RADIO ENGINEERING

POINT-TO-POINT RADIO

ONE- AND THREE-CHANNEL PACKAGED SYSTEMS

CONTENTS PAGE

1. GENERAL

A. Scope

1.01 Several types of commercial radio and terminal equipment may be obtained on a "package" basis and used to provide 152 to 162 and 450 to 470 MHz radio circuits for message toll or other services. General engineering aspects of this type of system are discussed in Sections 940-250-100 and -101. These Sections also contain information as to the performance which such systems will provide under various conditions of path loss and site noise.

1.02 This section is issued to describe several types of commercial radio equipment available at this time for one- and three-channel point-to-point applications. Information in this section was formerly covered in Section 940-102-104.

B. Application

1.03 Equipment of the type described in this section may be used to provide from one to three telephone grade circuits over moderate distances where:

(1) Features of terrain make construction of wire plant difficult or impracticable such as over water, swampy, rocky, or mountainous areas.

(2) Temporary relief is required to supplement existing plant.

(3) Sudden demand requires that service be established with a minimum of delay.

(4) Diversification between types of facilities is required to protect against various emergencies.

(5) Order-wire and alarm facilities for a microwave radio system can best be served in this manner.

(6) It may be arranged to provide for emergency restoration of service.

C. Service Features

1.04 Types of terminal and carrier equipment such as Lynch B28R, B37R, B120R, B121R, Western Electric H1 or Lenkurt 33B may be utilized in conjunction with radio equipment of a type used in mobile radio base station service, modified to provide for three-channel service. The Lenkurt 33B terminal and carrier equipment is described in this section but the selection of carrier as well as radio equipment will depend upon local considerations. Equipment assemblies offered provide service features as follows:

(1) Single channel, compandored, with E and M lead or 20-Hz ringdown signaling.

(2) Single channel, noncompandored, with E and M lead or 20-Hz ringdown signaling.

(3) Single channel, compandored or noncompandored, using carrier interruption for ringdown signaling.

(4) Three channel, compandored, with optional E and M lead or ringdown signaling.

D. Physical Arrangements

1.05 Radio equipment may be of the "pole mounted" type for outdoor applications or it may be rack or cabinet mounted for indoor service. The Lenkurt type telephone terminal equipment described in this section will usually be factory assembled in a rack or in a weatherproof cabinet. Inter-unit wiring will be factory installed and the entire assembly tested. Where terminal equipment is to be mounted in an existing bay, the panels may be shipped loose with a factory-made wiring "form," or the units may be factory-assembled into an apparatus unit, tested and shipped with the factory wiring in place. Part 4 of this section offers a more detailed description of the various systems and shows the available options.

1.06 Installations of this type will commonly be made in existing telephone buildings. Where this is not the case, minimum housing arrangements are dictated principally by the temperature requirements of the apparatus items making up the system and by the transmission variations which may be tolerated in the overall system. Based upon suppliers' data, it appears that ambient temperature ranges within which satisfactory operation can be expected are as follows:

APPARATUS ITEM	PROBABLE TEMP RANGE
Radio Equipment	−35° F to +160° F
Carrier and Signaling	+32° F to +120° F
Compandors	−10° F to +120° F

2. TRANSMISSION DESIGN AND SYSTEM LINEUP

A. Performance Objectives

2.01 Effective channel noise of 34 dBa or less at the 0TLP (zero transmission level point) is considered to be satisfactory for VHF and UHF toll end link facilities. Section 940-250-100 discusses the radio transmission characteristics which are required to meet this objective.

2.02 The channel and signaling levels as shown in Fig. 1 are based on the application of FM characteristics of the radio transmitter. When multiplex equipment is used with phase-modulated radio equipment, different level values at the radio terminals will be required.

B. System Planning

2.03 It is desirable to make transmission tests over a proposed path before the final engineering of a radio system is undertaken. When the radio path is optical, or when only small shadow losses are expected, path loss computations in connection with site noise tests as described in Section 940-250-102 will generally provide a satisfactory basis for system engineering. Computations should not be relied upon in situations involving long or obstructed paths.

C. Recommended System Adjustments

2.04 Circuit net loss should, in general, be assigned in accordance with Sections of the Transmission Engineering Series. Figs. 1, 2, 3, and 4 of this section show suitable voice and

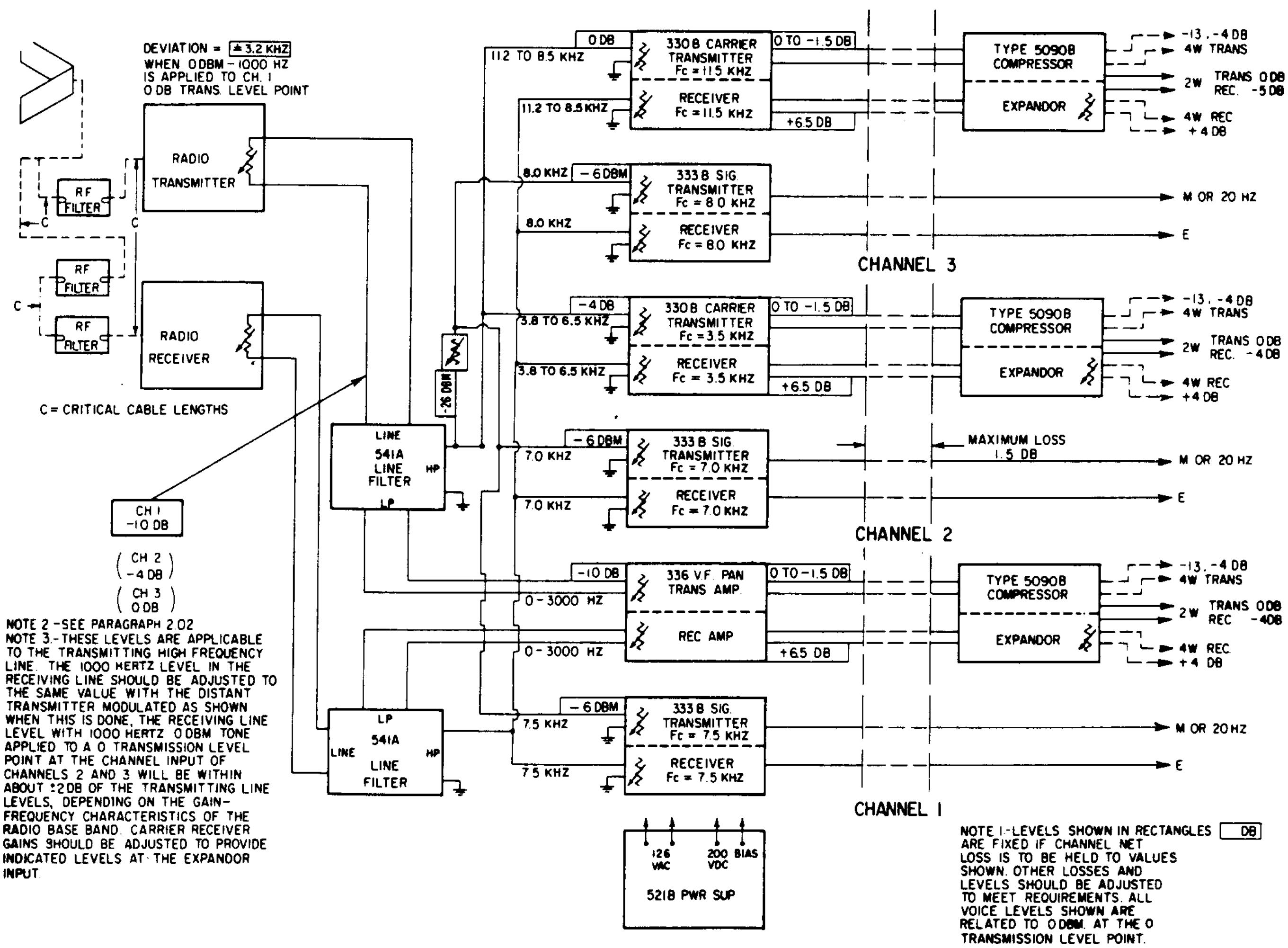

Fig. 1 — Block Diagram Showing Transmission Levels — Three-Channel Compandored System with 2- or 4-Wire Voice-Frequency Extensions with E & M Lead or Ringdown Signaling

