

TYPE O AND ON CARRIER TELEPHONE SYSTEMS - TERMINALS AND JUNCTIONS
GENERAL INFORMATION - OVER-ALL SYSTEM
DESCRIPTION - TYPE O1 CARRIER TELEPHONE SYSTEM

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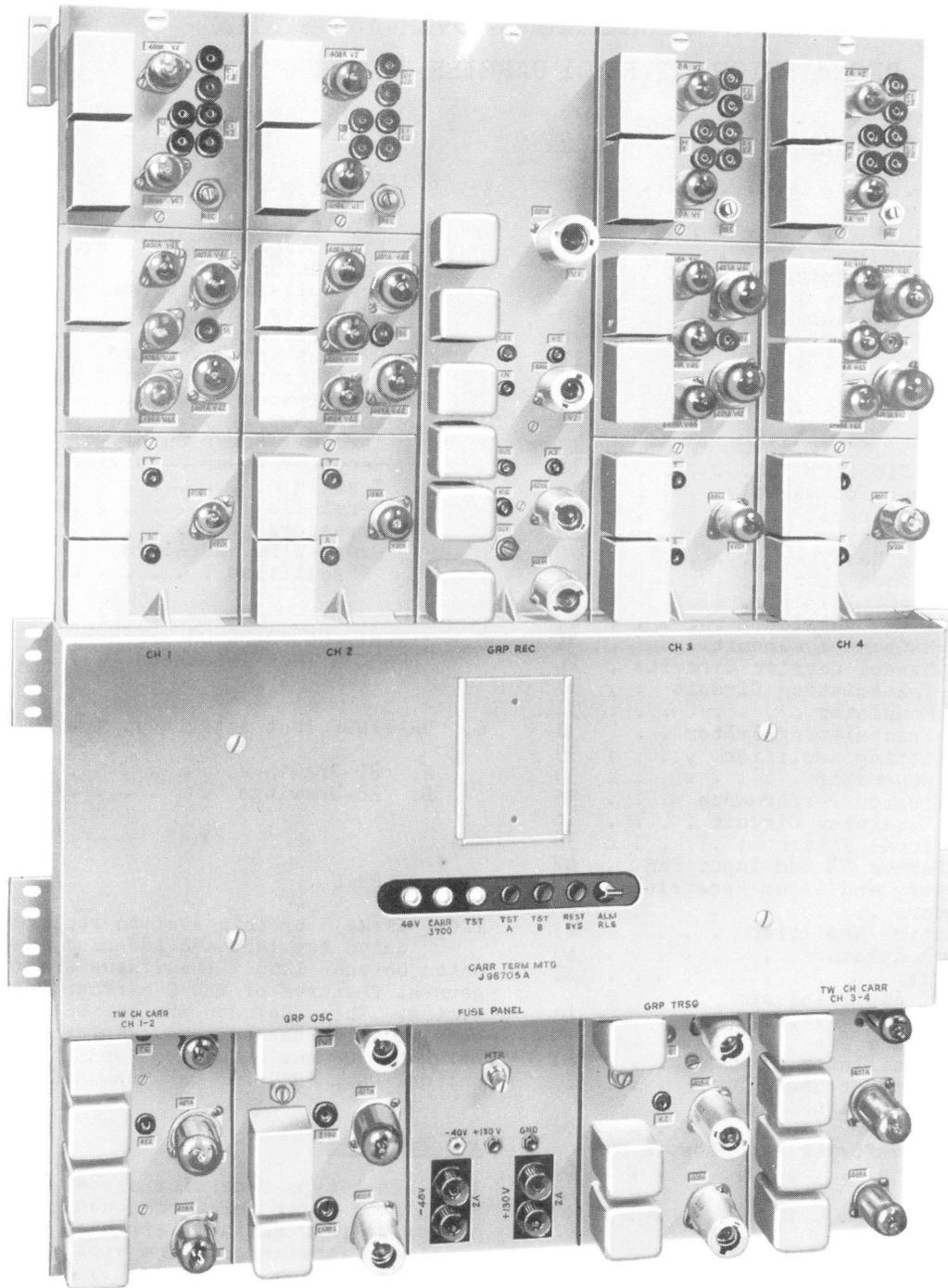


Fig. 1 - OB1, OC1, or OD1 Carrier Terminal

1.03 The line frequencies employed by the O systems extend from 2 to 156 kilocycles, and are assigned as shown in Fig. 5. Each of the O systems uses two adjacent 16-kc bands, one band called the low group and used for one direction of transmission, and one called the high group and used for the other direction of transmission.

1.04 Single sideband transmission is used, with the upper and lower sidebands of a single carrier providing two channels transmitted in the same direction. Two carriers spaced 8 kc apart are transmitted at reduced level and their combined power is used to control the flat gain regulation at repeaters and terminals, correcting for transmission changes due to weather conditions.

1.05 The terminals are arranged to transmit either low- or high-group frequencies. A low-group transmitting terminal (LGT) transmits the low group and receives the high group. Conversely, a high-group transmitting terminal (HGT) transmits the high group and receives the low group.

1.06 In the case of the OB, OC, and OD systems, frequency-frogging repeaters interchange and invert low- and high-group frequency bands. The repeaters are arranged to transmit either low- or high-frequency bands alternately. The low-high (L-H) repeater receives at its input the low group of frequencies which are converted to the high group before amplification. The high-low (H-L) repeater does

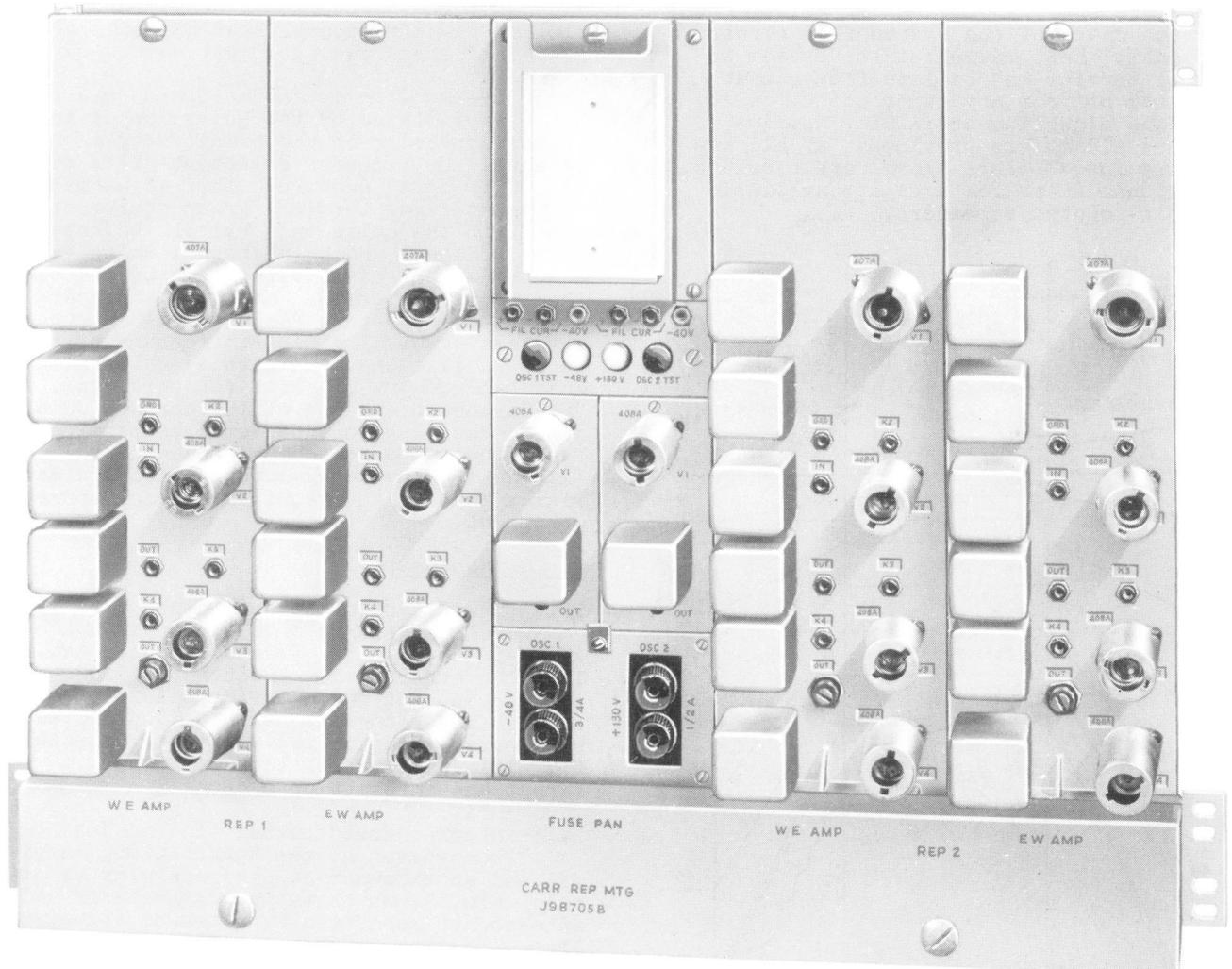


Fig. 2 - Two OB1, OC1, or OD1 Carrier Repeaters (with fabricated fuse panel)

are already of sufficiently high level to override noise and crosstalk they are transmitted over the line with little or no change in level. At the expander the reverse process occurs which restores the speech to its original level.

