at SF End	Ground	Ground	Seized	Ground	Ground	On	Seized	Battery	Open	Off
Stop Dialing*	Battery	Ground	Stop Dialing*	Battery	Ground	Off	Stop Dialing*	Battery	Ground	Off
Start Dialing*	Ground	Ground	Start Dialing*	Ground	Ground	On	Start Dialing*	Battery	Open	Off
Dialing at DX End	Ground Battery	Open	Dialing at DX End	Ground Battery	Open	On Off	Dialing at DX End	Ground	Open Ground	On
Dialing at SF End	Ground	Open Ground	Dialing at SF End	Ground	Open Ground	On	Dialing at SF End	Ground Battery	Open	On Off
Talking	Battery	Ground	Talking	Battery	Ground	Off	Talking	Battery	Ground	Off
Ring Forward*	Ground Battery	Ground	Ring Forward*	Ground Battery	Ground	On Off	Ring Forward*	Battery	Open Ground	Off
Ringback*	Ground Battery	Ground	Ringback*	Ground Battery	Ground	On Off	Ringback*	Battery	Open Ground	Off
Flashing*	Ground Battery	Ground	Flashing*	Ground Battery	Ground	On Off	Flashing*	Battery	Open Ground	Off
Disconnect at DX End	Ground	Ground	Disconnect at DX End	Ground	Ground	On	Disconnect at DX End	Battery	Open	Off
Disconnect at SF End	Battery	Open	Disconnect at SF End	Battery	Open	Off	Disconnect at SF End	Ground	Ground	On
Disconnect at Both Ends	Ground	Open	Disconnect at Both Ends	Ground	Open	On	Disconnect at Both Ends	Ground	Open	On

*Either end can initiate signal. This table assumes that signal was initiated at DX end of trunk.

TABLE D

TYPE OF CIRCUIT	CGA	TIGHTEN DOWN SCREW(S)	BACK OFF SCREW(S)
2-Way or 1-Way Outgoing Trunks Requiring Release and Make-Busy	W/ALM OVRD	ALO,ALB	ALM
	W/O ALM OVRD	ALM,ALB	ALO
1-Way Incoming Trunks Requiring Release Only (Also ESS)	W/ALM OVRD	ALO	ALM,ALB
	W/O ALM OVRD	ALM	ALB,ALO

TABLE E

NONLOADED REPEATER SECTION				
WIRE GAUGE	COLUMN 1 (600-600) SHORT LENGTH	COLUMN 2 (150-600) MEDIUM LENGTH	COLUMN 3 (150-150) LONG LENGTH	COLUMN 4 (150-150) EXTRA LONG LENGTH
19LC*	8 — 11 Kf	11.1 — 18 Kf	18.1 — 33Kf	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 — 12.5	12.6 — 17	17.1 — 24
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 at the F-signaling unit and at the far end equipment.

TABLE F

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FHM UNIT FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 18H88 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 G

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FHM UNIT 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 H

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FHM UNIT 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 I

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FHA UNIT 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 J

PRESCRIPTION ADJUSTMENTS AND COMPONENT VALUES OF EQUALIZER SECTION OF FHM UNIT FOR CABLE END SECTIONS 1500 TO 4500 FEET

CABLE GAUGE: 26H88							
CABLE LENGTH KILOFEET*		0-12	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".