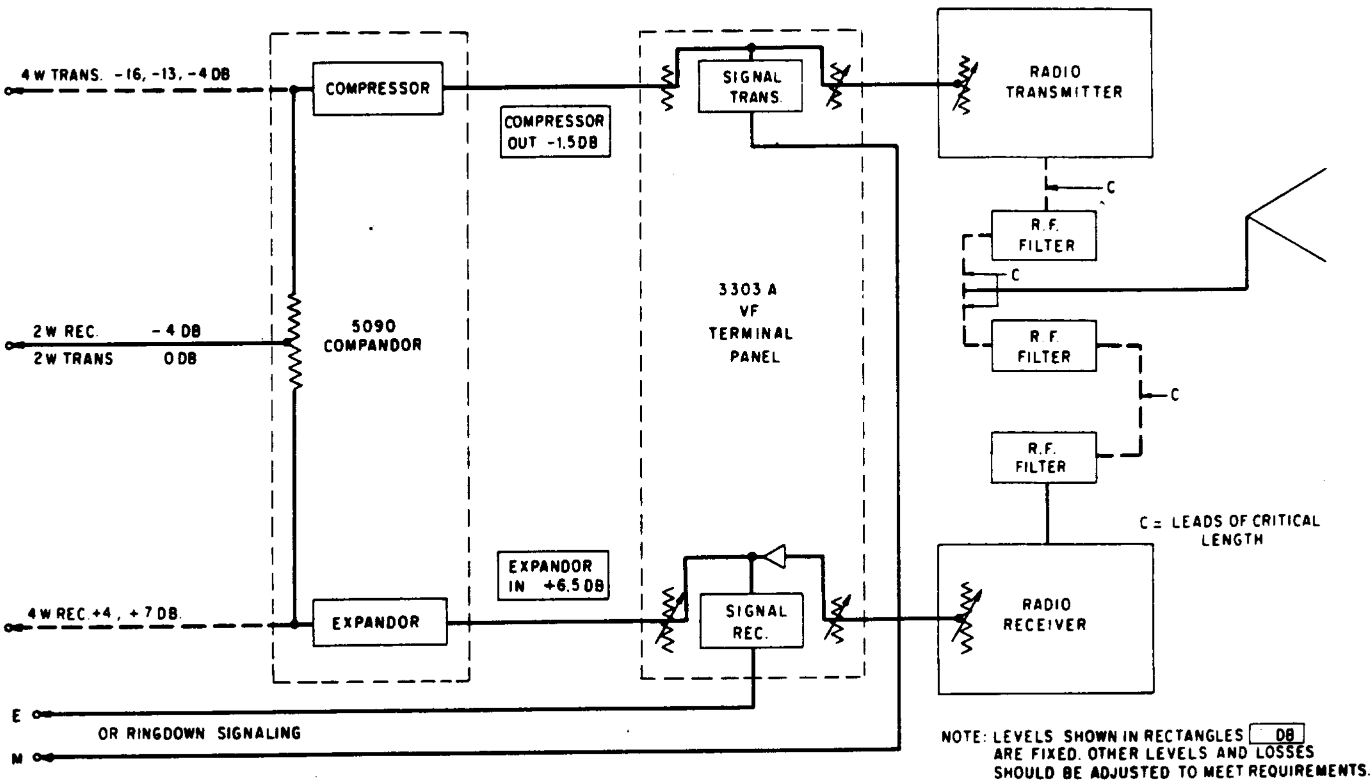

Fig. 2 — Block Diagram Showing Transmission Levels — Single-Channel Compandored System with 2- or 4-Wire Extensions and E & M Lead or Ringdown Signaling

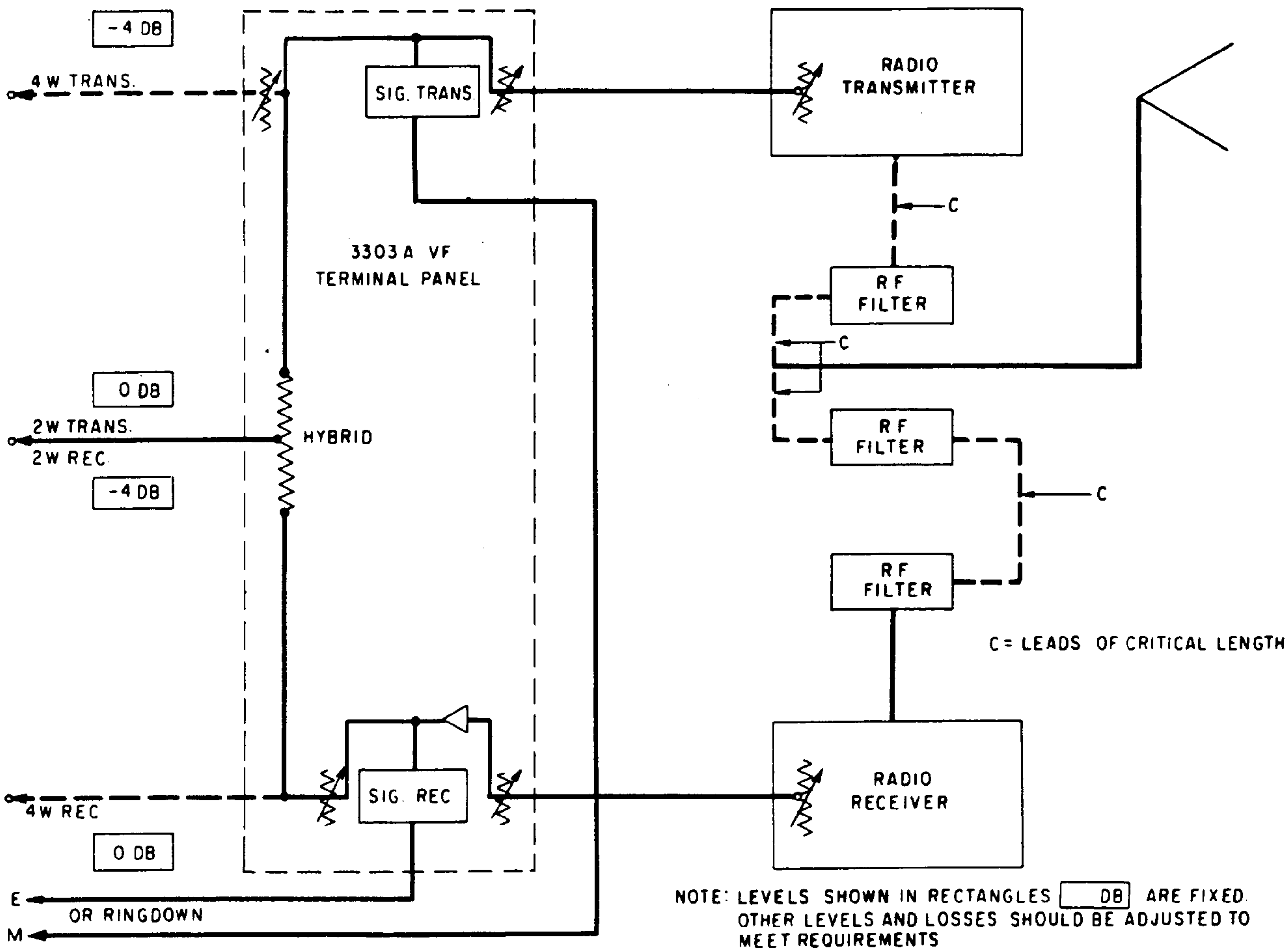

Fig. 3 — Block Diagram Showing Transmission Levels — Single-Channel Noncompandored System with 2- or 4-Wire Extensions and E & M Lead or Ringdown Signaling