1.16 The foregoing discussion indicates the necessity for a clear understanding of the levels in the various portions of a companded circuit. Within the compressed portion of the circuit a zero-level point is defined as the point where there is zero gain or loss to the transmitting toll switchboard when the input power at the switchboard is +5 dbm. With other power inputs the gain or loss between a zero-level point within the compressed portion of the circuit and a zero-level point outside this portion is dependent upon the switchboard power.

1.17 It will be noted from Fig. 3 that a change in compressor input of 10 db

appears at the compressor output as a change of 5 db and at the expander output as a change of 10 db again. The compression and expansion ratios are therefore 2 to 1. This performance necessarily requires a circuit having variable gain or loss under control of the applied signal. As indicated in Fig. 3, this is accomplished by the vario-lossers in the compressor and expander, the losses of which are controlled by the strength of the signal passing through the devices.

1.18 Fig. 4 shows the idealized zero-level input-output characteristics of the compressor, the expander, and their resultant over-all net effect which is identical to the noncompanded circuit characteristic. The 2 to 1 compression ratios exist only above a point called the knee of the characteristic which occurs at -23 dbm compressor output or expander input both at zero-level. Below the knee both the compressor and expander act like a fixed gain amplifier or fixed loss pad of 28 db gain or loss respectively.

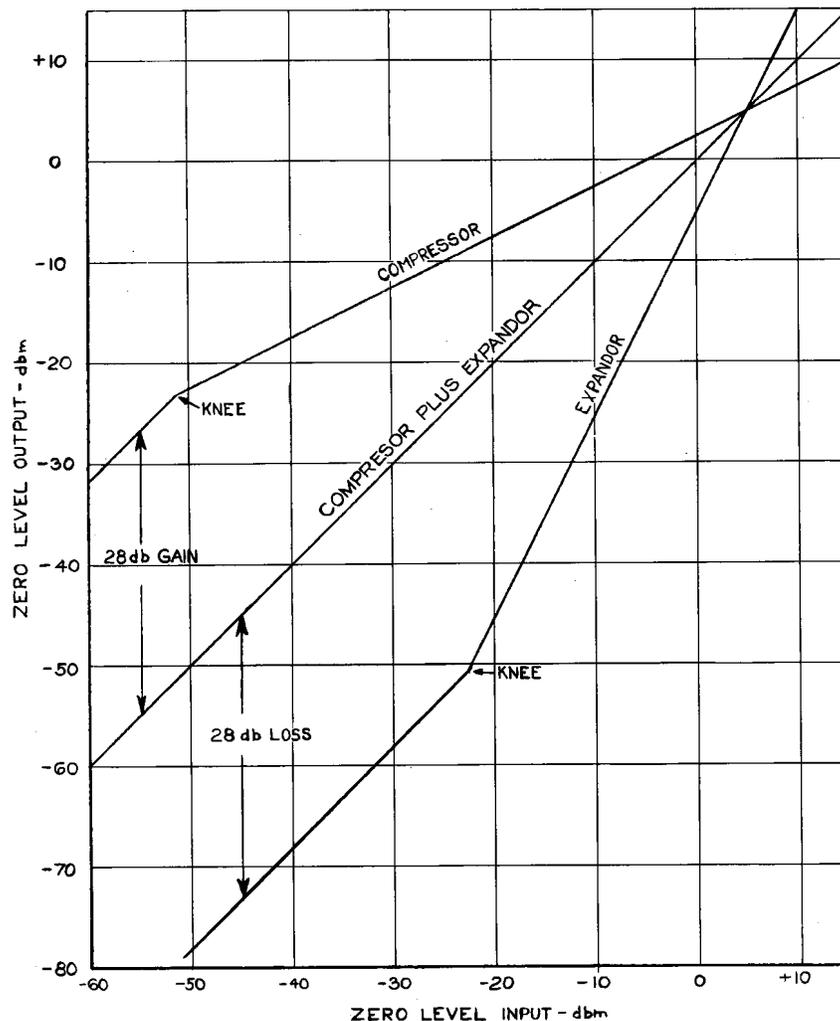


Fig. 4 - Ideal Zero Level Compressor and Expander Level Characteristics

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1.19 Knowing that +5 dbm at zero level goes through the whole system unaltered, the line levels for other inputs may be computed by the use of the 2 to 1 ratio. For example, an input signal of -20 dbm at zero level (a reduction of 25 db from the reference +5 dbm) becomes -7.5 dbm at zero level following the compressor (a reduction of only 12.5 db from the reference +5 dbm). A simple relationship between the powers at zero level in the compressed section is as follows:

$$P_c = \frac{P}{2} + 2.5$$

where P is the power in dbm outside the compandor and P_c is the power in the compressed section, all at zero level.

1.20 The relationship given in the preceding paragraph may be generalized for powers at any level by applying a correction for levels as follows:

$$P_c = \frac{P-L}{2} + L_c + 2.5$$

where P is the power in dbm and L the level at some point outside the compandor. L_c is the level in the compressed section at which it is desired to know the corresponding power P_c.

1.21 As an example, with a test power of -32 dbm applied to the input of the compressor (a -16 db level point) it is desired to find the corresponding power at a -10 db level point in the compressed portion of the circuit.

$$\begin{aligned} P_c &= \frac{(-32)-(-16)}{2} + (-10) + 2.5 \\ &= \frac{-16}{2} - 10 + 2.5 = -15.5 \text{ dbm} \end{aligned}$$

1.22 These relationships only hold in the companding range, that is, above -51 dbm at zero level outside the compandor and above -23 dbm at zero level inside the compandor (see Fig. 4).

1.23 As pointed out in 1.18, and as is apparent from Fig. 4, the expander loss below the knee at zero level input and output is 28 db. If no speech is being transmitted at the moment, any noise or crosstalk present on the line, say of -30 dbm at the zero-level point, is attenuated by the expander to -58 dbm at zero level which is a noise improvement of 28 db.

1.24 The presence of speech removes loss from the expander so that noise at the expander output increases. The increased noise is sufficiently noticeable to increase the effective noise about 5 db when speech is being transmitted. During silent periods,

however, the full 28 db advantage is effective for noise and crosstalk reduction.

1.25 The speed with which the compressor and expander adjust themselves from one level of speech to another is determined by the time constants of the control rectifiers. The attack and recovery times are 3 and 30 milliseconds, respectively, for the compressor, and 5 and 50 milliseconds for the expander.

C. Frequency Allocations and Frequency Frogging

1.26 The frequency allocations of the type O systems are shown in Fig. 5. Fig. 6 shows, for the OB system, the modulating processes and frequencies involved in a system with two LGT terminals and an LH repeater. For two HGT terminals, and an HL repeater, the same figure applies if the arrows showing directions of transmission are reversed. For the OC and OD systems, different group carriers and, as a result, different line frequencies, and a different repeater modulating carrier are used; otherwise, the same figure applies. For the OA system, since no frequency frogging occurs at the repeater, there is no repeater modulating carrier. As shown in Fig. 6, two different bands of frequencies are used for transmission over the line. This permits transmission in both directions on a single pair of wires.

1.27 Frequency frogging is an essential feature of the OB, OC, and OD systems. Without the interchange of frequency bands serious interaction crosstalk would be incurred. Because of the interchange of the frequency bands, repeater outputs at a repeater are always in one frequency group, and the inputs are in the other frequency group. The interaction crosstalk path around a single repeater is then between equal level points. As a result longitudinal coils and suppression filters are not generally required. In order to coordinate with the type C carrier, the repeaters of the OA system do not provide frequency frogging. This is feasible because of lower crosstalk couplings at OA frequencies.

1.28 Another advantage of interchanging the frequency bands in the OB, OC, and OD systems is that the frogging repeater also inverts the frequency position of the channels and inverts each channel as shown in Fig. 6. Channel 4, the highest frequency channel in the high group, becomes the lowest channel in the low group and is also in-

FREQUENCY ALLOCATIONS FOR O CARRIER SYSTEMS

SYSTEM	REP MOD CARRIER	LG MOD CARRIER	HG MOD CARRIER
OA	NONE	198KC	216KC
OB	116KC	236KC	256KC
OC	196KC	276KC	296KC
OD	276KC	316KC	336KC