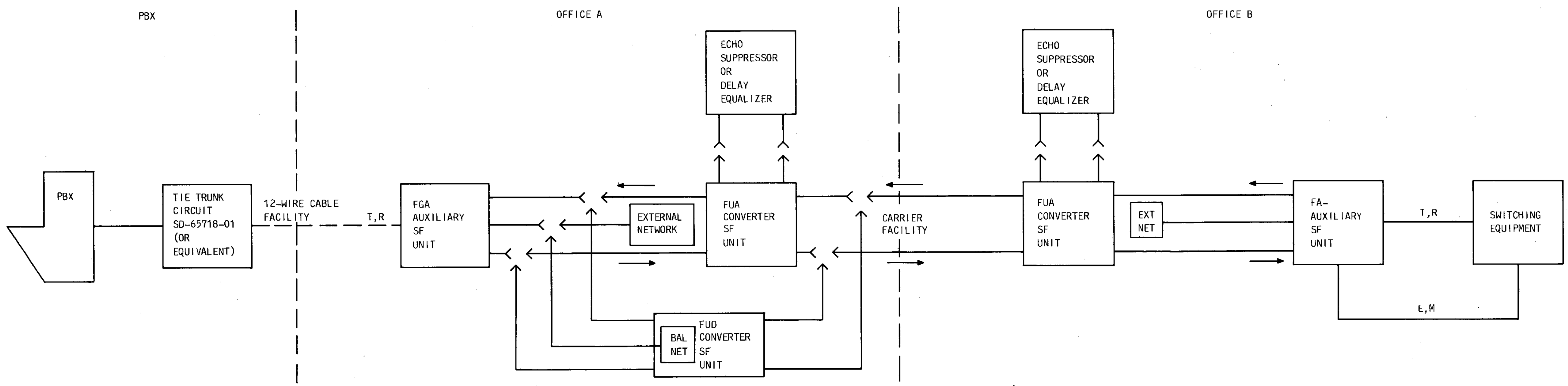


Fig. 3—Typical Application of FGA Unit on PBX to CO Nontandem Tie Trunk

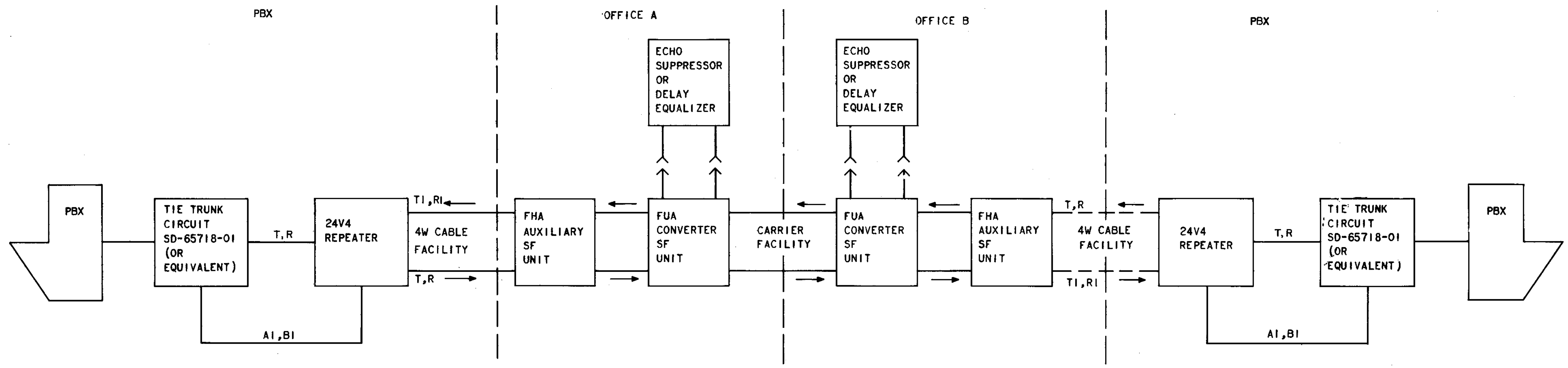


Fig. 4—Typical Application of FHA Unit on PBX Tie Trunk

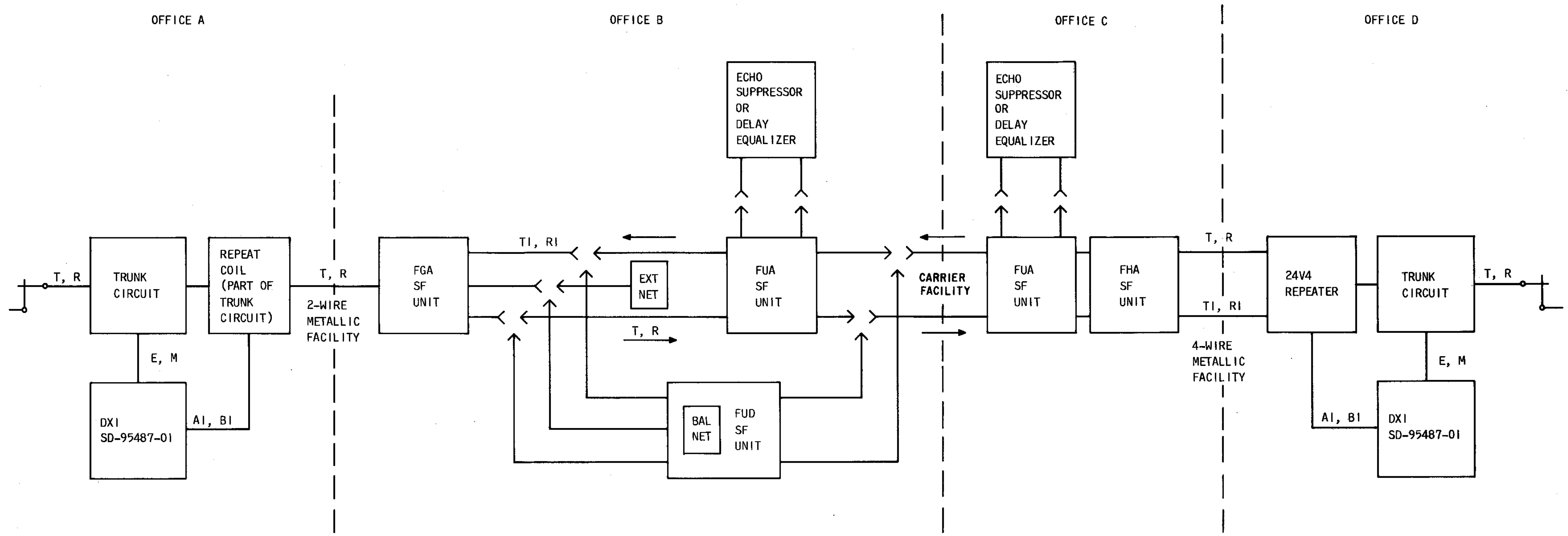
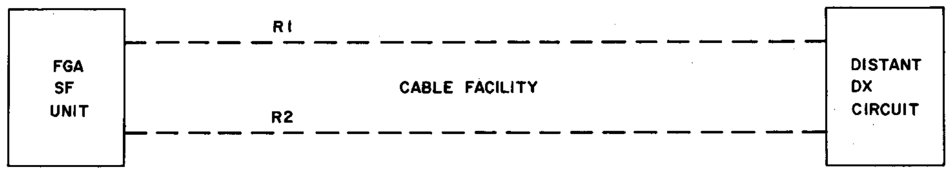
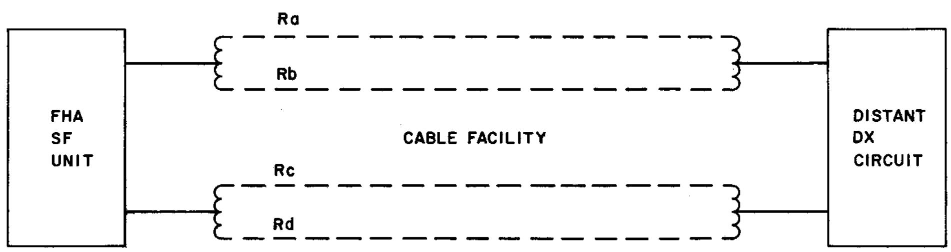