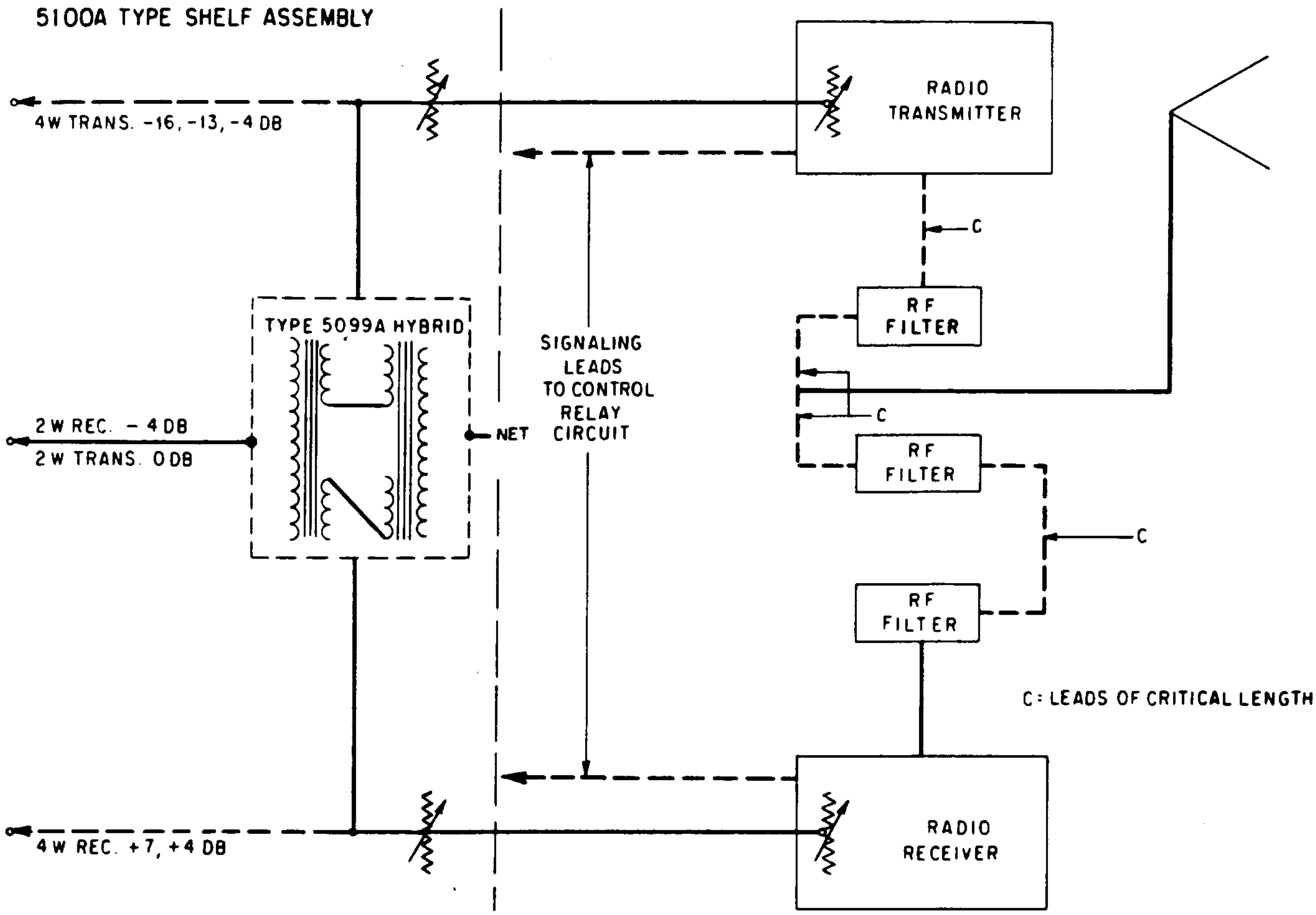

Fig. 4 — Block Diagram Showing Transmission Levels — Single-Channel Non-compandored System with 2- or 4-Wire Extensions Using Carrier Interruption for Ringdown Signaling

signaling levels for the various systems described. These are based upon values developed in Section 940-250-100 but may be modified for specific applications if local conditions require. In situations where SF, MF, or 1000-hertz signaling is used instead of the 33-type signaling (see Paragraph 3.05), these should be applied in the standard manner.

3. INTERCONNECTION ARRANGEMENTS

A. General

3.01 Some situations will be encountered which require the installation of the radio equipment (or the radio and terminal equipment) at locations away from the central office. Depending upon local circumstances, including such factors as space for equipment, availability of wire facilities, etc, one of several plans may be used. These will be discussed in succeeding paragraphs.

B. Extension of Talking Circuits

3.02 Single-channel systems may be extended on a 2- or 4-wire basis. Where 2-wire extensions are indicated, the 4-wire radio portion of the circuit will usually be operated at the losses shown on the transmission diagram for the particular system, and the loss of the wire extension should be limited to a value which will provide a satisfactory circuit net loss in the particular application. Four-wire extensions between radio and terminal equipment should be limited in length to the losses indicated in Fig. 2, 3, and 4 unless V-type repeaters are installed. Where 4-wire VF extensions are made on the equipment side of repeating coil-type hybrids, care must be taken to assure that the impedance-frequency characteristics of the facilities used will result in satisfactory hybrid balance. Situations requiring carrier line extensions on three-channel systems will require special consideration of the problems of slope and crosstalk which may be encountered.

3.03 Two-wire terminations may be obtained by the use of resistor hybrids which are available as part of the Lenkurt type 5090B compandor or 3303A signaling panel. These are satisfactory for use at nongain switching points, but do not have adequate balance characteristics for use at gain switching points. At gain switching points it is necessary to provide repeating coil type hybrids with either compromise or precision networks.

C. Extension of Signaling Circuits

3.04 Installation of radio equipment at locations other than the central office will also require consideration of signaling needs. Where Lenkurt 333B or 3303A signaling panels are located at the radio equipment, E and M leads may be extended over distances equivalent to about 1500 feet of 22-gauge cable (approximately 40 ohms) using composite sets or A and B lead arrangements. Extensions of greater length will require the use of E and M lead extension circuits such as SD-95487-01 and SD-95488-01. As an alternative in the case of single-channel installations having 4-wire extensions, the 3303A signaling panel may be installed at the central office subject, of course, to the limitations imposed by the frequency-attenuation characteristics of the connecting facilities.

3.05 Where installations of the type described are made between offices having existing SF, MF, or 1000-Hz signaling suitable for the particular application, it may be desirable to install the radio and terminal equipment without the built-in signaling panels and use the existing signaling facilities.

3.06 Three-channel systems will usually operate with radio transmitters and receivers continuously energized. Single-channel systems having very high usage may also operate on this basis. Single-channel systems having only low or moderate usage may be operated on an intermittent carrier basis with the transmitter filaments energized but with the radio carrier under control of the "sleeve" circuit of the switchboard equipment. This arrangement may permit substantial economies in power consumption and will generally be effective in providing better tube life in the transmitters.

D. Automatic Station Identification

3.07 To conform to FCC regulations, unattended single-channel radio systems require the application of a station identifier.

Several commercial manufacturers can provide units for this purpose.

4. APPARATUS DESCRIPTION

A. General

4.01 Figures 1, 2, 3, and 4 provide block schematic and level diagrams for the apparatus arrangements discussed in this section. Terminal equipment required for the systems of Fig. 1, 2, and 3 is manufactured by the Lenkurt Electrical Company and information is contained in the following Lenkurt papers:

33B — 14939-AD

33B — 14939-DES

33B — 14939-ORD

These papers are obtainable from the Lenkurt Electric Company and any changes or revisions will be noted in the monthly supplement to the Lenkurt master index on the same basis as their 45A and 73B equipments. (See PEL 5380.)

4.02 The system shown in Fig. 4 provides ringdown signaling by means of a locally assembled relay circuit. This unit, which is described in Part 5 of this section, may be used together with radio equipment of the type used in other single-channel systems and available 4-wire terminating to provide a satisfactory low cost facility under some conditions. In situations requiring ringdown signaling along with the transmission advantages obtainable through the use of compandors, this relay equipment may be substituted for the 3303A-type signaling in the system of Fig. 2.

4.03 All systems described may be operated with 2- or 4-wire voice-frequency drops. Transmission levels contemplated in the equipment design are as follows:

	SINGLE-CHANNEL NONCOMPANDORED	ONE- OR THREE-CHANNEL COMPANDORED
2-wire Transmit	0 dB	0 dB
2-wire Receive	—4 dB	—4 dB or lower
4-wire Transmit	—4 dB	—16*, —13, —4 dB
4-wire Receive	+4 dB	+7*, +4, +4 dB

* Available single-channel terminals only.