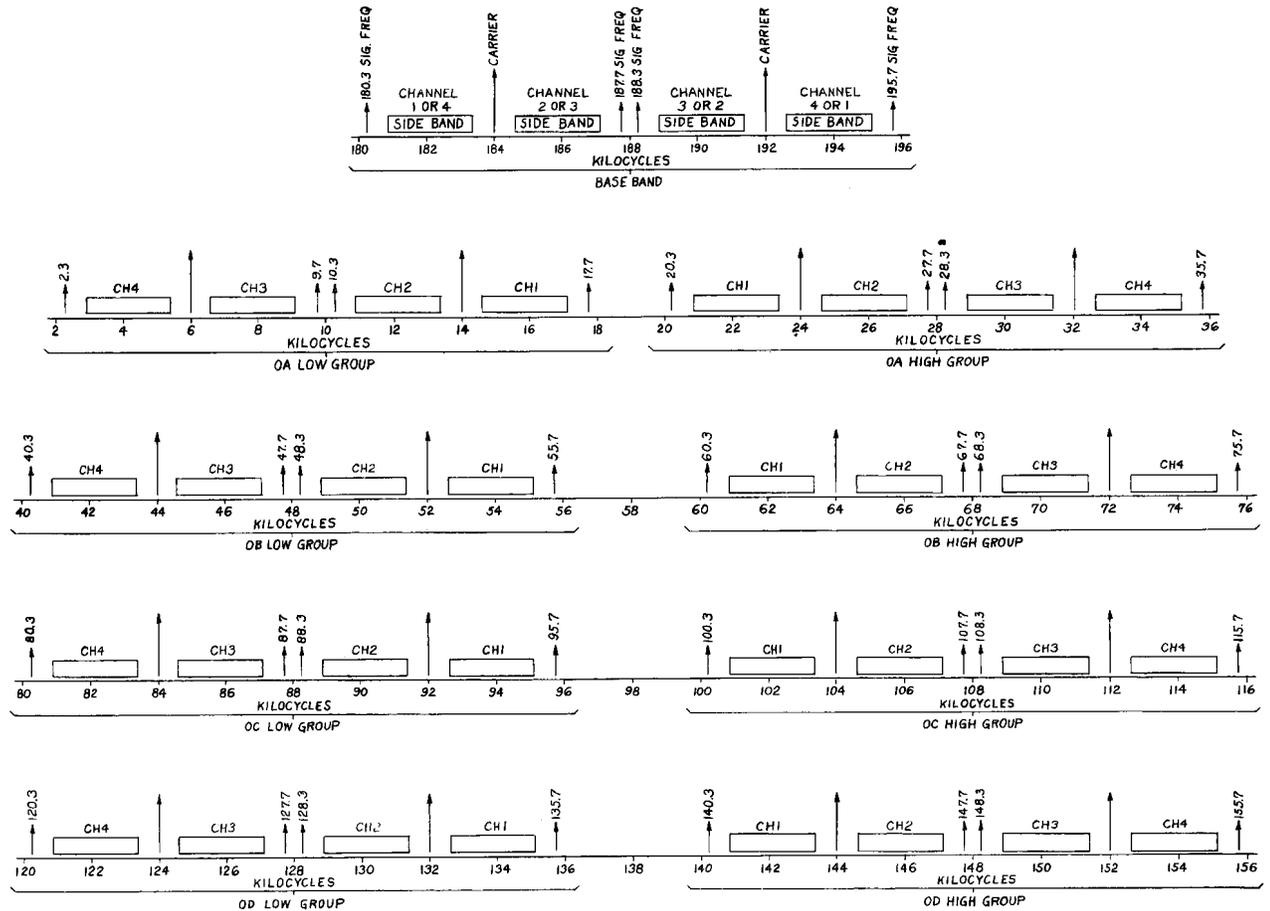


Fig. 5 - Frequency Allocations for O Carrier Systems

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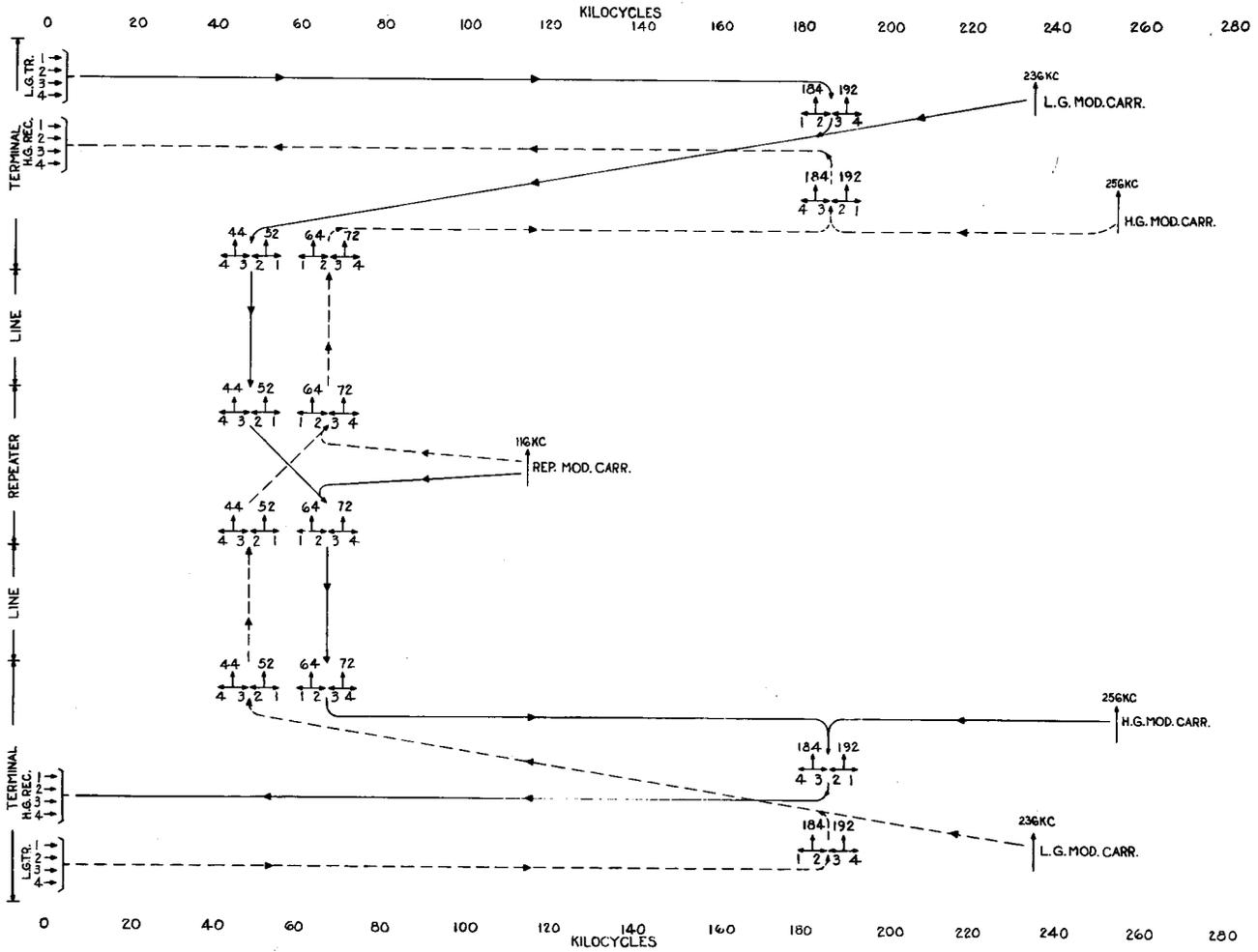


Fig. 6 - Frequencies and Modulations in OB Carrier System

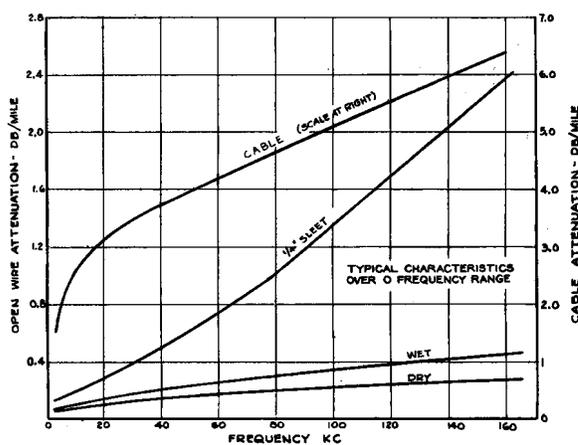
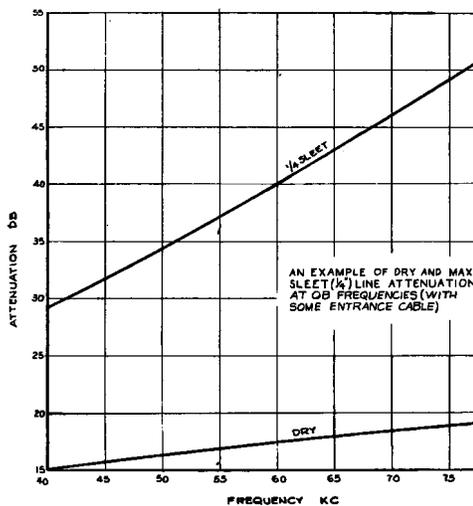
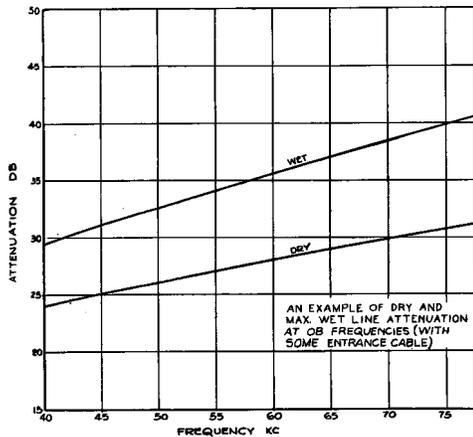


Fig. 7 - Examples of Line Attenuation Frequency Characteristics

verted. Because the line attenuation characteristic has a nearly constant slope, (see Fig. 7 for example), the effect of the line slope is nearly equalized in an even number of repeater sections, assuming equal repeater spacings, similar line facilities, and similar weather conditions for adjacent sections. The resulting advantage from the repeater-design standpoint is that a flat gain-frequency characteristic is adequate without slope equalizing or slope regulating networks. Further, the repeater gain needed is less so that appreciably less suppression is required in the directional filters at repeaters.