Fig. 5—Typical Application of FGA and FHA SF Units on 2-Wire and 4-Wire Metallic



TOTAL LOOP RESISTANCE EQUALS $R1 + R2$

A. TOTAL LOOP RESISTANCE FOR DX LOOP OF FGA UNIT



TOTAL LOOP RESISTANCE EQUALS $\frac{Ra\,Rb}{Ra+Rb} + \frac{Rc\,Rd}{Rc+Rd}$

B. TOTAL LOOP RESISTANCE FOR DX LOOP OF FHA UNIT

Fig. 6—Method of Determining Total DX Loop Resistance

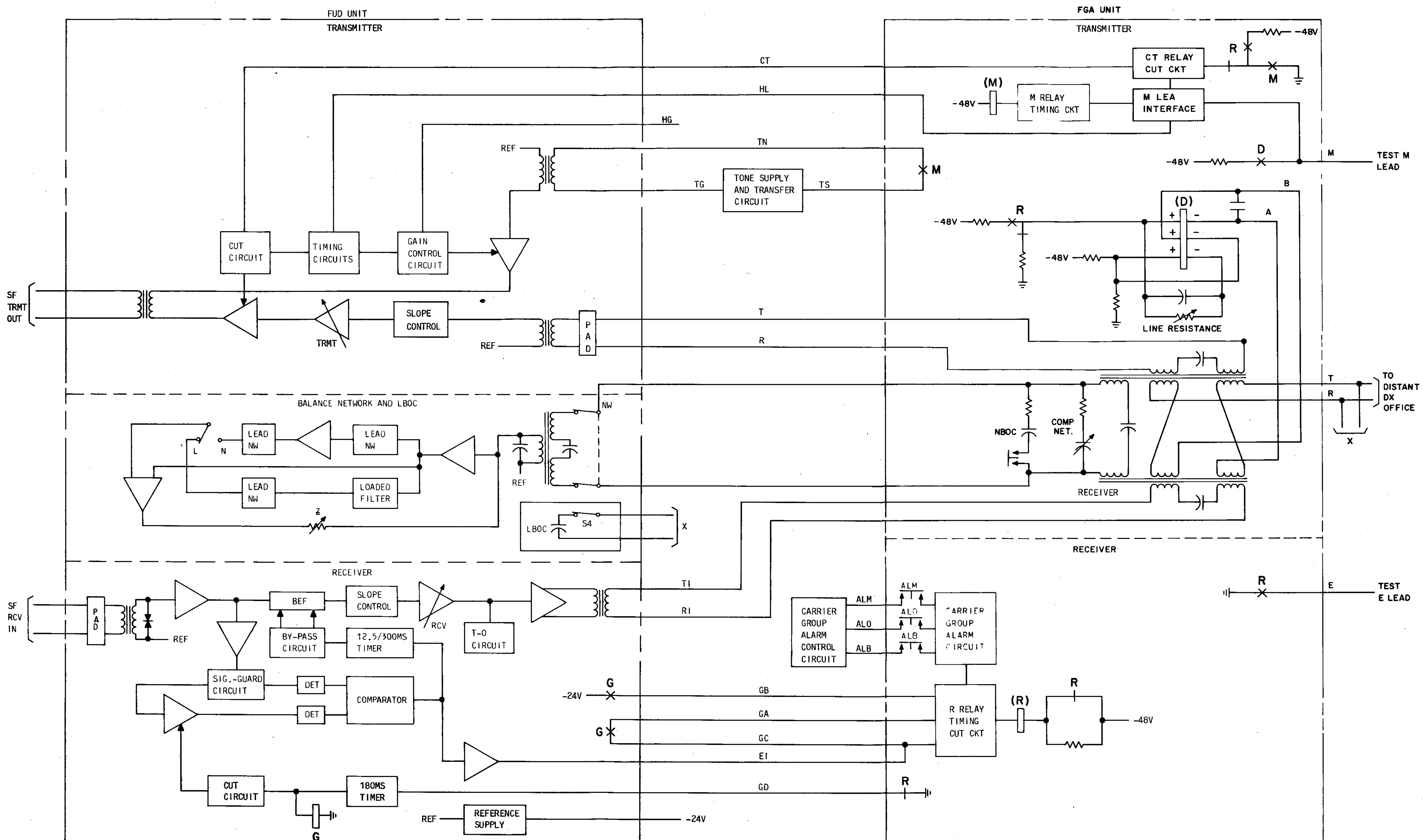


Fig. 7—FUA Plus FGA Unit

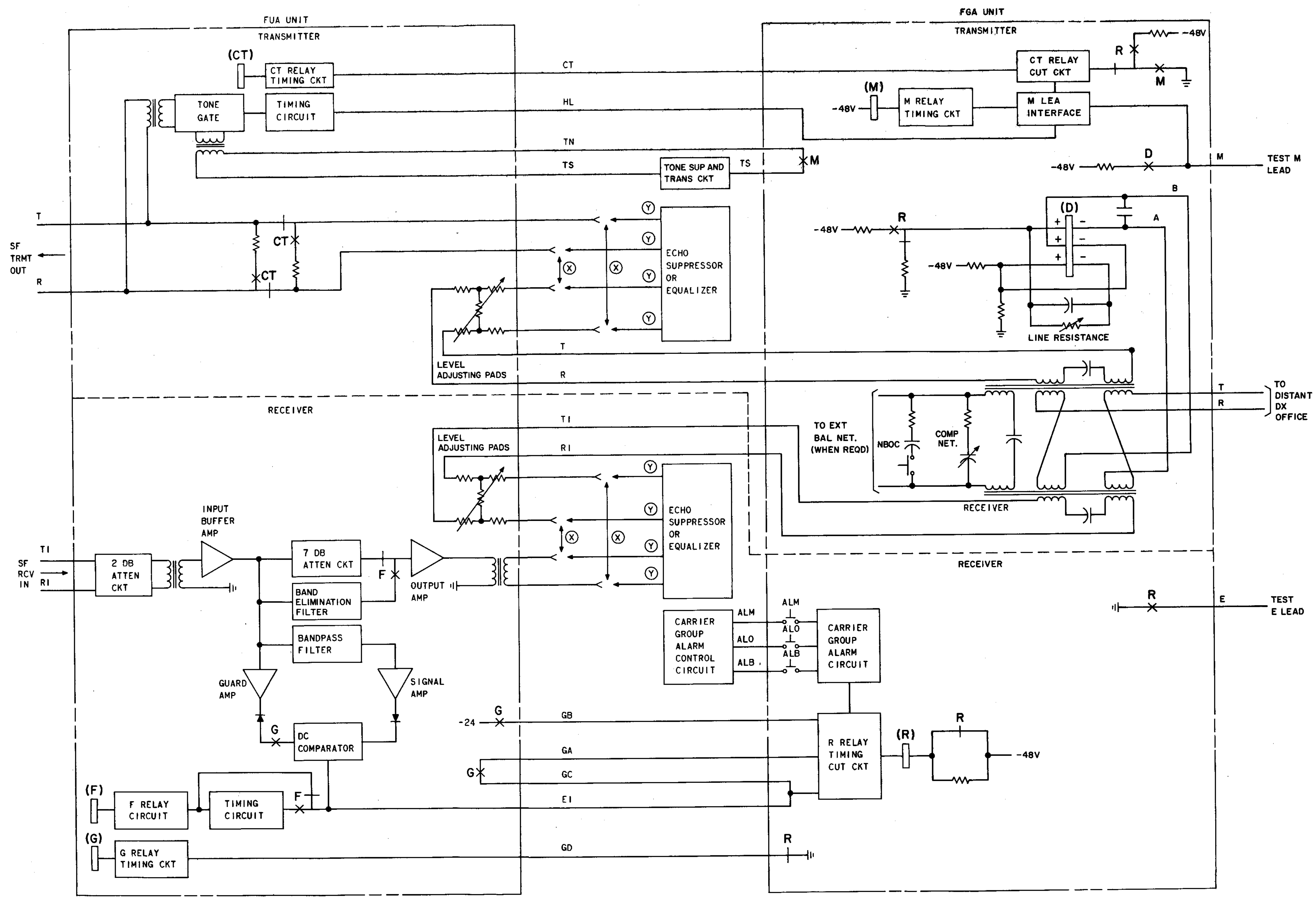


Fig. 8—FUD Plus FGA Unit

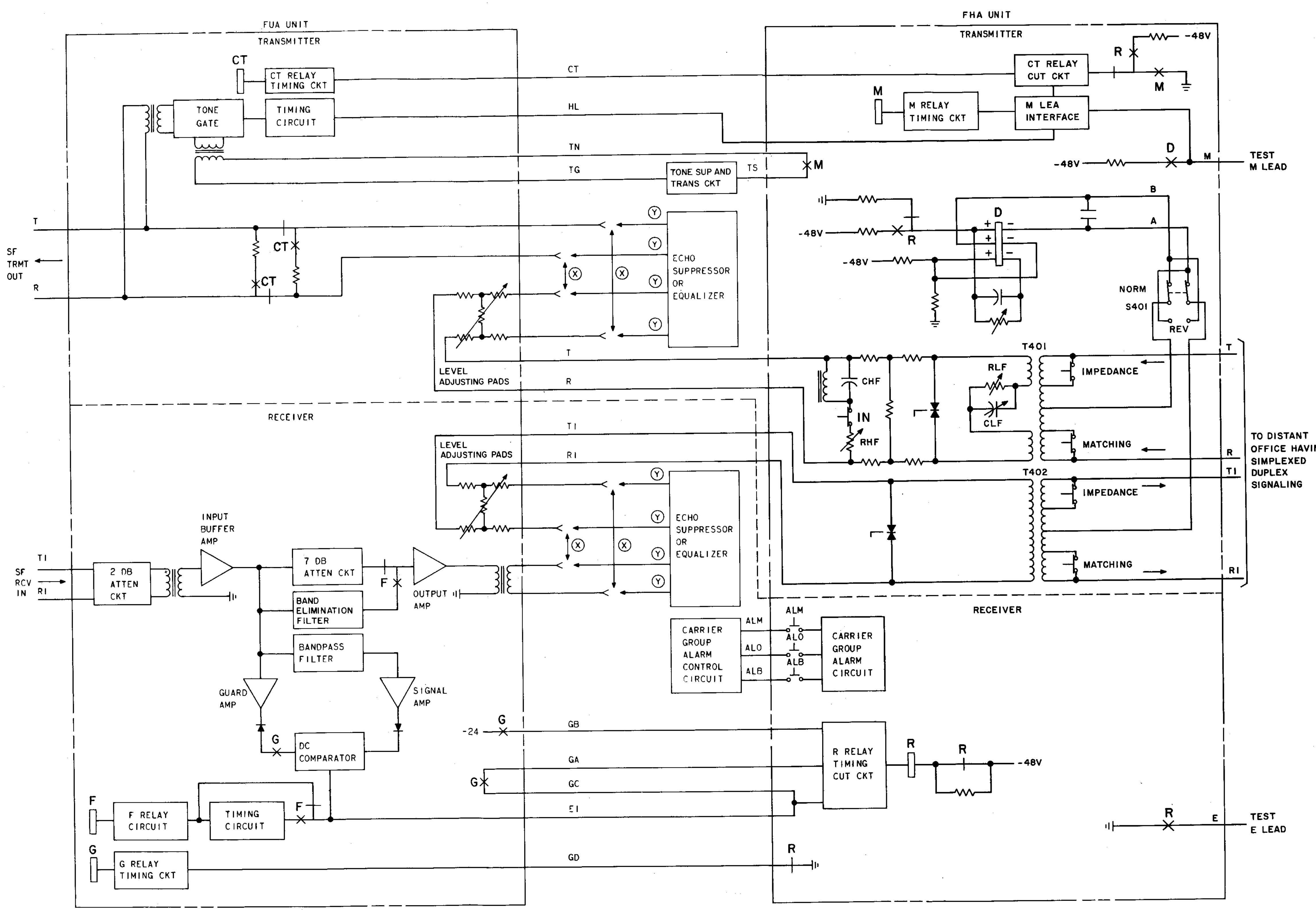