4.04 Other characteristics of the Lenkurt terminal assemblies are as follows:

	SINGLE-CHANNEL (EA-14939-01, FIG. 4)	THREE-CHANNEL RACK TYPE (EA-14939-01, FIG. 1)	THREE-CHANNEL RACK OR CABINET TYPE (EA-14939-01, FIG. 2)
19-inch rack space	29-3/4 in	71-3/4 in	63 in
Depth (in front of rack)	7-1/4 in	7-1/4 in	7-1/4 in
Weight (complete assembly — exclusive of rack)	69 pounds	172 pounds	167 pounds
Power requirement (117 Vac)	Approx 50 watts	Approx 100 watts	Approx 100 watts
IMPEDANCE			
VF drop, 2- or 4-wire		600-ohm balanced	
Carrier line or equipment		600-ohm balanced	

4.05 Table 1 provides a summary of the apparatus items making up the several systems. Part 5 of this section describes the various equipment panels briefly and Part 6 provides information relative to the combinations of radio equipment available for point-to-point service.

5. DESCRIPTION OF TERMINAL EQUIPMENT UNITS

5.01 This section provides a brief description of the various Lenkurt panels making up the terminals described in Part 4. More detailed information concerning these units may be found in the Lenkurt bulletins which are referred to in the equipment descriptions below:

(a) ***Type 330B Terminal Panel.*** Each Lenkurt type 330B panel provides a complete single sideband suppressed carrier terminal, including transmitting and receiving oscillators, modulator and demodulator, transmitting and receiving amplifiers, and necessary pads and filters. In addition, a repeating coil hybrid and compromise network are included. The coil acts as an output transformer when VF drops are operated 4-wire. Terminal panels used in the three-channel application have carrier frequencies of 3.5 kHz and 11.5 kHz transmitting upper and lower sidebands, respectively.

TABLE 1

SUMMARY OF LENKURT APPARATUS PANELS MAKING UP VARIOUS TERMINAL ASSEMBLIES

LENKURT APPARATUS PANEL DESIGNATION	SINGLE-CHANNEL TERMINAL (EA-14939-01, FIG. 4)	THREE-CHANNEL TERMINAL WITH CHANNEL COMPANDORS RACK-MOUNTED TYPE (EA-14939-01, FIG. 1)	THREE-CHANNEL TERMINAL WITH CHANNEL COMPANDORS CABINET OR RACK-MOUNTED TYPE (EA-14939-01, FIG. 2)
330B carrier terminal panel		2	2
333B signaling panel		3	3
3303A VF terminal panel	1**		
336A voice-frequency panel		1	1
510A-P terminal block	1		
510B-P terminal block		1	1
521B power supply		1	1
521C power supply	1		
534B alarm panel	1*	1*	1*
5027A ac junction box panel	1		
5086A-2A transformer panel	1*	1*	1*
5090B compandor	1*	3	3
5083B compandor shelf assembly	1*	1	1
5099A 4-wire term. set	1*	3*	3*
5100A 4-wire term. set shelf assembly	1*	1*	1*
5103A telephone set panel	1*	1*	1*
5220A jack field	1*	1*	1*
Rack or cabinet	1	1	1

Note: These terminals may be assembled in rack or weatherproof cabinet as desired.

* Equipment items not required for any particular installation may be omitted. (See ordering information.) Details of the arrangements are shown on Lenkurt Drawing EA-14939-01, the latest issue of which should be consulted.

** The 3303A VF terminal panel is to be used in place of the 333B signaling panel shown in Fig. 4 of EA-14939-01 for single-channel terminals.

Physical and electrical characteristics of the unit are as follows:

CARRIER LINE	TRANSMIT	RECEIVE
Impedance	600-ohm unbal	600-ohm unbal
Level	+10 dBm max	—16 dBm min (for 4 dB circuit)
	0 dBm nom	+5 dBm max
VF Line		
Impedance	600-ohm	600-ohm
Level	Commensurate with compandor	
Tube Complement	1 — 6AL5 and 2 — 5692 or 2 — 6SN7	
Power Require-ments*	200 Vdc 12.6 Vac —6 Vdc	22 mA 0.9 AMP bias

* AC operation with 521-type power supply. May also be operated with 130 V plate battery and 24 V filament battery.

Size	Height	8-3/4 in
	Length	19 in
	Depth	7-1/4 in (in front of panel)
Weight	22 pounds	
Manufacturer's Specification Bulletin	330B-S	

(b) ***Type 333B Signaling Panel:*** The 333B signaling panel provides E and M lead or ringdown signaling. A signaling tone is generated by the transmitting oscillator and is controlled by the transmitting relay. It is applied to the transmission path through an integral filter. The panel also contains a receiver unit which is made up of a filter, limiting amplifier, detector, dc amplifier, and receiving relay. Transmitting and receiving relays are plug-in type and permit selection of ac or dc signaling as required. Characteristics are as follows:

Transmitter	Impedance	Bridging (unbal)
	Level (cont. var.)	—10 to 0 dB
	Strap	+10 dB max
Receiver	Impedance	Bridging (unbal)
	Level	—30 dB
Options	E and M Signaling AC Ringdown Full or Half Duplex Signaling	
Tube Complement	1 — 5691, 1 — 5692, 1 — 6AL5, or 1 — 6SL7, 1 — 6SN7, and 1 — 6AL5	
Power Require-ments*	200 Vdc 20 mA 12.6 Vac 0.9 AMP	

* AC operation with 521-type power supply. May also be operated with 130 V plate battery and 24 V filament battery.

Size	Height	5-1/4 in
	Length	19 in
	Depth	7-1/4 in (in front of rack)
Weight	12 pounds	
Manufacturer's Specification Bulletin	333B-S	

(c) ***Type 3303A VF Terminal Panel:*** The 3303A VF terminal panel is a full-duplex voice-frequency panel which provides terminating and signaling equipment for one voice channel. Each panel includes transmitting and receiving 2400-hertz low-pass filters, a receiving VF amplifier, level adjusting pads, and a resistor hybrid network. Signaling oscillator, sending and receiving circuits, including relays, are incorporated in the panel.

Impedances—Input and Output—600 ohms unbalanced

Transmitting Levels

2- or 4-wire drop	0 dBm nominal
VF Transmitting Line	—7 dBm maximum

Receiving Levels		
2-wire drop		−6 dBm nominal −2 dBm maximum
4-wire drop		0 dBm nominal +7 dBm maximum
VF Receiving Line		−20 dBm minimum

Options	AC Ringdown Full or Half Duplex DC Signaling E and M Signaling
Power Requirements*	200 Vdc 40 mA 12.6 Vac 1.2 AMP

* AC operation with 521C power supply. May also be operated with 130 V plate battery and 24 V filament battery.

Tube Complement	4 — 6SN7	
Size	Height	7 in
	Width	19 in
	Depth	7-1/4 in
Weight	24 pounds	
Manufacturer's Specification Bulletin	3303AS	

(d) ***Type 336 VF Terminal Panel:*** The 336A terminal panel is used to terminate the voice-frequency channel of three-channel systems. It provides an amplitude limiting transmitting amplifier, a receiving amplifier, hybrid coil, compromise network, and necessary pads. It also provides transmitting and receiving carrier line filters. Characteristics are as follows:

VF Line	Transmit	600-ohm bal
	Receive	600-ohm bal
HF Eqpt.	Transmit	600-ohm unbal
	Receive	600-ohm unbal
Line	Transmit	600-ohm bal
	Receive	600-ohm bal
Transmitting Amplifier	Gain	26 ± 1 dB
	Output	+10 dBm max
Receiving Amplifier	Gain	24 ± 1 dB
	Output	+10 dBm max
Power Requirements*	200 Vdc	14 mA
	12.6 Vac	0.6 AMP

* AC operation with 521-type power supply. May also be operated with 130 V plate battery and 24 V filament battery.

Tube Complement	2 — 5692 or 2 — 6SN7	
Size	Height	8-3/4 in
	Width	19 in
	Depth	7-1/4 in
Weight	20 pounds	
Manufacturer's Specification Bulletin	336A-S	

(e) ***Type 510 Terminal Block Panels:*** The Lenkurt type 510A and B terminal block panels provide facilities for connecting interrack wiring to other equipment and for connecting and terminating local wiring as needed. Type 510A provides 40 or 80 wiring terminals while type 510B provides 160 terminals. Facilities for mounting small auxiliary equipment such as attenuation pads, transformers, etc, may be provided. When this is done, the code of the panel is modified, thus a 510A-P indicates a panel equipped with pads. Connecting blocks and other items are protected by a metal dust cover.