D. Signaling

1.29 The signaling system built into the terminal is arranged so that connection from the switchboard or trunk circuit is similar to that employed with present "CX" signaling circuits, that is, use is made of standard "E" and "M" lead signals. On-hook and off-hook dc signals, received as ground and battery potentials respectively on the "M" lead from the associated drop circuits, are transformed into corresponding interruptions of a 3700-cycle tone which is transmitted over the system as a sideband 3700 cycles away from the channel carrier. The on-hook or idle-circuit condition is indicated by the presence of the 3700-cycle tone; an off-hook or busy condition turns the tone off. Dial pulsing consists of turning the tone on and off under control of the opening and closing of the dial contacts. At the receiving end the tone interruptions are translated back into dc pulses on the "E" lead. For the on-hook condition the E lead is open; for off-hook the E lead is grounded. O carrier to O carrier connections can be made without use of a pulse link circuit, as discussed in 2.17. Similar direct connections can be made to N carrier, arranged for this use.

1.30 A time-delay feature is provided in the 3700-cycle signal detector circuit to prevent registration of false pulses of short duration due to noise bursts and hits on the line. Another feature provides for disconnect of connected subscribers in the event of carrier failure. Where required in certain offices, circuits are automatically made busy by the carrier failure alarm to eliminate futile seizure of defective circuits.

1.31 In ringdown operation 1000/20-cycle ringing signals may pass over the voice channel without need for the O signaling circuit, which is then disabled; or ringing may be converted to dc and passed over the system as 3700-cycle tone. In multifrequency key pulsing the frequency combinations are transmitted directly over the voice channel for dialing, while the 3700-cycle tone is used for supervision. When 1600/2000- or 2400/2600-cycle single-

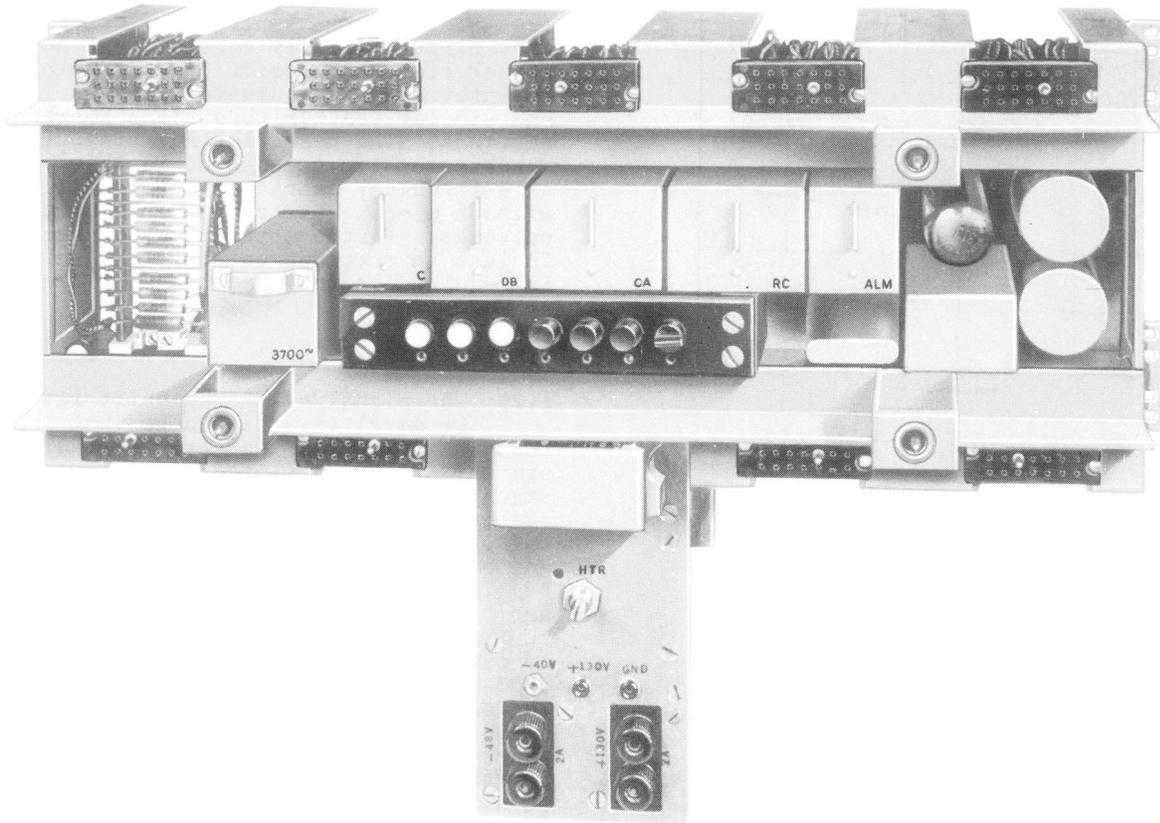


Fig. 8 - O1 Carrier Terminal Mounting

frequency signaling is used, the single frequency signals are transmitted over the voice band and the 3700-cycle signaling is disabled.

E. Equipment Features

1.32 The unit method of construction has been followed in designing the equipment of the O carrier system. Die-cast aluminum alloy frameworks for terminal and repeater mountings, units, and unit sub-assemblies are used throughout. The external connections of each unit terminate in a plug which engages a jack in the terminal or repeater mounting. This method permits the testing of the units without jack fields and allows the removal of any unit in trouble to a convenient location for maintenance and its replacement by a spare unit. It makes efficient use of the full depth (10 inches) of available relay rack space. Access for maintenance is required only on the front. Either terminals or repeaters can be mounted back-to-back or against a wall. All equipment is designed for 19-inch wide duct, channel, or bulb-angle type bays.

Terminal

1.33 A complete terminal, as shown in Fig. 1, includes four channel units, two twin-channel carrier units, a group oscillator unit, a group transmitting unit, and a group receiving unit plugged into jacks in the terminal mounting. This mounting is secured to the bay and contains jacks, terminal strips, and interconnecting wiring, power supply fuses, and the alarm circuits. A 4-channel terminal, exclusive of line transformer and network, occupies a vertical bay space of 24-1/2 inches (14, 1-3/4-inch mounting plate spaces). Four complete terminals, including line transformer and network panels, can be mounted in an 11-foot, 6-inch bay.

1.34 The terminal mounting shown in Fig. 8 consists of two identical die-cast aluminum shelves linked together and arranged for attachment to any standard bay which will mount 19-inch panels. The upper shelf is equipped with jacks into which the four channel units and the group receiving unit are plugged. The lower shelf, which is an inverted upper shelf, is equipped with