Fig. 9—FUA Plus FHA Unit

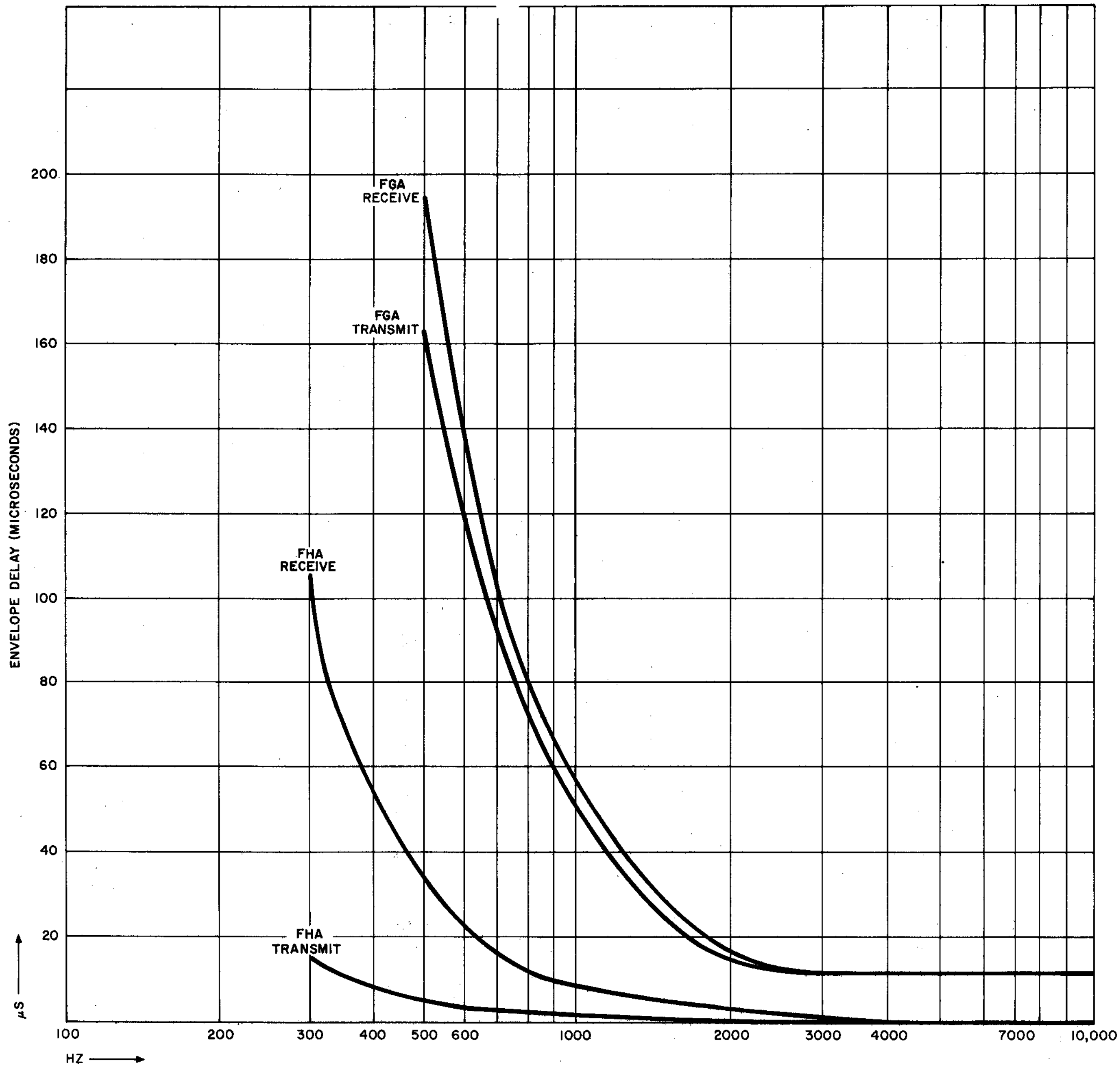


Fig. 10—Nominal Envelope Delay Distortion for the FGA or FHA Unit

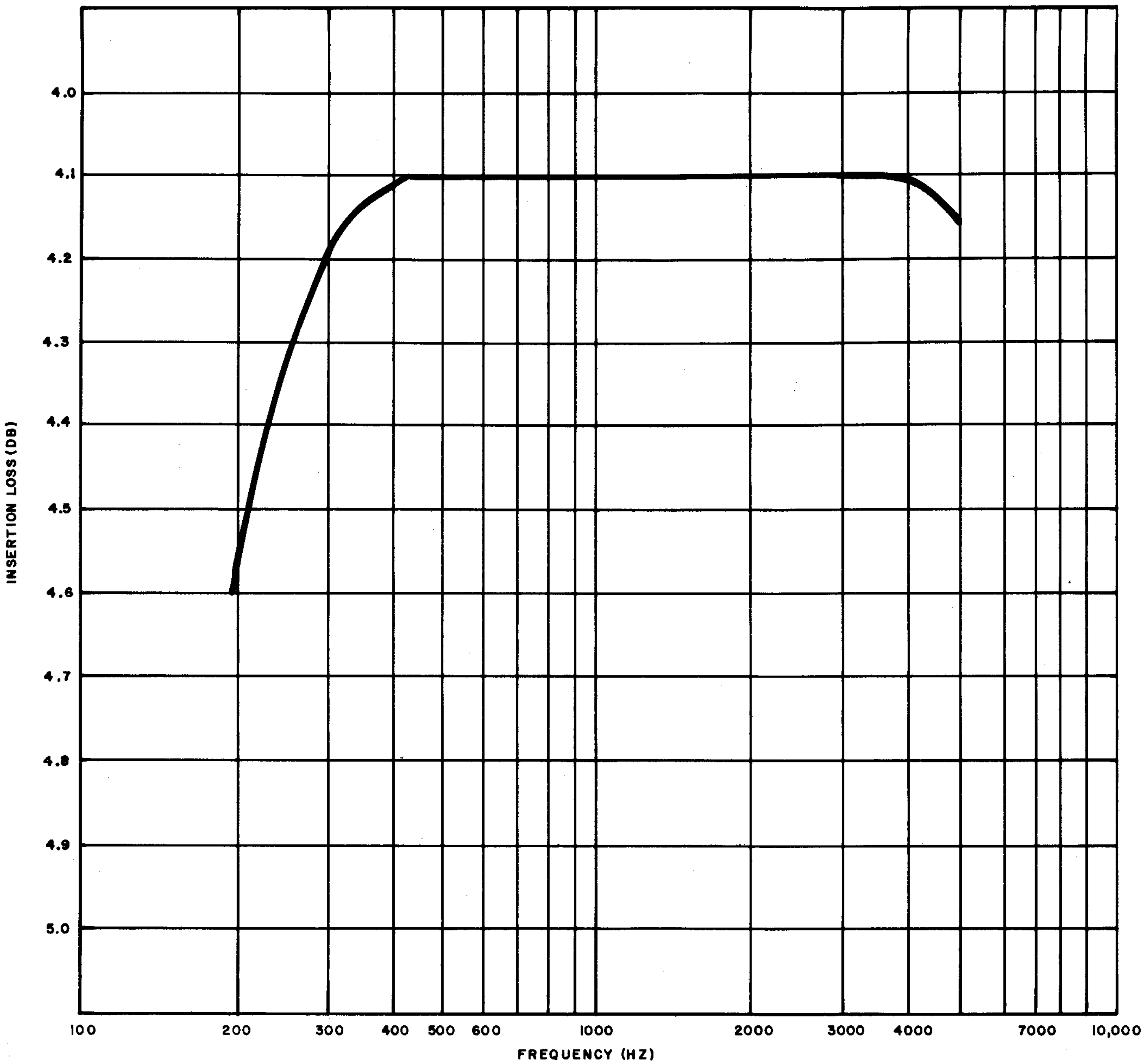


Fig. 11—Nominal Transmit Circuit Insertion Loss for the FGA Unit Plus the FUA ▶or FUD Unit With the Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz◀

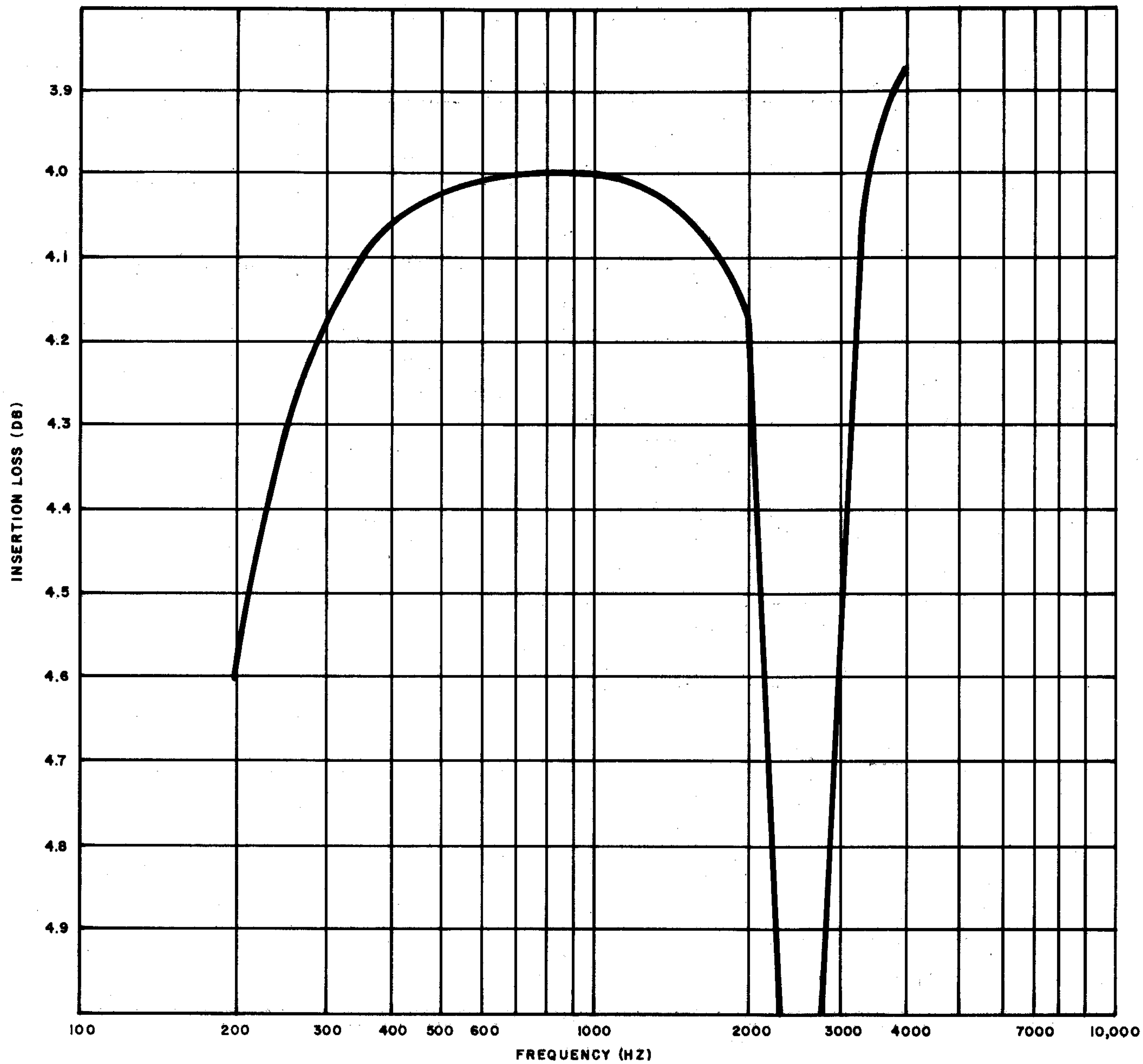


Fig. 12—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter In for the FGA Unit ▶With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz◀