Size	Height	3-1/2 in
	Width	19 in
	Depth	7-1/4 in
Weight	5 pounds	

(f) ***Type 521B Power Supply (For Three-Channel Systems):*** The 521B power supply is a compact nonregulated power supply which will provide plate, filament, and bias potentials to the various panels making up the three-channel system. It provides primary and secondary fusing and alarm facilities. Characteristics are as follows:

Output	200 Vdc 12.6 Vac 6 Vdc	200 mA 7.2 AMP bias
Tube Complement	1 — 5R4GY	
Size	Height Length Depth	7 in 19 in 7-1/4 in (in front of rack)
Weight	40 pounds	
Manufacturer's Specification Bulletin	521B-S	

(g) ***521C Power Supply (For Single-Channel Systems):*** The 521C power supply is a compact nonregulated power supply designed to supply plate and filament potentials required by the 3303A VF terminal panel and 5090B compandor. It provides both primary and secondary fusing and alarm facilities. Characteristics are as follows:

Output	200 Vdc 12.6 Vac 6 Vdc	85 mA 3.6 AMP bias
Tube Complement	1 — 5R4GY	
Size	Height Length Depth	7 in 19 in 7-1/4 in (in front of rack)
Weight	24 pounds	
Manufacturer's Specification Bulletin	521C-S	

(h) ***Type 534B Alarm Panel:*** This unit is designed to supplement the 521-type power supplies in situations requiring "dry" contacts for connection to office alarm systems. Characteristics of the unit are as follows:

Size	Width Height	19 in 1-3/4 in
Weight	2 pounds	
Manufacturer's Specification Bulletin	534B-S	

(i) ***Type 5027A AC Junction Box Panel:*** This panel provides a convenient means of connecting ac supply leads to system rack assemblies. It is equipped with one or two junction boxes and may be mounted at the top or bottom of the carrier bay.

Size	Height Width	1-3/4 in 19 in
Weight	Approx 2 pounds	
Manufacturer's Specification Bulletin	5027A-S	

(j) ***Type 5086A Transformer Panel:*** The Lenkurt type 5086A transformer panel is designed to accommodate one or two isolating or impedance matching transformers for operation of the terminal assemblies into unbalanced lines or into lines of other than 600 ohms. Isolating transformers with 600:600-ohm impedance ratio, or impedance matching transformers with 130:600 ohm impedance ratios are among those available.

Size	Height Width Projection	1-3/4 in 19 in 7 in
Weight	Approx 2 pounds	
Manufacturer's Specification Bulletin	5086A-S	

(k) ***Type 5083B Compandor Shelf Assembly and Type 5090B Compandors:*** The Lenkurt type 5090B compandor is a plug-in unit consisting of a compressor and an expandor and, if desired, a resistor-type hybrid. The compressor and expandor each consists of an amplifier and variolosser network arranged to work between 600-ohm balanced circuits. A plug-in terminating unit permits selection of 2-wire or 4-wire operation. When used on a

2-wire basis, an internal resistor hybrid is provided. This is not satisfactory for use at gain switching points where external coil-type hybrids must be used. A signal-to-noise improvement of about 22 dB results from the use of the compandor. The compandor is mounted on a plug-in basis in the Lenkurt type 5083B shelf which is capable of handling from one to four units. This shelf provides terminations for power and other wiring as well as mounting facilities. Characteristics of the compandor are as follows:

Input Impedance	600 ohms	
Output Impedance	600 ohms	
Transmitting Level	2-wire	0 dB
Transmitting Level	4-wire	−16, −13, −4 dB
Receiving Level	2-wire	0 dB or less
Receiving Level	4-wire	+7 dB or less (adjustable)
Test Jack on Eqpt Face (Bridging)		
Built-In Resistor Hybrid		
Tube Complement (each compandor)	2 — 5670 or 2 — 407A	
Power Requirements*	200 V @ 15 mA 12.6 V @ 0.35 mA	

* AC operation with 521-type power supply. May also be operated with 130 V plate battery and 24 V filament battery.

Physical Size One to four units mounted in shelf	Depth Height Length	10 in 3-1/2 in 19 in
Weight	Shelf Each Compandor	6 pounds 2 pounds
Manufacturer's Specification Bulletins	5090B-S, 5083B-S	

(l) ***Type 5099A 4-Wire Terminating Set and Type 5100A 4-Wire Terminal Set Shelf Assembly:*** The type 5099A 4-wire terminating unit is a coil-type hybrid arranged to terminate 4-wire, voice-frequency circuits. One to four units may be mounted in a type 5100A shelf assembly on a plug-in basis. Each unit includes a built-in compromise network, screwdriver adjustable pads (0 to 20 dB) in transmitting and receiving legs, and provision for the connection of external precision networks if required. Characteristics of the unit are as follows:

1000-hertz Minimum Loss	Transmitting Branch Receiving Branch	4 dB ±0.5 dB 4 dB ±0.5 dB
Network	Internal Compromise (external precision optional)	2 μF and 600 ohms
Size (each unit)	Height Width Depth	1-3/4 in 3-1/4 in 8-5/8 in
Weight (per unit)	2 pounds	
Size (one to four in shelf)	Height Length Depth (5 in front of rack, 5 in through rack)	1-3/4 in 19 in 10 in
Manufacturer's Specification Bulletins	5099A-S, 5100A-S	

(m) ***Type 5103A Telephone Set Panel:*** This unit is used to provide talking and monitoring facilities on a patching basis. It provides 2- or 4-wire operation as well as E and M lead signaling. It may be used with a 52A or similar operator's telephone set. Characteristics are as follows:

Size	Height	1-3/4 in
	Width	19 in
	Depth	9-3/4 in
Weight	6-1/2 pounds	
Power Requirements	24 or 48 Vdc @ 100 mA	
Impedance	"Tel Line" jacks 600 ohms "Tel Send" jacks 600 ohms "Tel Rec" jacks (With 52-type set) 6300 ohms "Tel Set" jacks ("Tel Line" jacks patched 2W) 300 ohms "Tel Set" jacks ("Tel Line" jacks patched 4W) 6600 ohms	

(n) ***Type 5230A Jackfield Assembly:*** This assembly provides line and equipment jacks in the VF and HF lines for test purposes.

Size	Height	1-3/4 in
	Width	19 in
Weight	Approx 5 pounds (fully equipped)	
Manufacturer's Specification Bulletin	5230A-S	

(o) ***Type 565A Weatherproof Cabinet:*** This is a weatherproof cabinet designed to accommodate the various terminal equipments. The cabinet provides 66 inches of relay rack space, with sufficient clearance front and rear to accommodate the 33-type terminal equipment. The cabinet is ventilated and insulated.

Size (outside)	Width	23 in
	Height	87 in
	Depth	17 in

(p) ***Relay Racks, Lenkurt Type 500:*** Standard 19-inch relay racks arranged for mounting of equipment on front or rear. Available in self-supporting or open frame type in six sizes from 7 ft 0 in to 11 ft 6 in. Furnished in standard gray enamel, arranged for guard rail but guard rail not supplied.

5.02 ***Radio to 20-Hertz Ringdown Toll Line Control Circuit:*** Situations requiring single-channel installations between manual offices, where dial conversion is not contemplated, may frequently be satisfied with a locally constructed arrangement employing RF carrier interruption for signaling. This may permit substantial saving in cost. Figure 5 shows the schematic diagram of a relay equipment for carrier control signaling which may be used with any switchboard having toll line circuits which transmit and receive 20-Hz ringing current for signal and recall. Where the toll line circuit can provide battery or ground to a control lead to indicate that a plug has been inserted in the line jack, the "radio control" key is not required, but will be necessary where this information is not otherwise obtainable. The detailed diagram and method of operation contained herein will permit local assembly of the unit. Characteristics are as follows:

Relay Rack Unit Size	1-19 in mtg plate
Power Required	24 volts, approx 250 mA 20 Hz ringing
Radio Term. Unit Size	Approx 2 in x 6 in x 6 in
Power Required	Obtained from radio receiver

5.03 The operation of the control circuit is as follows:

(a) ***Operation on Outgoing Call:*** Insertion of plug* operates relay SL which grounds the trans start lead, causing transmitter to radiate, operating relay SL1, and transferring the locking ground for relays C3 and C4 to its own contacts. Application of ringing current to line operates relay RO which interrupts radio carrier, restoring carrier at end of ringing period.

* In offices where trunk circuit can not provide sleeve information, the radio control key may be provided.