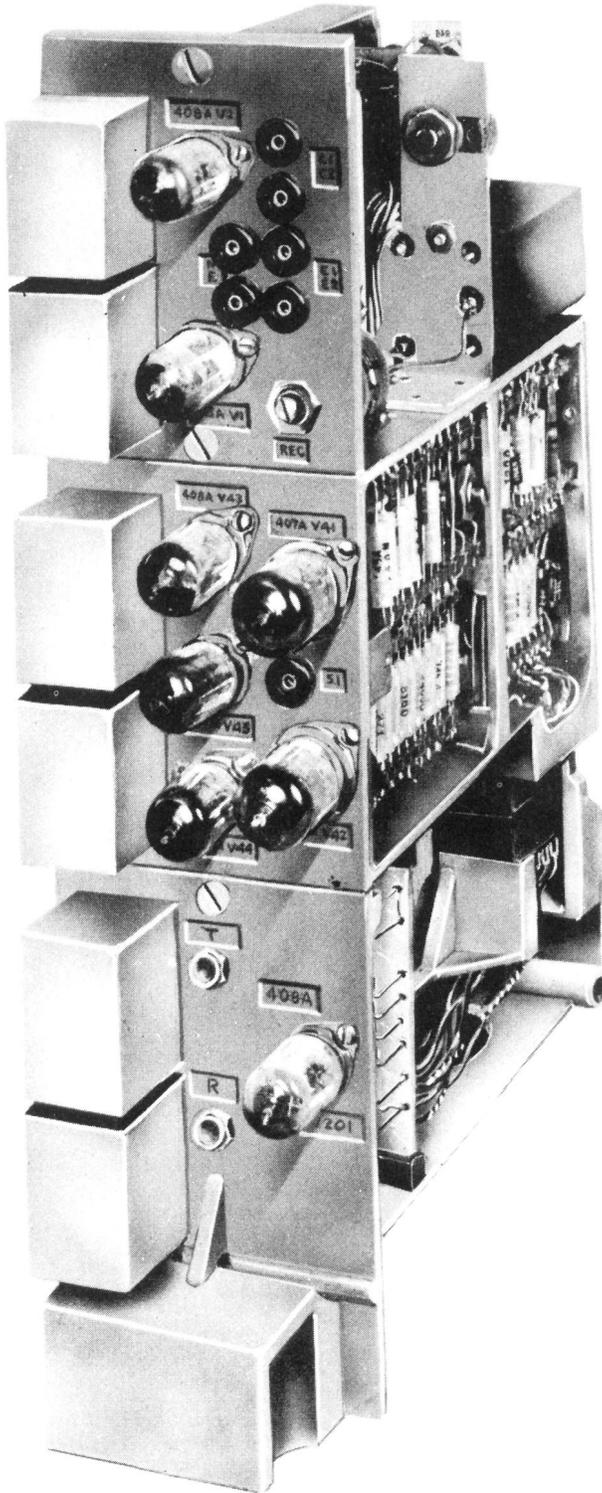


Fig. 9 - O1 Channel Unit

jacks into which the two twin-channel carrier units, the group transmitting unit, and the group oscillator unit are plugged. Also attached to the lower shelf is a small plug-in panel with the power distribution equipment for one terminal. The relays, keys, and lamps associated with the alarm circuits are located on a removable panel between the two shelves. When work is required on the wiring side of this panel and that side is inaccessible because of location (such as against a wall), supporting details per ED-92717-01, G1 may be used. These supports fit into the slides normally holding the two twin-channel units. The alarm relay panel may be removed and placed wiring side up on the supports to make the wiring accessible. The relays on this panel are accessible for adjustment after the removal of a faceplate. This faceplate also serves as a means for holding both the upper and lower rows of plug-in units securely in place by a clamping action. The top of each plug-in unit in the upper row rests against a channel-section supporting detail, attached to the bay independently of the shelf assembly, and is secured by means of a quick-acting fastener. All wiring external to the terminal mounting is brought to terminal strips mounted on the lower shelf directly back of the power distribution panel. Power wiring is brought to a power receptacle on the terminal mounting and connections to the fuses are made by means of a cord and plug attached to the power distribution panel.

1.35 The channel units (see Fig. 9) for channels 1 and 4 are identical in every respect, and assignment of a unit to one of the two channels determines the orientation of the reversible plug-in band filter which selects the proper channel frequency bands for the two directions of transmission. The unit for channel 2 or 3 differs from the one for use on channel 1 or 4 only in the code of the reversible plug-in band filter employed. The two twin-channel carrier units (see Fig. 10) are identical except for the frequency of the oscillator which supplies the transmitting twin-channel carrier and the filter which picks off the proper incoming twin-channel carrier. One of these units is used for channels 1 and 2 at an HGT terminal or for channels 3 and 4 at an LGT terminal; the other type of unit is used for channels 3 and 4 at an HGT or for channels 1 and 2 at an LGT terminal. Thus they need only be interchanged in their positions to fit both types of terminals. The same channel and twin-channel units are used in all of the type O1 terminals. For O1 terminals which connect through an open-wire pair to an ON1 junction, (see Section 362-100-150), twin-channel units having wider band pick-off filters are required; otherwise they are identical.

1.36 The group transmitting unit, (see Fig. 11), the group oscillator unit, (see

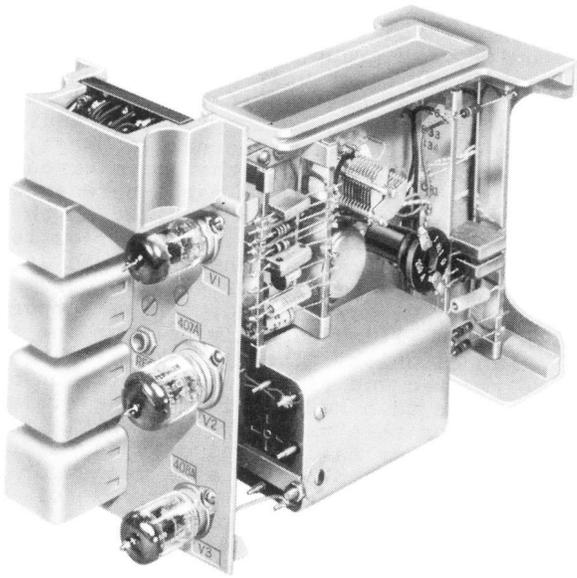


Fig. 10 - O1 Twin-Channel Carrier Unit

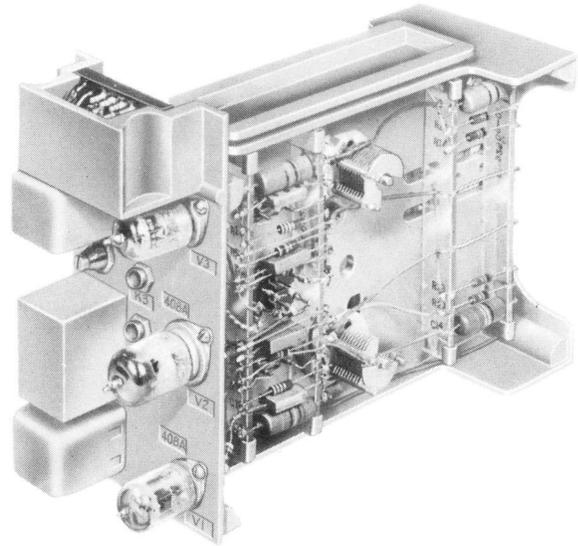


Fig. 12 - O1 Terminal Group Oscillator Unit

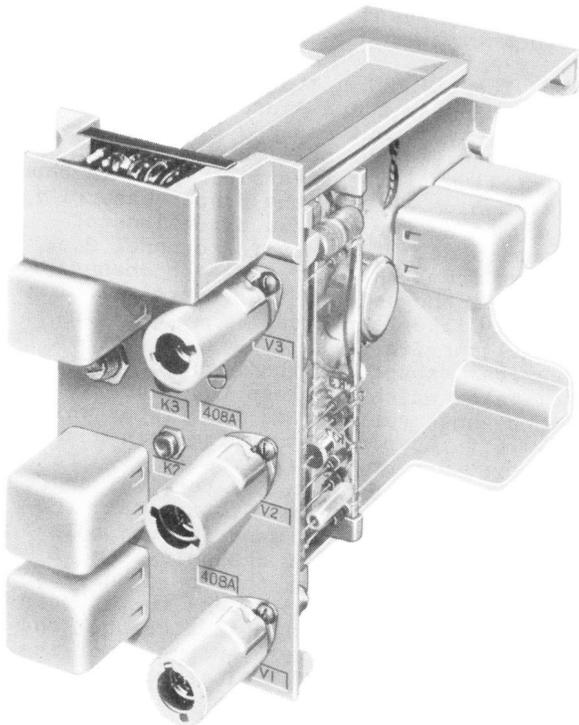


Fig. 11 - OBl, OC1, OD1 Group Transmitting Unit

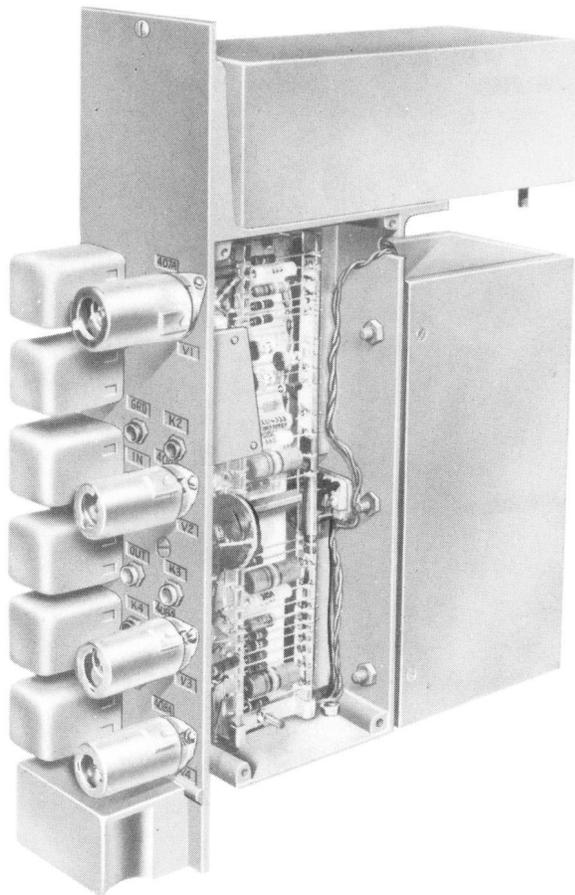


Fig. 13 - OBl, OC1, OD1 Group Receiving Unit

Fig. 12), and the receiving modulator-amplifier unit (group receiving unit, Fig. 13, less plug-in filters) are the same for both high-group and low-group transmitting terminals of a particular O system. A double section filter and a reversible directional filter are plugged into sockets on the modulator-amplifier chassis to complete a group receiving unit. The code of the former filter and the orientation of the latter are determined by the type of terminal (LGT or HGT) in which the unit is to be used. The proper group carriers from the group oscillator unit are supplied in accordance with the type of terminal (HGT or LGT) by strapping the correct terminals on a terminal block in the group oscillator unit. For OAL terminals, straps on an inductor in the group transmitting unit and a terminal block in the group receiving unit are also changed according to their use in an HGT or LGT terminal. The group transmitting unit

and the receiving amplifier-modulator unit are the same for OBl, OC1, and OD1 terminals, different plug-in filters being required for the receiving amplifier-modulator unit to make the proper group receiving unit for a particular terminal. The group transmitting and receiving amplifier-modulator units for OAL terminals are different from those of the OBl, OC1, and OD1 terminals, although their external appearances are similar. The group oscillator unit for each system is different in that different group carriers must be supplied for each type of terminal (OAL, OBl, OC1, or OD1); their external appearances are identical.