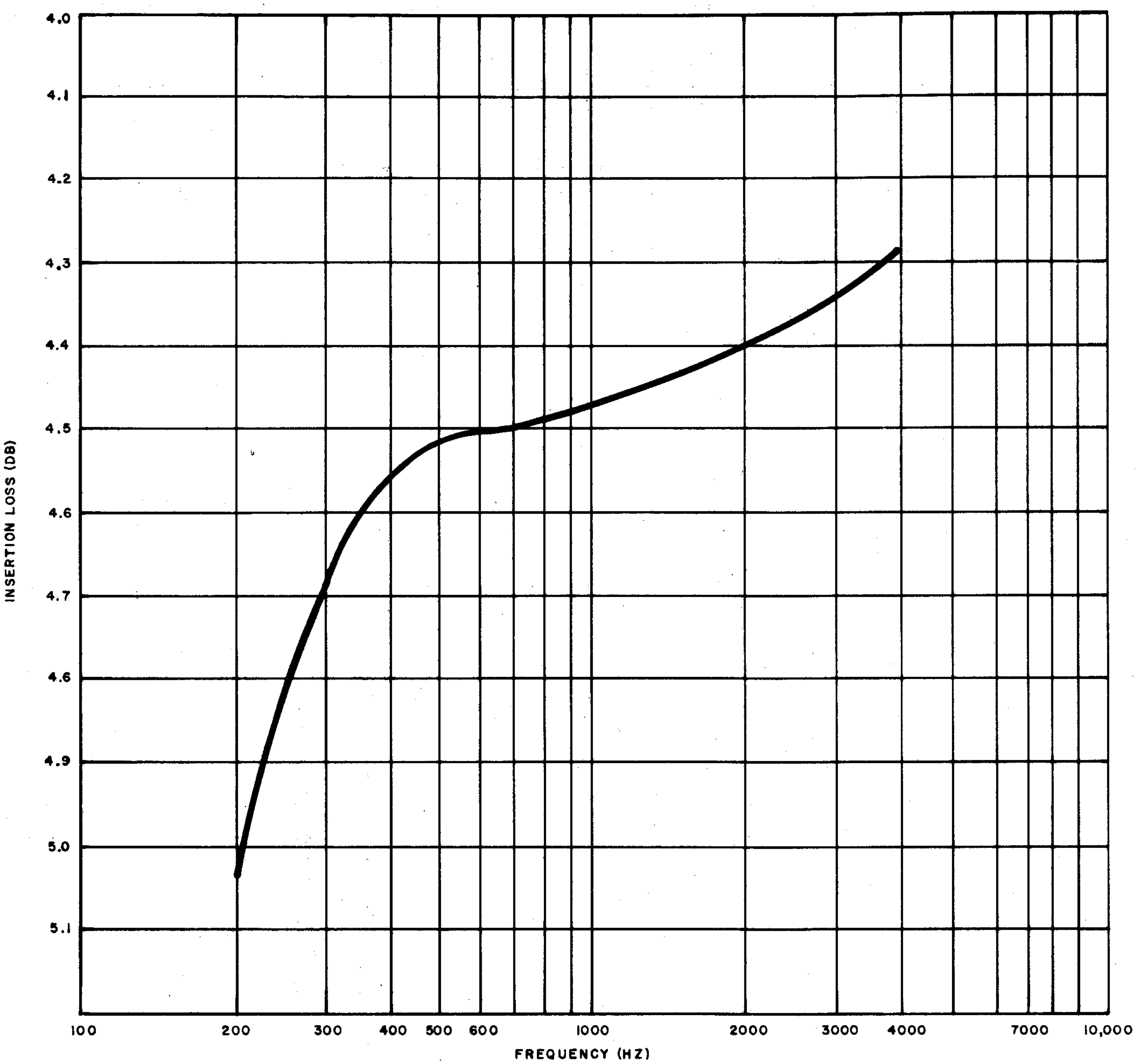


Fig. 13—Nominal Receive Circuit Insertion Loss With Band-Elimination Filter Out for the FGA Unit ▶With Gain of the FUA or FUD Unit Set for Zero Loss at 1 kHz◀

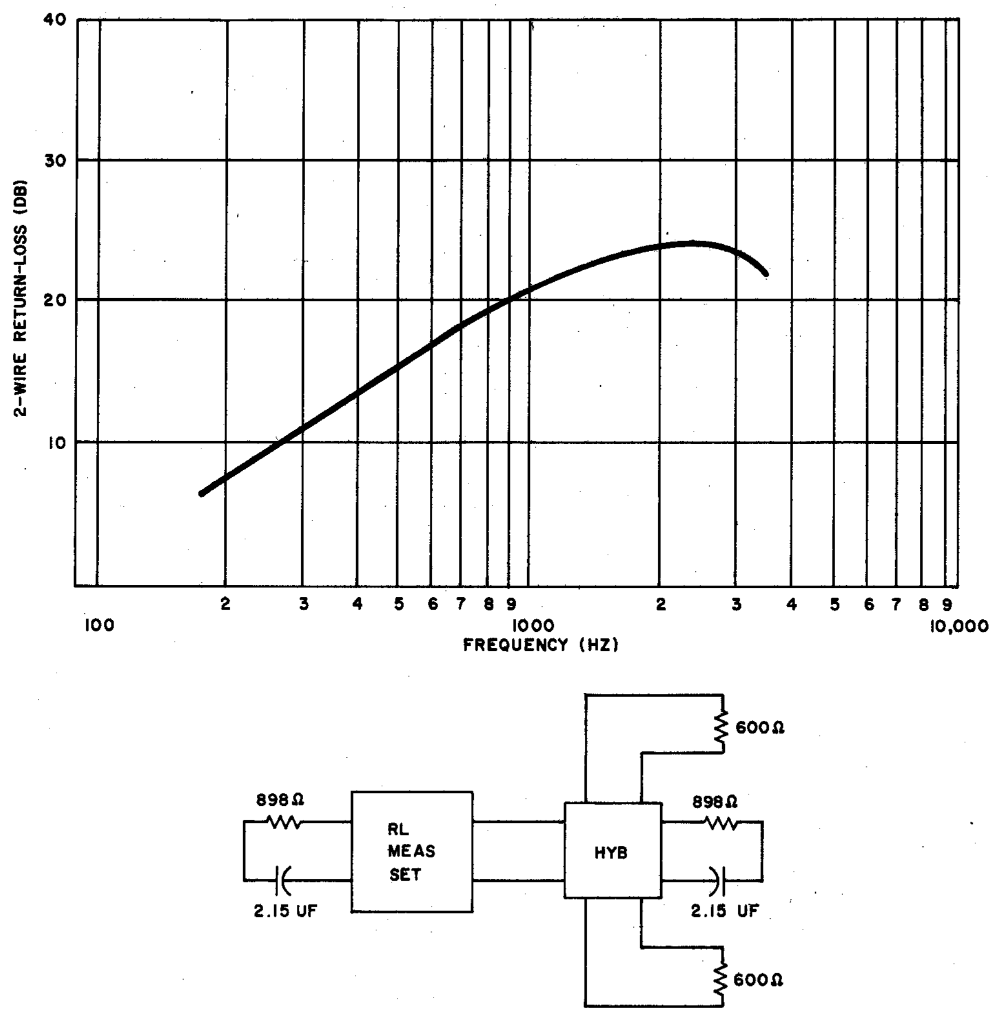
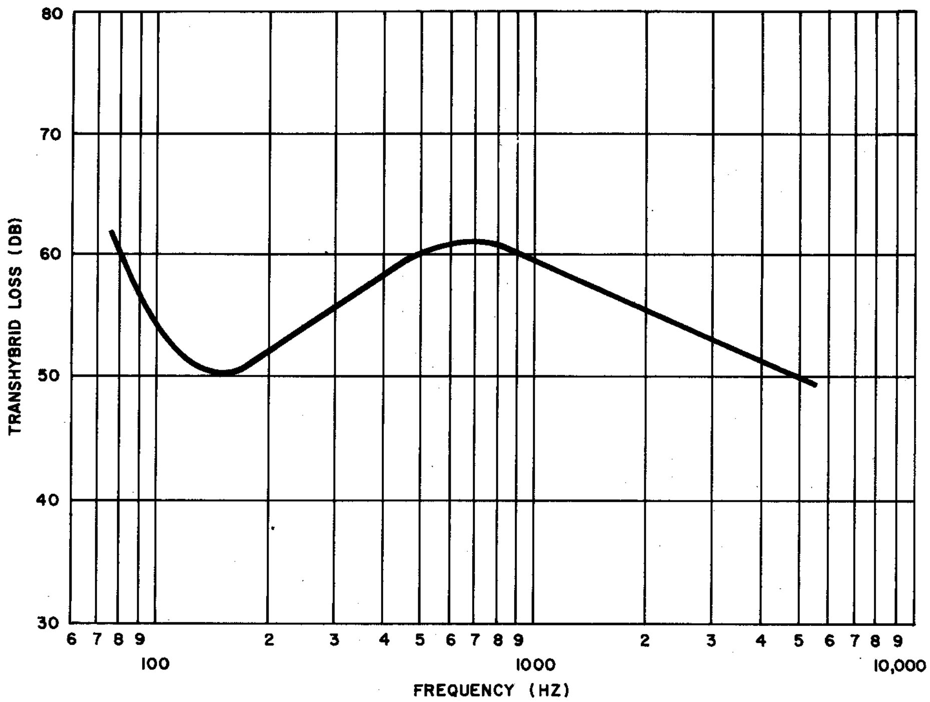