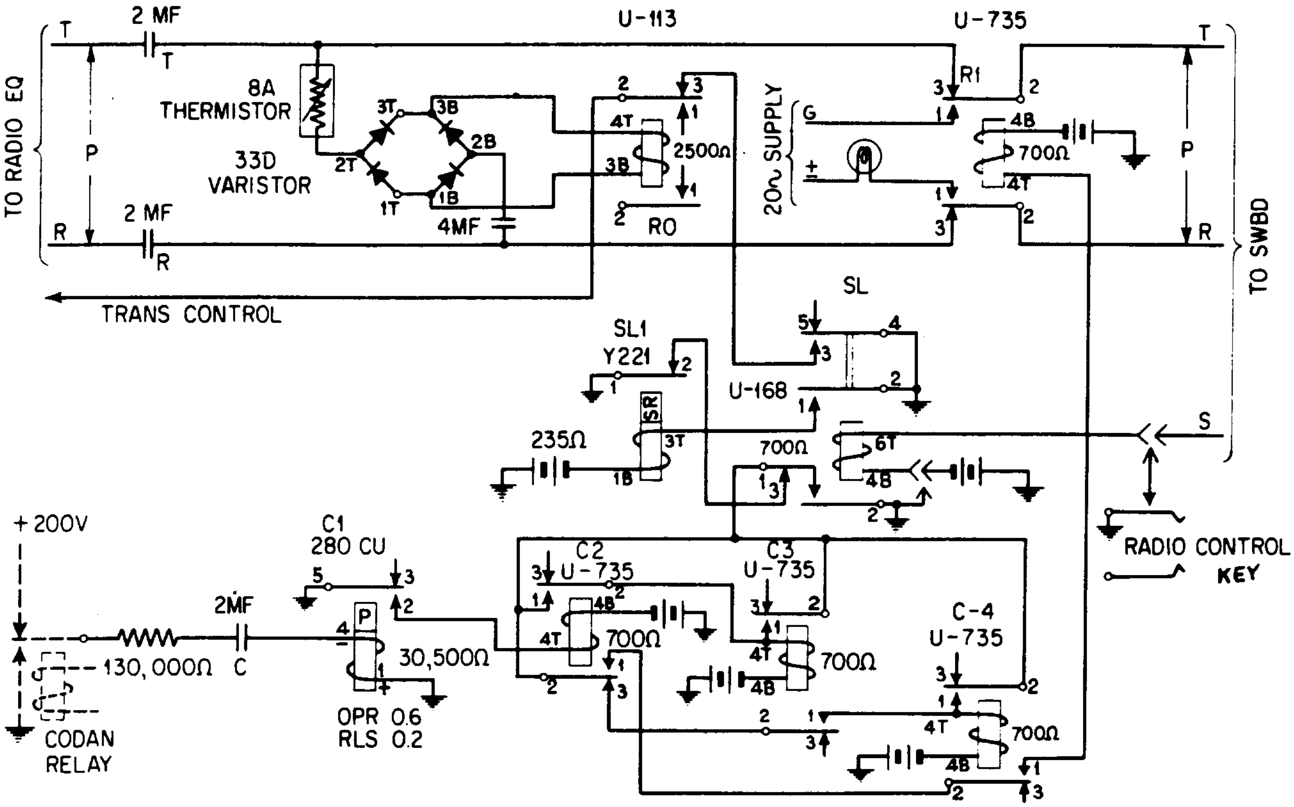

Fig. 5 — Typical Control Circuit — Connects Single-Channel Radio to 20-Hertz Ringdown Toll Line Switchboard Circuit — Provides Signaling by Carrier Control

(b) ***Incoming Call:*** Presence of carrier causes codan relay to operate. Discharge of the 2 μF condenser causes operation of relay C1, which holds for 0.6 second, then releases. Ground from C1 causes operation of relay C2 which in turn locks relay C3 under control of relays SL and SL1. It also prepares an operating path for relay C4. Release of C2 completes path to permit relay C4 to operate. C4 operated locks under control of SL and SL1. Remote end ringing results in interruption of the carrier and release of the codan relay. The 2 μF condenser is charged, but C1 relay does not operate since it is polarized. Carrier return causes 0.6-second pulse from relay C1, which causes operation of C2 and of RL through make contacts of C4; R1 remains operated 0.6 second, then releases, passing a pulse of 20 Hz ringing to the toll line circuit.

(c) ***Answering:*** Insertion causes operation of relays SL and SL1, transferring holding ground for C3 and C4 from SL1 to SL and energizing radio transmitter. At receiving terminal C1, C2, and C3 operate; C4 operates on release of C1 and C2.

(d) ***Re-ring:*** Re-ring from either end pulses C1 and C2 at remote terminal, operating R1 and recalling operator.

(e) ***Disconnect:*** Relay SL releases, transferring holding path for C3 and C4 to relay SL1 which releases slowly, resulting in release of C3 and C4. Upon release of SL1, ground is again waiting on locking contacts of C3 and C4.

(f) ***False Operation:*** False operation of the receiver codan may result in a false ring under certain conditions. This makes it necessary to adjust the receiver squelch circuit for maximum operating margin.

6. RADIO EQUIPMENT

A. Types Available

6.01 Combinations of commercial radio equipment in the 152 to 162 and 450 to 470 MHz range of frequencies and type accepted by the FCC are available for one- or three-channel systems. Performance data and characteristics are provided in bulletins and instruction manuals issued by the manufacturer. The selection of radio equipment will depend upon local consideration. A list of equipment available at this time is shown in Table 2.

B. Equipment Features

6.02 Both General Electric and Motorola can provide telephone terminal equipment which in conjunction with the single-channel equipment, provides the necessary features for operation in either a dial or manual subscriber's loop circuit or toll circuit.

6.03 Modifications of the General Electric equipment per RC718 and RC914 consist of extending the baseband frequency response to about 11,000 hertz, providing 600-ohm input and output impedances and removing the deviation limiter circuitry from the transmitter. A cabinet blower is provided for continuous operation.

C. Frequency Response and Distortion Characteristics

6.04 The frequency response and distortion characteristics of the broadbanded General Electric and DuMont equipment fall within the shaded area of the typical response and distortion graphs shown in Fig. 6.

6.05 For the application of data circuits, the envelope delay distortion of the General Electric single-channel and DuMont equipment is shown in Fig. 7. An example of the equalization obtained when utilizing 200-type envelope delay equalizers is also shown. The 200-type

TABLE 2

LIST OF COMMERCIAL RADIO EQUIPMENT

SINGLE-CHANNEL SYSTEMS

MANUFACTURER	DESIGNATION	FREQUENCY RANGE	POWER OUTPUT
General Electric (See Paragraph 6.02)	PO36NR (42 inch outdoor cabinet)	144 – 174 MHz	50 Watts
	VO36NR (69 inch indoor cabinet)	144 – 174 MHz	50 Watts
	PO42NR (42 inch outdoor cabinet)	450 – 470 MHz	15 Watts
	VO42NR (69 inch indoor cabinet)	450 – 470 MHz	15 Watts
Motorola (See Paragraph 6.02)	J53AAB (54 inch outdoor cabinet)	152 – 174 MHz	50 Watts
	B53AAB (68 inch indoor cabinet)	152 – 174 MHz	50 Watts
	J44AAB (54 inch outdoor cabinet)	450 – 470 MHz	15 Watts
	B44AAB (68 inch indoor cabinet)	450 – 470 MHz	15 Watts
Western Electric Co.	MCBTR1 per J41630 (Motorola)	152 – 174 MHz	50 Watts
	MCBTR3 per J41630 (GECo)	152 – 174 MHz	50 Watts
	THREE-CHANNEL SYSTEMS		
General Electric (See Paragraph 6.03)	PO36NR, modified per RC718	144 – 174 MHz	50 Watts
	VO36NR, modified per RC718	144 – 174 MHz	50 Watts
	PO42NR, modified per RC914	450 – 470 MHz	15 Watts
	VO42NR, modified per RC914	450 – 470 MHz	15 Watts
DuMont	MCA474B (40 inch indoor cabinet)	450 – 470 MHz	15 Watts
	MCA484B (72 inch indoor cabinet)	450 – 470 MHz	15 Watts