Repeater

1.37 Construction of the repeater equipment is similar to that of the terminal. The mounting, as shown in Fig. 14, accommodates two complete repeaters, each consist-

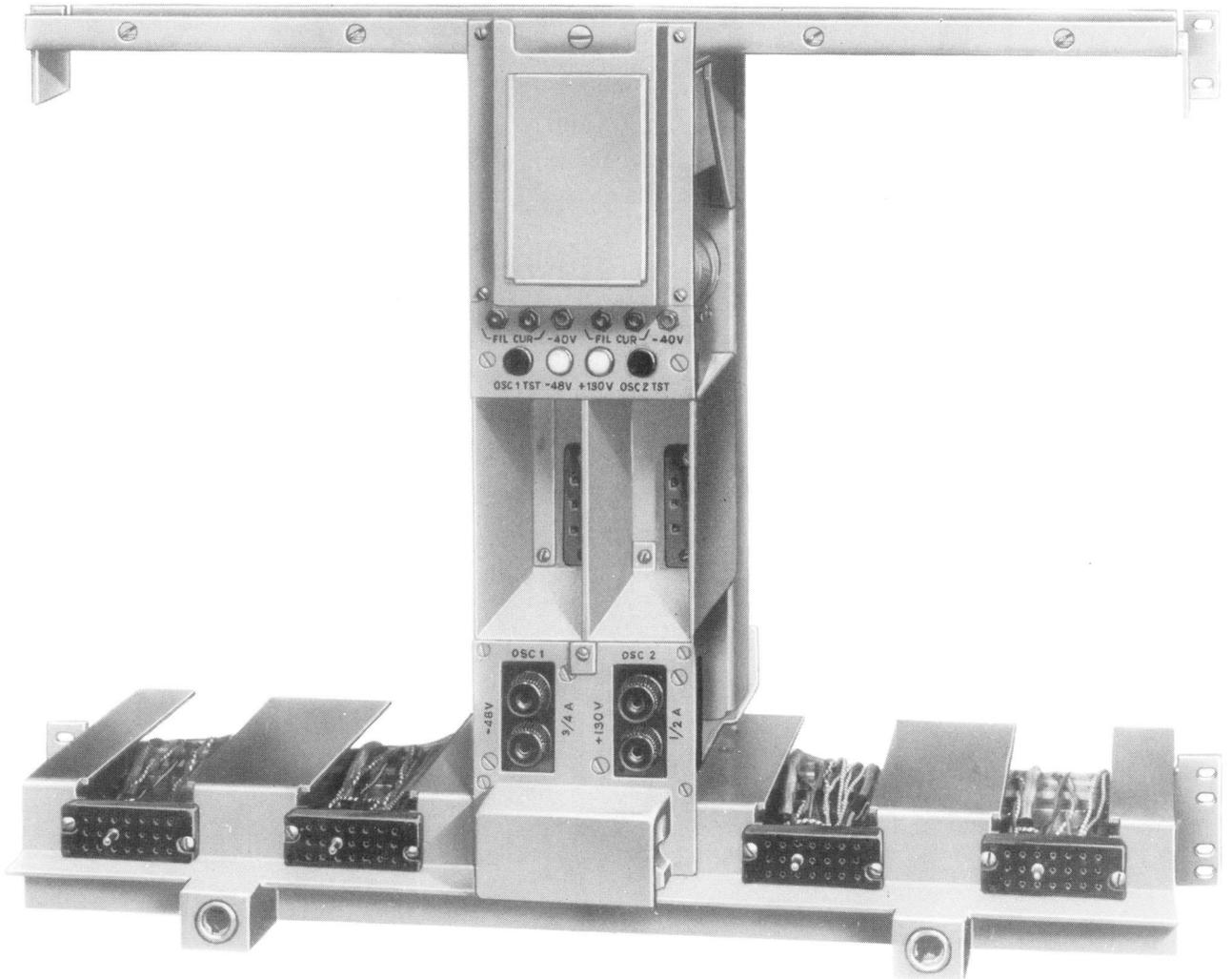


Fig. 14 - O1 Carrier Repeater Mounting (with fabricated fuse panel)

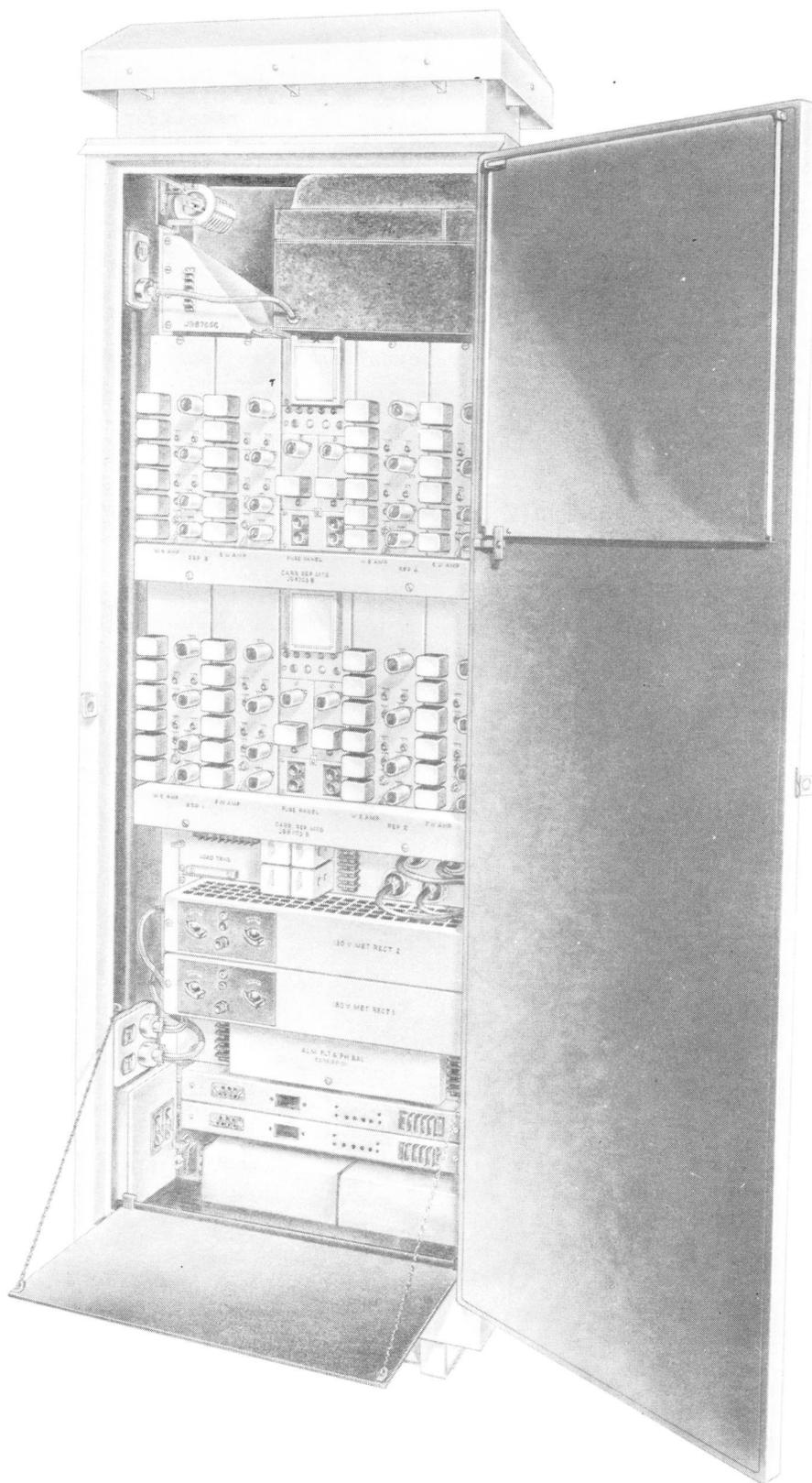


Fig. 15 - Pole-Mounted Repeater Cabinet - Typical Arrangement

ing of three plug-in units (two one-way repeater amplifiers and an oscillator or dummy oscillator). As in the terminal, power fuses and fuse alarm circuits are furnished as part of the mounting. A 2-repeater installation, exclusive of line networks, occupies a vertical bay space of 14 inches (8, 1-3/4-inch mounting plate spaces). Twelve repeaters mount on an 11-foot, 6-inch bay. Four repeaters, together with an ac power supply and other auxiliary equipment, can be housed in one cabinet approximately 2 feet wide, 15 inches deep, and 6 feet high arranged for pole mounting, (see Fig. 15).

1.38 The repeater mounting consists of a die-cast aluminum shelf arranged for attachment to any standard bay which will mount 19-inch panels. This shelf is identical with the shelves used with the terminal mounting and is equipped with jacks into which the four repeater amplifier units required for two, 2-way repeaters are plugged. Attached to the shelf, between the two repeaters, is a plug-in fuse panel containing the power distribution equipment, alarm circuit equipment, voltage adjusting resistors, equipment required for certain oscillator tests, and jacks into which the two repeater oscillator or dummy oscillator units are plugged. A removable faceplate on the panel below the shelf clamps the units in place on the shelf. As in the terminal, the top of each plug-in unit is secured to a supporting detail by a quick-acting fastener. All line leads external to the repeater mounting are brought to a terminal strip mounted in back of the removable panel in the center of the repeater mounting. Power wiring is brought to a power receptacle on the repeater mounting and connections to the fuses are made by means of a cord and plug attached to the removable panel. The earlier fuse panels, ED-92601-01, and oscillators, J98705J, had fabricated frameworks; the later fuse panels, ED-92742-01 and oscillators, J98705W have die-cast frameworks. The fuse panels may be used interchangeably in the repeater mounting frameworks, but the oscillators are not interchangeable in the fuse panels. That is, fabricated oscillators must be used in fabricated fuse panels and die-cast oscillators in die-cast fuse panels. The die-castings were furnished in equipment shipped after about the beginning of 1954.