Fig. 14—FGA Unit—Minimum Return Loss-Frequency Characteristics—2-Wire Line Against 900 Ohms Plus 2.15 μf—COMP NET Position of Auxiliary Unit



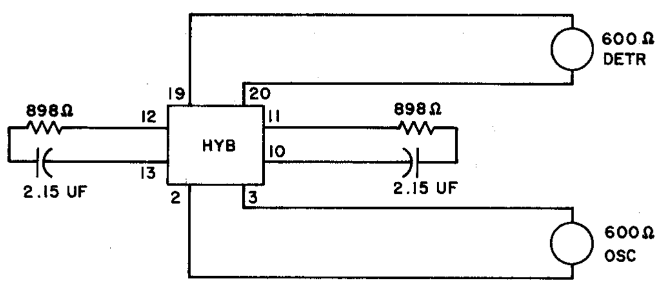


Fig. 15—FGA Unit—Nominal Transhybrid Loss—COMP NET Position of Auxiliary Unit

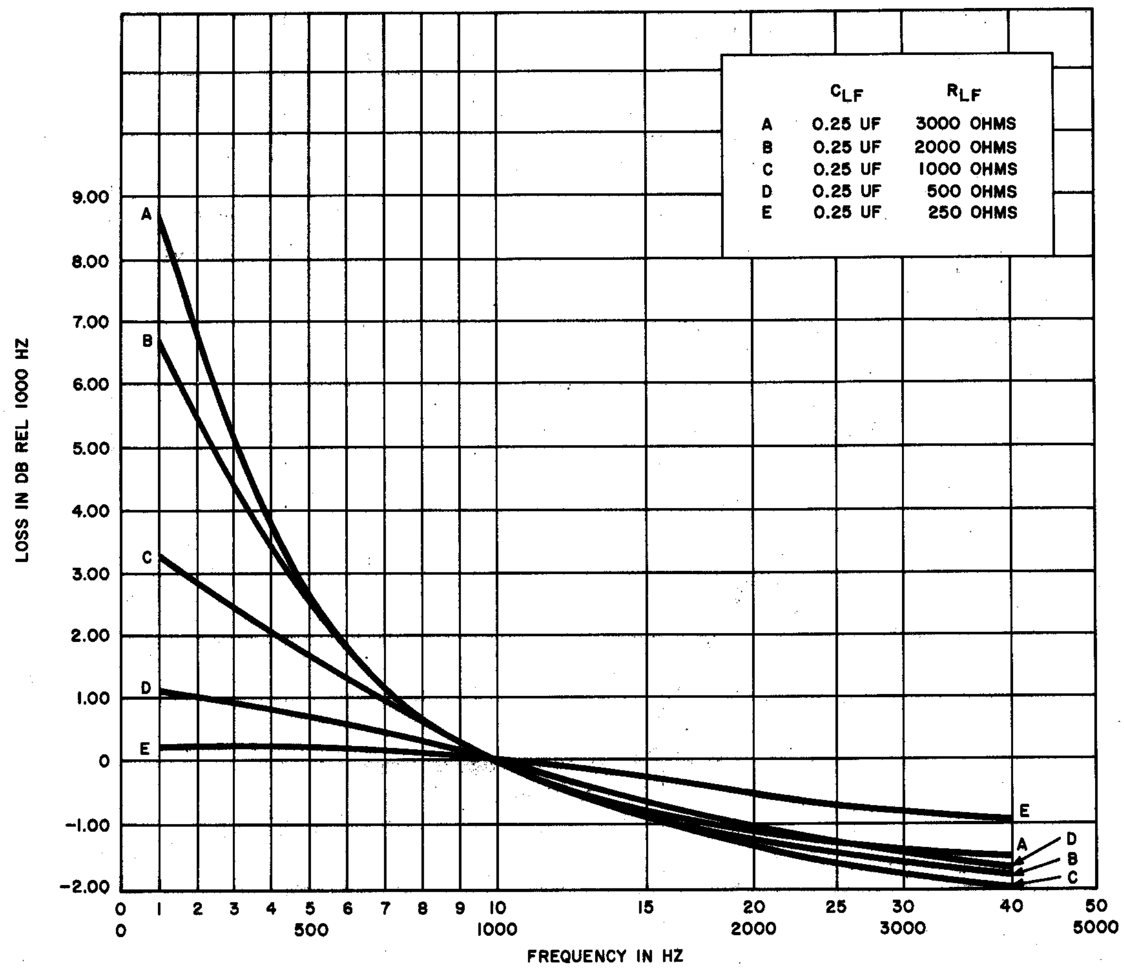


Fig. 16—FHA Unit Low-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—Varying RLF for CLF Constant of 0.25 μf