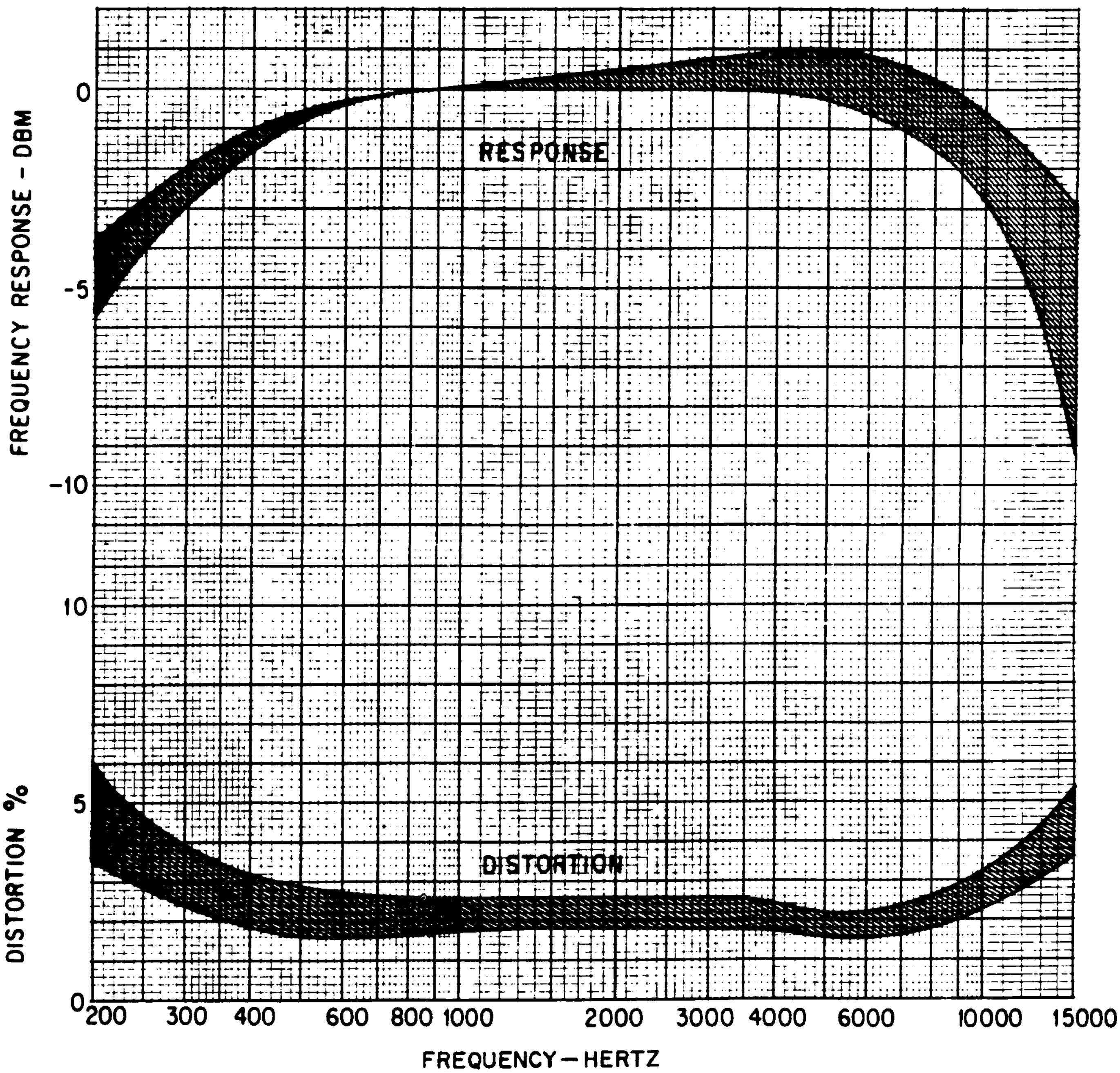

Fig. 6 — Typical Frequency Response and Distortion Characteristics GECo RC718 and DuMont MCA 474/484B Equipment

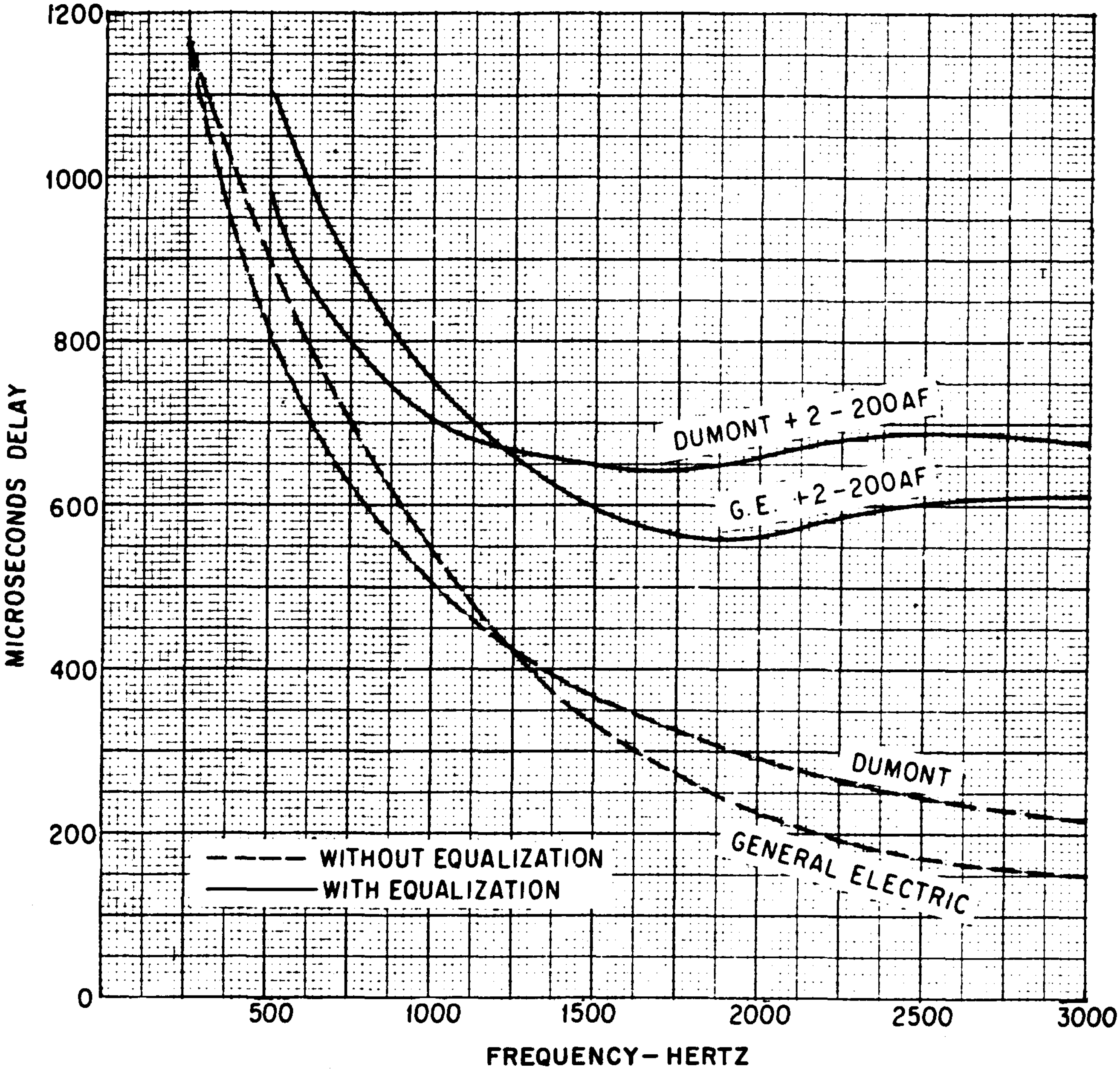

Fig. 7 — Envelope Delay Distortion — GE Single-Channel Equipment — DuMont MCA 474/484B Equipment

envelope delay equalizers used to correct for delay distortion are fully described in Section 314-820-100. The application of these equalizers will depend upon local considerations.

7. AUXILIARY EQUIPMENT

A. Antennas

7.01 The selection of antennas for VHF and UHF point-to-point installations and the physical and electrical arrangement in which they are used will vary with the type of service and method of operation. Within limits imposed by service requirements, other factors, including the type of antenna, required height and available space, type of antenna support, location, etc, will influence the particular arrangement chosen. Service requirements from the point of view of antenna arrangements may be separated into cases involving single- or two-frequency carrier operation, those requiring simultaneous transmission and reception and those in which simultaneous operation of several transmitters and receivers is required at one location.