1.39 For the OB, OC, and OD systems, the repeater amplifier unit is identical to the group receiving unit used in the terminal except for the plug-in auxiliary band filter. The orientation of the plug-in directional filter and auxiliary band filter, both of which are reversible, determines whether the unit is an LH or an HL repeater amplifier. Different filters are used according to whether the unit is to be used in an OBl, OC1, or OD1 repeater. Because the

OAl repeater does not frequency frog and because of the lower frequencies involved, the final amplifier in the OAl repeater is different from that of the OAl group receiving unit. The conversion between low-group and high-group OAl repeater amplifier is accomplished by reversing the directional filter, changing the auxiliary filter, and changing the strapping on a terminal block.

2. TERMINAL

A. General

2.01 An O1 carrier terminal transmits to and receives from a carrier pair, at carrier frequencies, the signals from four voice frequency circuits; provides built-in signaling arrangements for each channel; provides associated system and terminal alarm circuits; and provides for terminal power distribution.

2.02 The drop side of each terminal connects to four separate voice frequency message circuits and associated signaling leads. On 4-wire message connections the required system input level at the 4-wire input is 16 db below transmitting toll switchboard, and the system output level at the 4-wire output can be adjusted, by potentiometer, to any desired value between +10 db and -16 db. A 4-wire to 2-wire resistance hybrid is furnished for optional use as part of the channel equipment but its use is limited to cases of terminating circuits or nongain 2-wire switch points. In this case the system input level is 0 db and the system output level is adjustable between +8 db and -18 db, all referred to transmitting toll switchboard. E and M signaling leads are provided with each channel for transmission of either dialing or supervisory information over the system.

2.03 A block schematic of an OB1 terminal and those features of OC1 and OD1 terminals which are different, are shown in Fig. 146 (on page 114). In addition, the frequency bands of the channels on the line and at the channel filters are shown; also the changes to be made in converting from an HGT to an LGT terminal or vice versa. To make the change, each channel band filter is rotated 180 degrees and the two twin-channel carrier units are interchanged. In the group receiving unit the 530A plug-in directional filter is rotated 180 degrees and the 530P or the 531B filter is removed and replaced by the 530R or the 531C, or vice versa. In the group oscillator unit the two oscillator outputs are interchanged by means of soldered straps. Also indicated on the figure are the different filters required for the OB1, OC1, and OD1 terminals, and the frequencies supplied by the group oscillator units for these terminals. A block schematic of the group equipment of an OAl terminal is shown in Fig. 145 (on page 110). The channel and twin-channel circuits are omitted since they

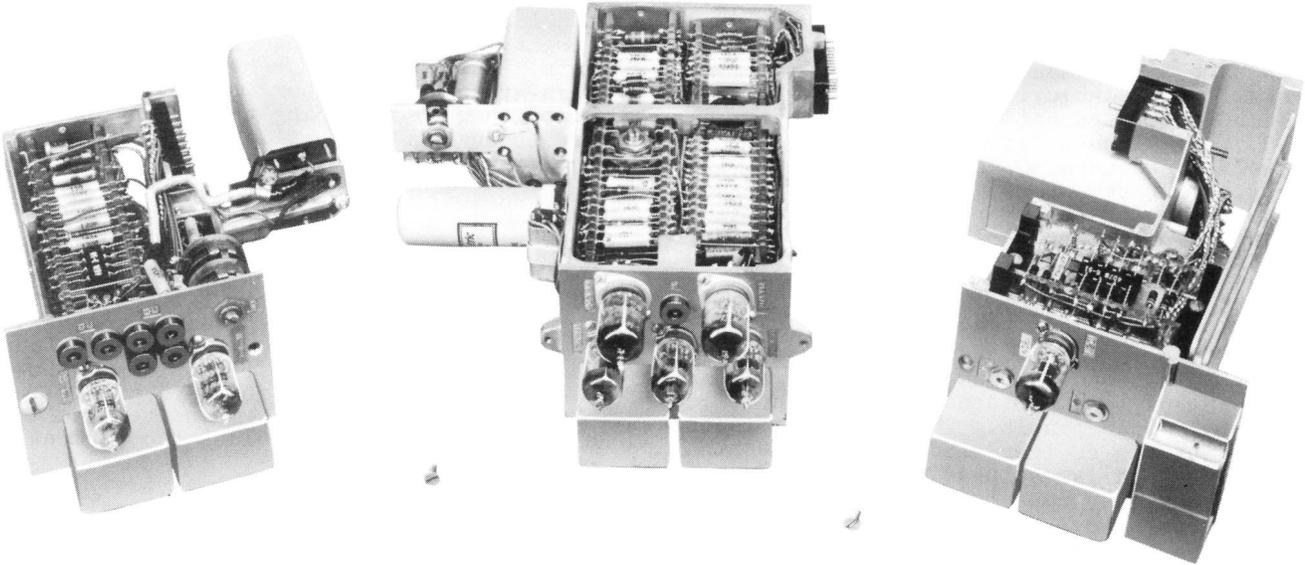


Fig. 16 - Channel Unit Subassemblies

are identical to those circuits shown in Fig. 146 (on page 114).

B. Channel Circuits

2.04 Two types of channel circuits are available. The more common one, known simply as a channel circuit, is used except where a channel is to be permanently connected in tandem with another O or N carrier channel. The other, known as a through channel unit, is used for such a through connection.

2.05 On the transmitting side the channel circuits modulate the four voice channels to the 180- to 196-kc range. On the receiving side the outputs of the channel filters, 180 to 196 kc, are demodulated down to voice. The channel circuits also provide compression and expansion of the voice signals and include the built-in signaling arrangements. The channel units are the same for all of the O systems. Channel units 1 to 4 are the same within any system except for the band filters. The latter are furnished as plug-in units of apparatus and only two codes are provided. Each code includes two filters of different frequency bands and four combinations are obtained by proper orientation of filters in the sockets. Two filters of each code are required at each O1 terminal.

2.06 Each channel unit is composed of three subassemblies (see Fig. 16) connected by plugs and jacks to form the complete plug-in unit. These are identified as the com-

pressor, expander-signaling, and carrier frequency subassemblies. The compressor and expander-signaling subassemblies are alike for all four channels of all the O systems.

Compressor Subassembly

2.07 As indicated in Fig. 17, the compressor subassembly includes the following parts: 4-wire terminating network, vario-losser, voice frequency amplifier, control circuit, and transmitting low-pass filter. Voice signals from the associated trunk pass through the terminating network (when used), the vario-losser (where 2:1 volume compression occurs), amplifier, and low-pass filter to a pad at the input of the channel modulator. Voice signals received from the expander are transmitted through a variable pad, for adjusting output level, and through the 4-wire terminating network, (if used), to the associated trunk or line.

2.08 The 4-wire terminating network employs a resistance hybrid having 16 db loss in the transmitting side and 2 db in the receiving side. It is adequate for terminal operation or for 2-wire switching at nongain switching points. Wiring options are furnished so that it may be used or not, as required. The 0 to 26 db pad REC provides means for adjusting the 4-wire output level between +10 and -16 db.