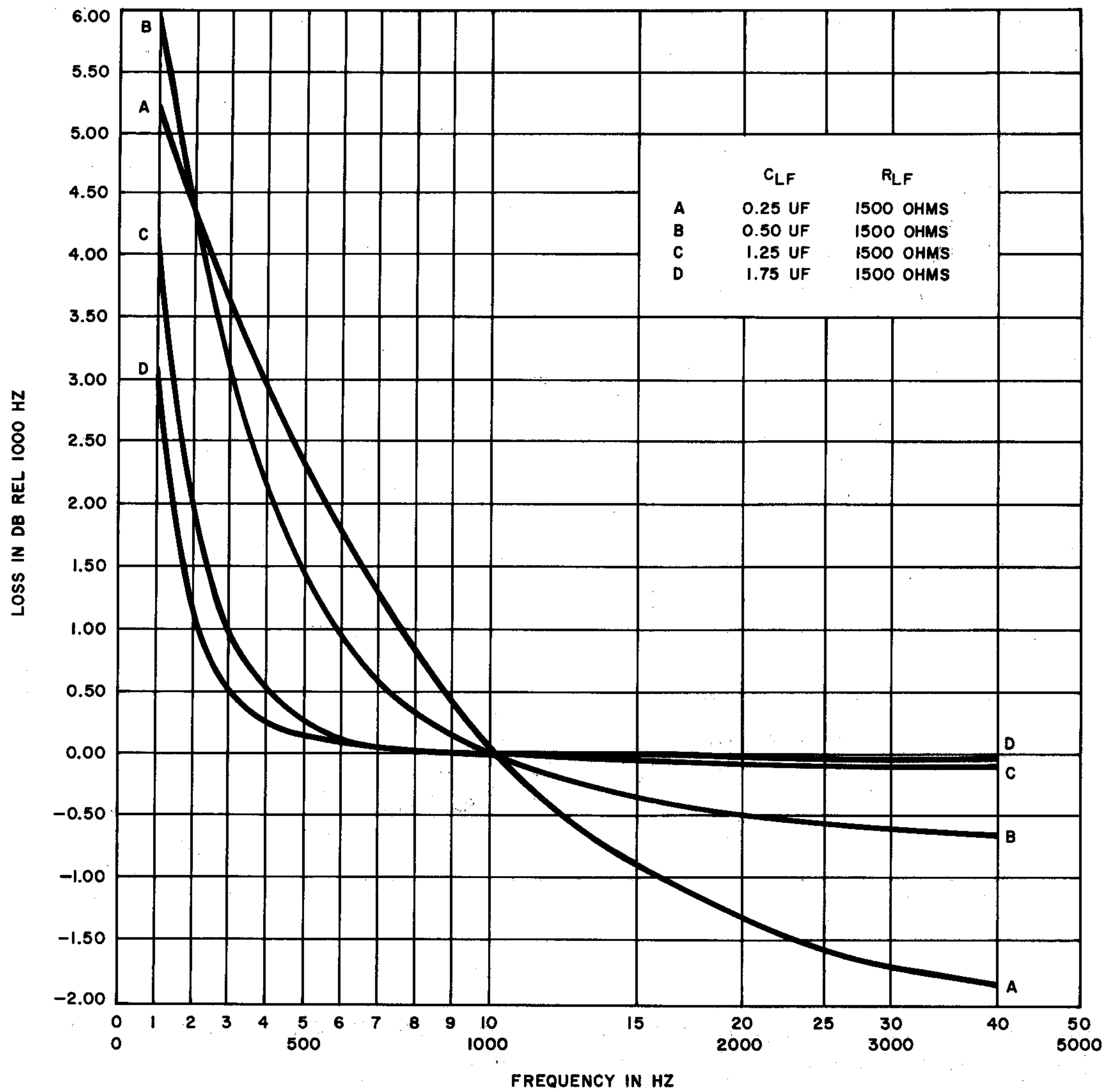


Fig. 17—FHA Unit Low-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—Varying CLF for RLF Constant at 1500 Ohms

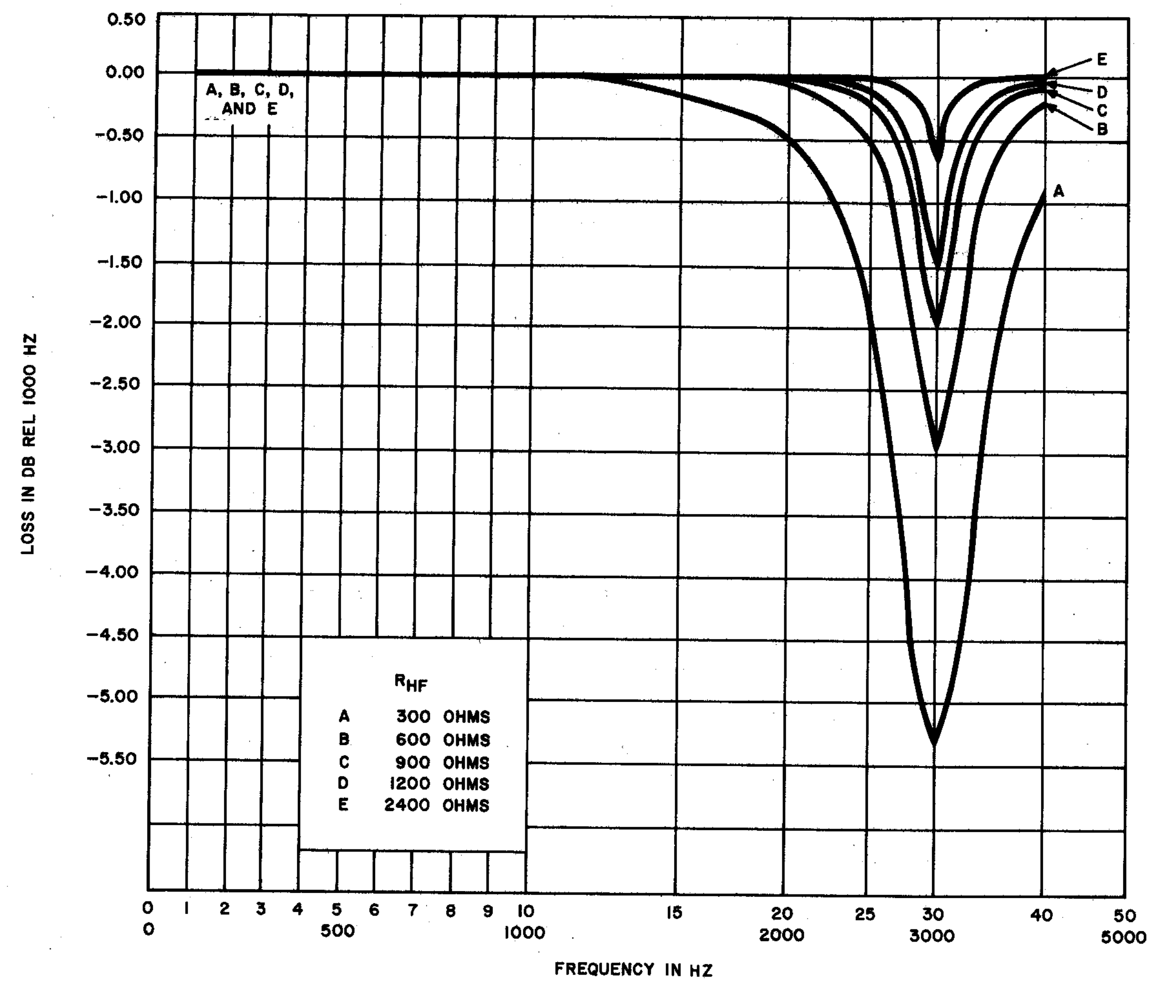


Fig. 18—FHA Unit High-Frequency Section, Loss-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—At Various Settings of RHF

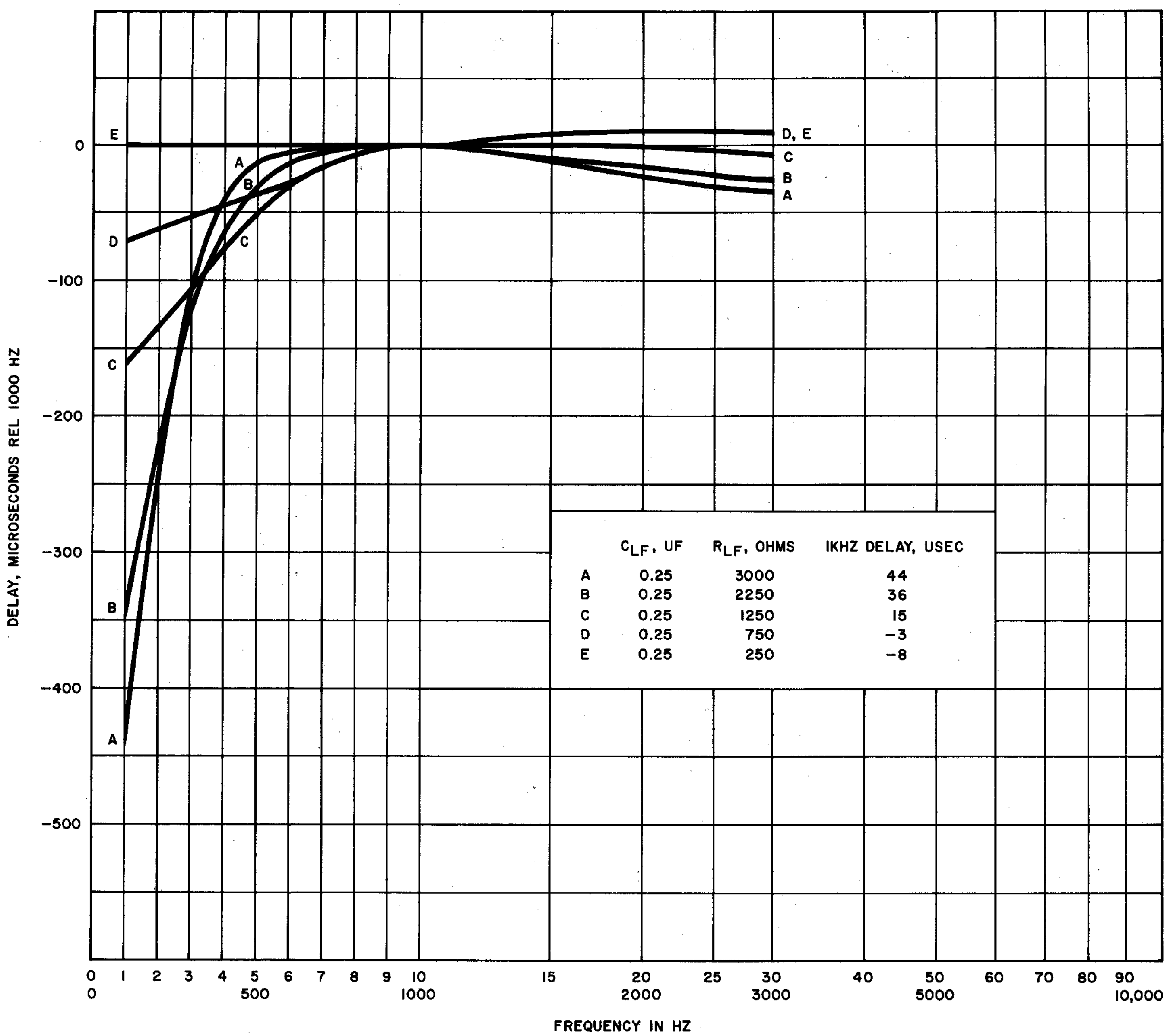


Fig. 19—FHA Unit Low-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—Varying RLF for CLF of 0.25 μf