7.02 Horizontally polarized corner reflector antennas provide satisfactory characteristics for most point-to-point installations. Typical corner reflectors operating between 150 and 160 megahertz may be expected to give gains of about 7.5 dB, compared to a dipole, with a front-to-back ratio of about 15 dB, while a similar antenna for 450-MHz operation can be expected to provide about 8 dB of gain with a front-to-back ratio near 25 dB.

7.03 In some cases, transmitting or receiving gains which are greater than can be obtained using a single corner reflector antenna may be needed. Such a situation may occur if a noise source is near one terminal of a system and on the line of the transmitter. In this case it would be desirable to increase the effective radiated power. This may be done by stacking two antennas, thus doubling the number of elements and providing a gain of about 3 dB greater than would be obtained from a single antenna. If the stacking is done in such a way as to narrow the vertical pattern, additional gain may also be obtained from the receiving antenna with accompanying improvement of the desired signal and discrimination against undesired noise.

7.04 In addition to corner reflector antennas, directional antennas may include Yagi arrays and, particularly at frequencies near 450 MHz, parabolic reflectors. Special cases may arise in which the use of other types of antennas such as rhombic, V, helical, etc, may warrant consideration.

7.05 When considering large antennas for additional gain, it is well to bear in mind the balance of cost between a large antenna and a transmitting power amplifier. Such factors as maintenance of the power amplifier, wind loading of a large antenna, etc, must also be considered.

7.06 A partial list of the types of antennas available at this time is shown in Table 3. These antennas have had widespread use and should provide satisfactory service for point-to-point applications. Manufacturers require that the operating frequency be specified as part of the ordering information. In some areas, it may be desirable to consider antennas with deicing heaters and some of those listed are available with these facilities to provide maximum performance during winter months.

7.07 After the choice of a suitable antenna for a system has been made and such factors as antenna height, type of support, location, etc are known, it must be determined whether separate transmitting and receiving antennas or a common antenna with suitable filters is to be preferred. The factors which will influence the choice of antenna arrangement will include the following:

(a) The relative ease and cost of placing two antennas and transmission lines compared to the cost of a single antenna with the necessary RF filters.

(b) The relative ease of maintenance of two antennas and lines compared to a single antenna and line.

(c) The relative height of the supporting structure required for a single antenna versus that required for a dual installation.

TABLE 3

LIST OF ANTENNAS FOR VHF AND UHF POINT-TO-POINT APPLICATIONS

MANUFACTURER	MODEL	TYPE	FREQUENCY RANGE	GAIN*
Andrew Corporation	KS-15704 L1**	Corner Reflector	150-170 MHz	7.5 dB
Chicago, Illinois	KS-15704 L2	Corner Reflector	150-170 MHz	7.5 dB
	3606-01	Corner Reflector	450-470 MHz	8.0 dB
Communications Products Co.	160-509	Corner Reflector	150-175 MHz	10 dB
Marlboro, New Jersey	161-509	Corner Reflector	450-470 MHz	10 dB
Communications Engineering Co.				
Dallas, Texas	CE-286	Directional Array	150-170 MHz	6 dB
Scala Radio Co.	CA5-150	Yagi	150-170 MHz	9 dB
San Francisco, California	CR-150	Corner Reflector	150-170 MHz	10 dB
	CA5-450	Yagi	450-470 MHz	10 dB
	PR-450	Paraflector	450-470 MHz	16 dB
Mark Products Co.	P472	6 ft Parabolic	450-470 MHz	15 dB
Morton Grove, Illinois	P-4120	10 ft Parabolic	450-470 MHz	20 dB
	P-4180	15 ft Parabolic	450-470 MHz	23 dB

*Gain relative to a dipole.
**Collapsible corner reflector with same characteristics as KS-15704 L2.

(d) The effect of increased wind loading of two antennas on the size and type of support required.

(e) The effect of filter insertion loss on transmission performance. In some cases where other factors favor single antenna installations, it may be desirable to use better transmission lines than would otherwise be chosen to compensate in part for the filter insertion loss.

B. RF Transmission Lines

7.08 Transmission lines connecting antennas and radio equipment in VHF and UHF installations will generally be chosen from three categories:

(a) Semirigid (copper-air dielectric).

(b) Semiflexible (Styroflex, Heliax, etc).

(c) Flexible (solid dielectric).

Rigid copper line (as contrasted to (a) and (b) above) will rarely be considered for this service because of the high cost of material, hardware, and difficult installation. General considerations concerning various transmission lines and connectors are discussed in Sections 940-250-101, 402-100-100, and 402-100-200.

7.09 Transmission loss and installed cost are the principal factors to be considered in selecting a line for any particular installation. Such factors as resistance to physical damage, to lightning burns, and to corrosion as well as the overall ease of maintenance will also influence the choice.

7.10 The transmission loss per 100 feet for several of the more commonly used types of transmission line is shown in Fig. 8. These losses, of course, assume that the line chosen is of a type having a characteristic impedance near that of the antenna, and that additional losses are not introduced as a result of impedance mismatch.

C. RF Filters

7.11 Simultaneous transmission and reception using a common antenna require the use of radio frequency filters to suppress extra-band radiation to avoid receiver desensitization. Three filter sections, two in the receiving branch and one in the transmitting branch, are required for each terminal. Some of the types of filters available for this application are listed as follows:

RF FILTER	FREQUENCY
Western Electric Type 552A	145-162 MHz
Western Electric Type 566A	450-470 MHz
Western Electric Type 567A	450-470 MHz
Motorola Type TU312H	132-174 MHz
Motorola Type TU255	400-470 MHz

The application, installation, and characteristics of these filters are fully covered in Section 402-307-000.

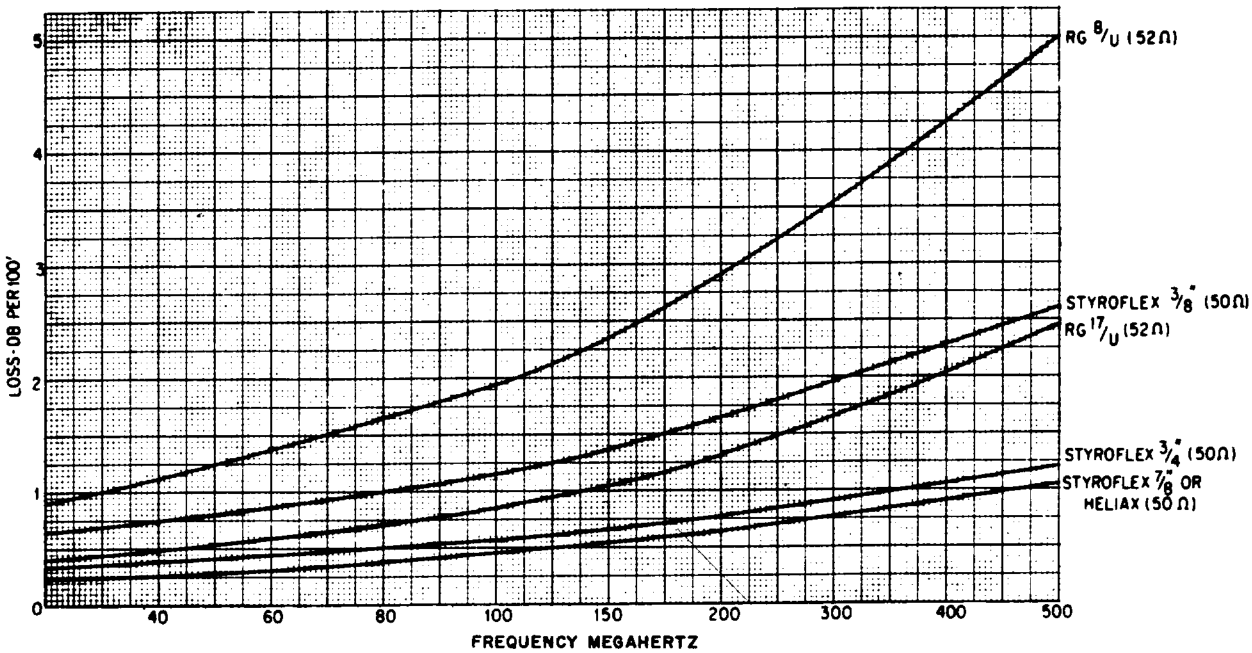

Fig. 8 — Approximate Loss of Common Types of Transmission Lines