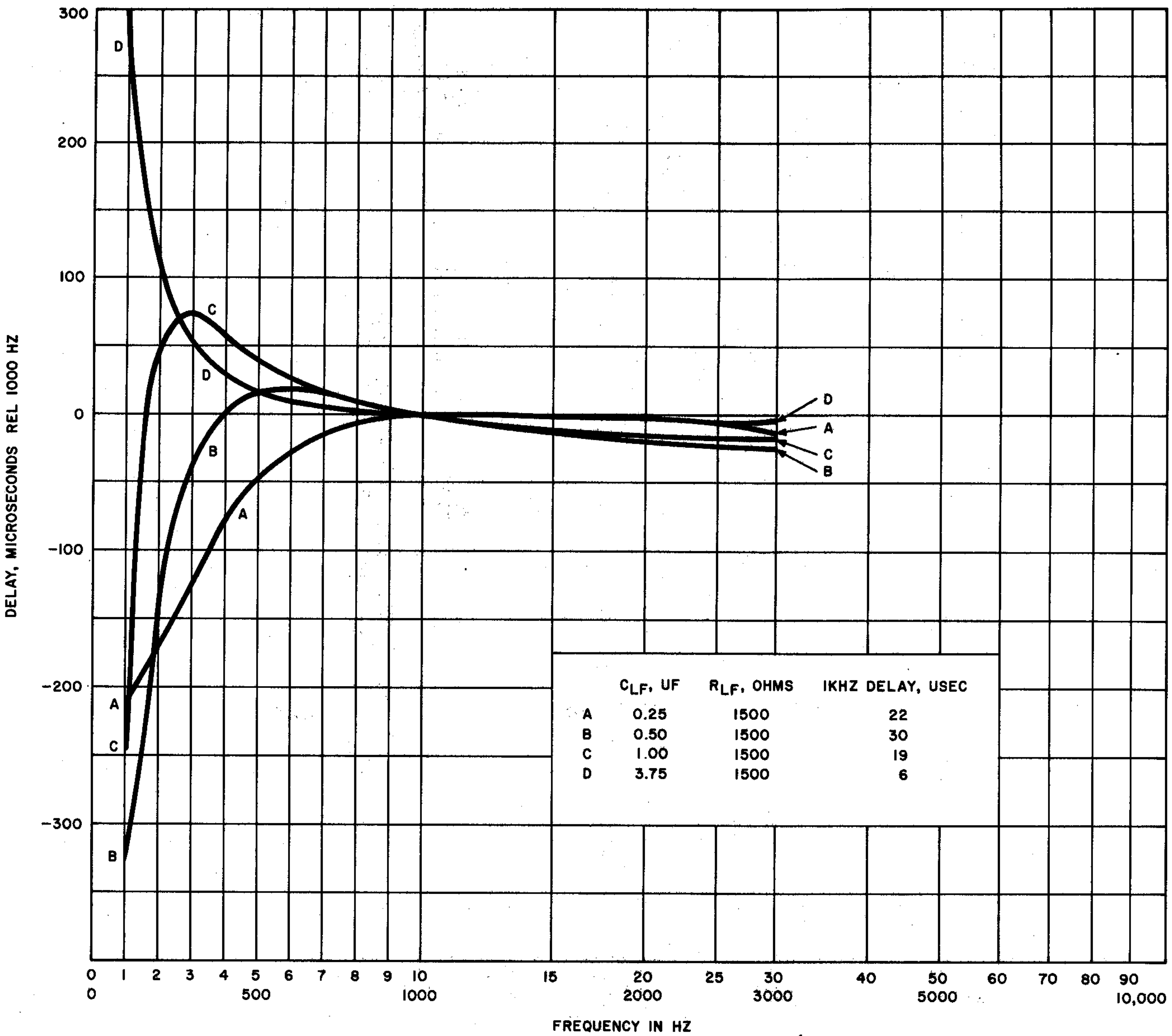


Fig. 20—FHA Unit Low-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—Varying CLF for RLF at 1500 Ohms

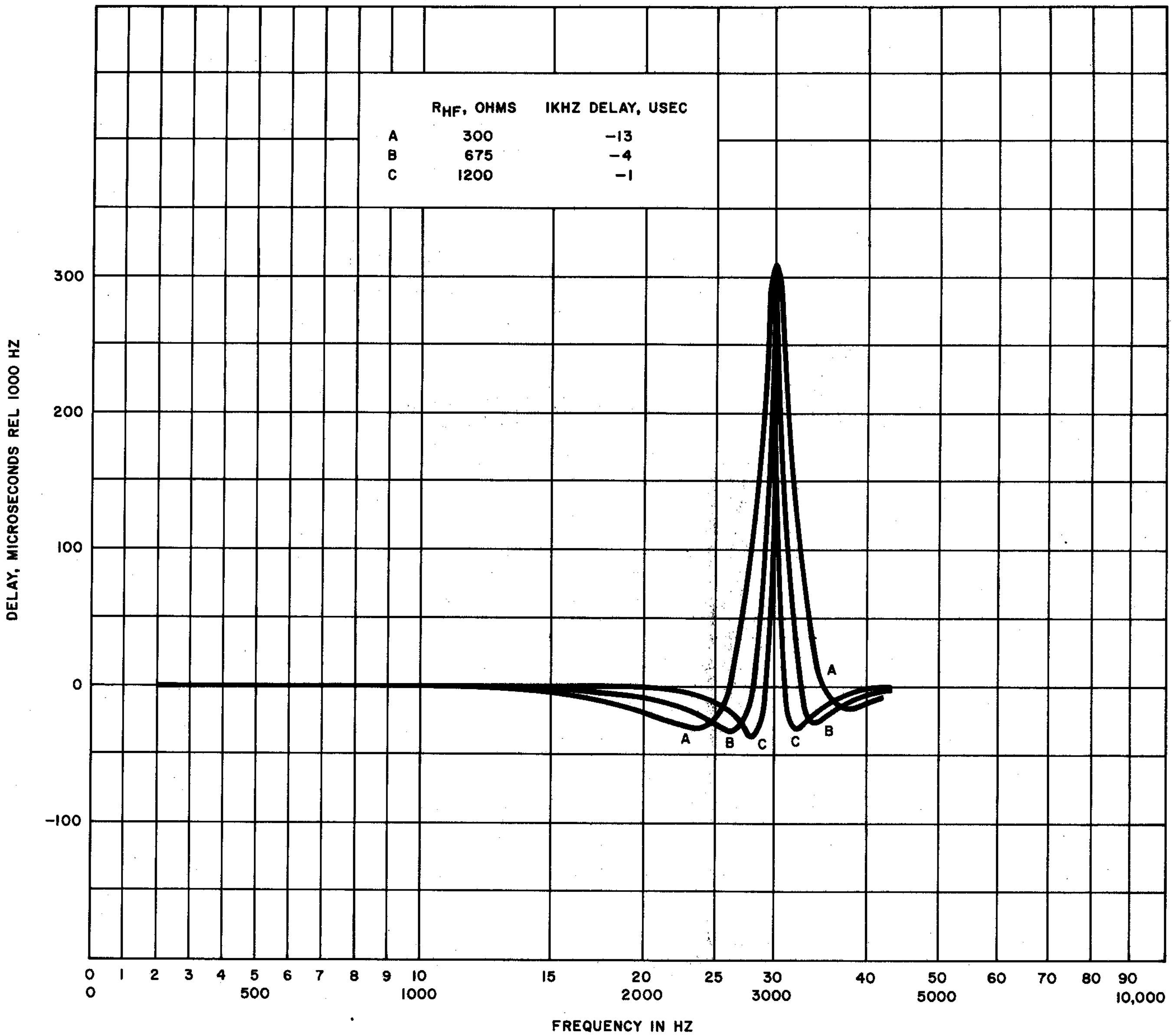


Fig. 21—FHA Unit High-Frequency Section, Delay-Frequency Characteristics Between 1200-Ohm Input and 600-Ohm Output Impedances—At Various Settings of RHF