2.09 The vario-losser is essentially a balanced attenuator whose loss depends upon the amount of dc current flowing

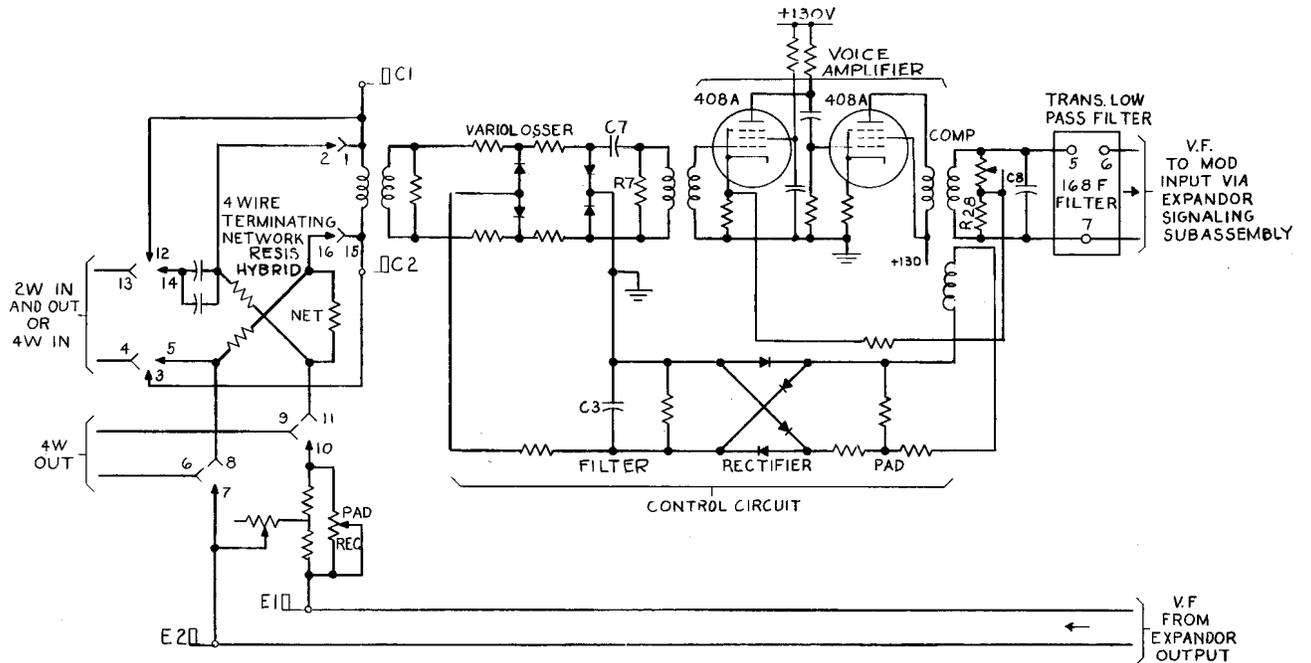


Fig. 17 - Compressor Subassembly Schematic

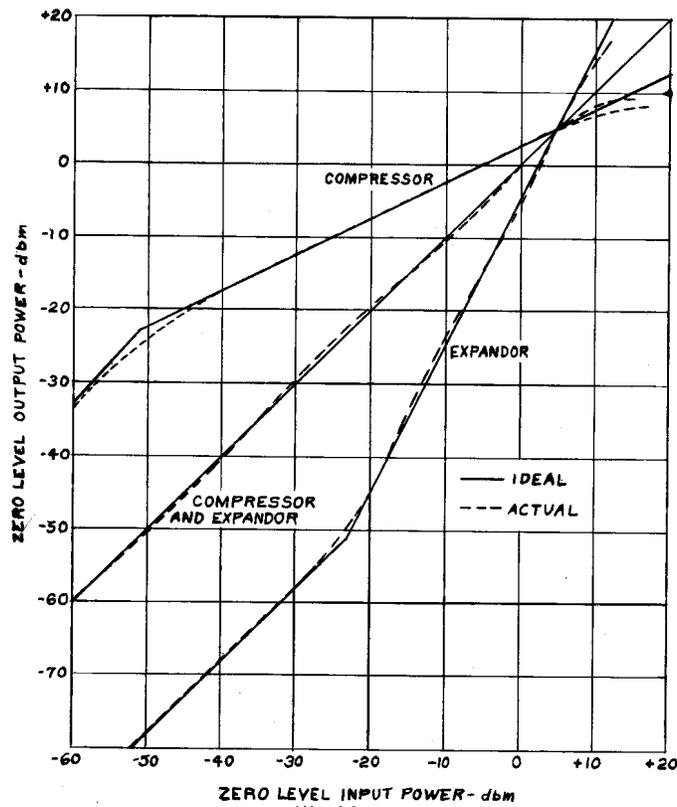


Fig. 18 - Zero-Level Input-Output Characteristics of Compressor

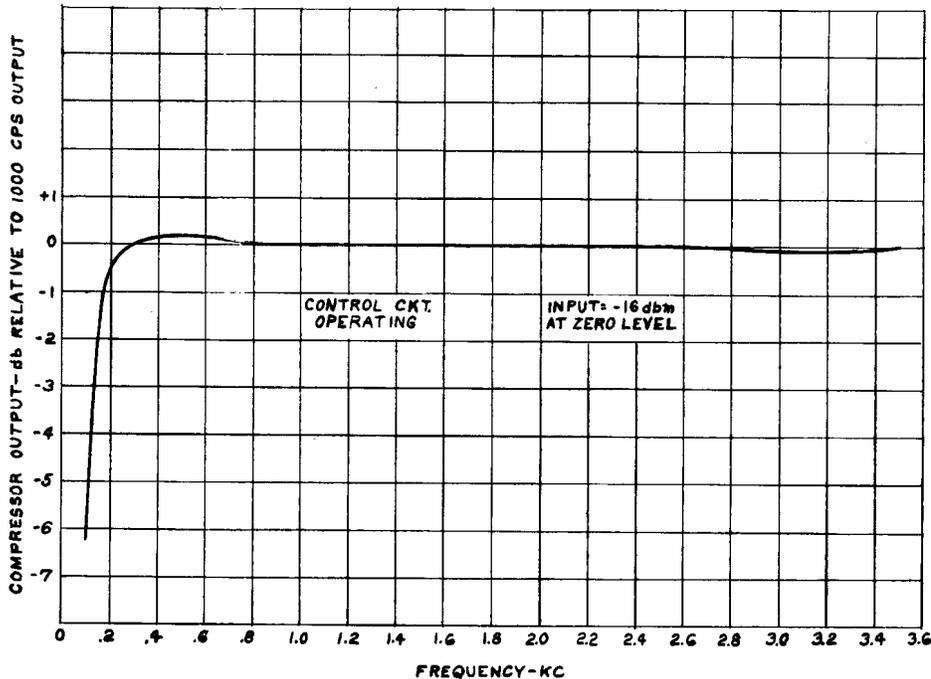


Fig. 19 - Typical Transmission Frequency Characteristic of Compressor Circuit

through the germanium varistors in the shunt arms. The current which controls the loss is obtained from the rectified output of the compressor amplifier via the control circuit. The action is such that, within operating limits, a 2 db change in input produces only a 1 db change in output.

2.10 The compressor voice frequency amplifier transmits speech currents to the low-pass filter and furnishes the power required for driving the rectifier which controls the vario-losser attenuation. Feedback is provided for stability and the gain with feedback is 40 db. The feedback-adjusting potentiometer COMP is used to set the output level for lining up the channel unit. The amplifier limits on input signals greater than +11 dbm at zero level.

2.11 A part of the compressor amplifier output is rectified by a full-wave rectifier composed of germanium varistors in the control circuit. The resulting dc current which varies at a syllabic rate with speech amplitude, is applied to the vario-losser to control its loss as required for 2:1 compression.

2.12 Fig. 18 shows how a typical compressor 2:1 load characteristic deviates from ideal for a 1000-cycle tone. Limiting in the voice amplifier is indicated by the leveling-off of output above +11 dbm input. At low levels the curve does not change

from 2:1 to 1:1 slope sharply, as the ideal indicates, because the varistors in the vario-losser cannot change from variable to fixed resistance abruptly. A typical transmission-frequency characteristic for the compressor circuit, exclusive of the low-pass filter, is shown in Fig. 19.

2.13 Fig. 20 shows the schematic and loss-frequency characteristic of the transmitting low-pass filter. It suppresses speech components above 3100 cycles and has a loss peak at 3700 cycles, to prevent these from interfering with the operation of the 3700-cycle signaling circuit and with the adjacent channel. The filter arrangement in the circuit (see Fig. 17) is such that the power delivered to the output load of the filter is 16.5 db below the power in the output stage of the voice amplifier.

Expander Circuit

2.14 The expander circuit is a part of the expander-signaling subassembly. It receives compressed speech signals from the demodulator amplifier and restores their original uncompressed range of volumes at its output.

2.15 The expander circuit (see Fig. 21) consists of the receiving low-pass filter which passes speech frequencies up to 3100 cycles and rejects 3700-cycle signaling tone and adjacent channel components,

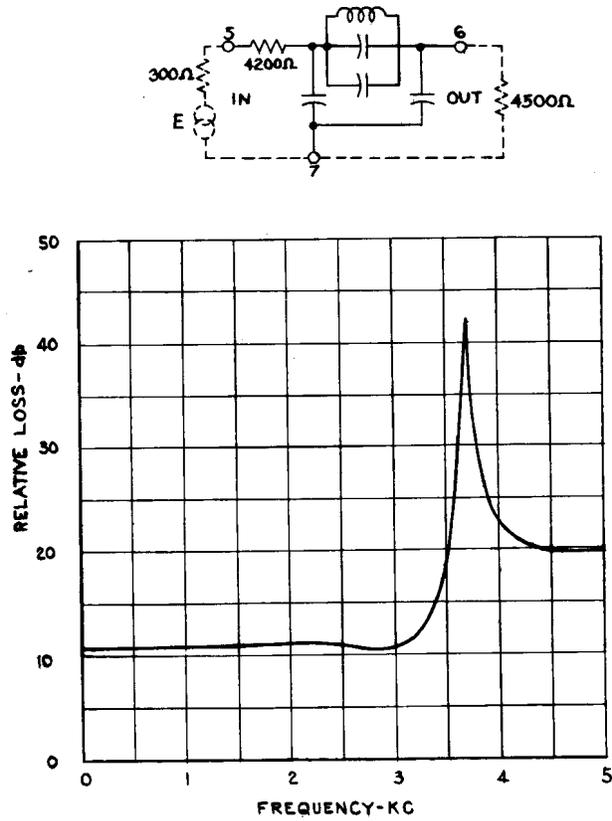


Fig. 20 - Schematic and Loss-Frequency Characteristic of Transmitting Low-Pass Filter 168F

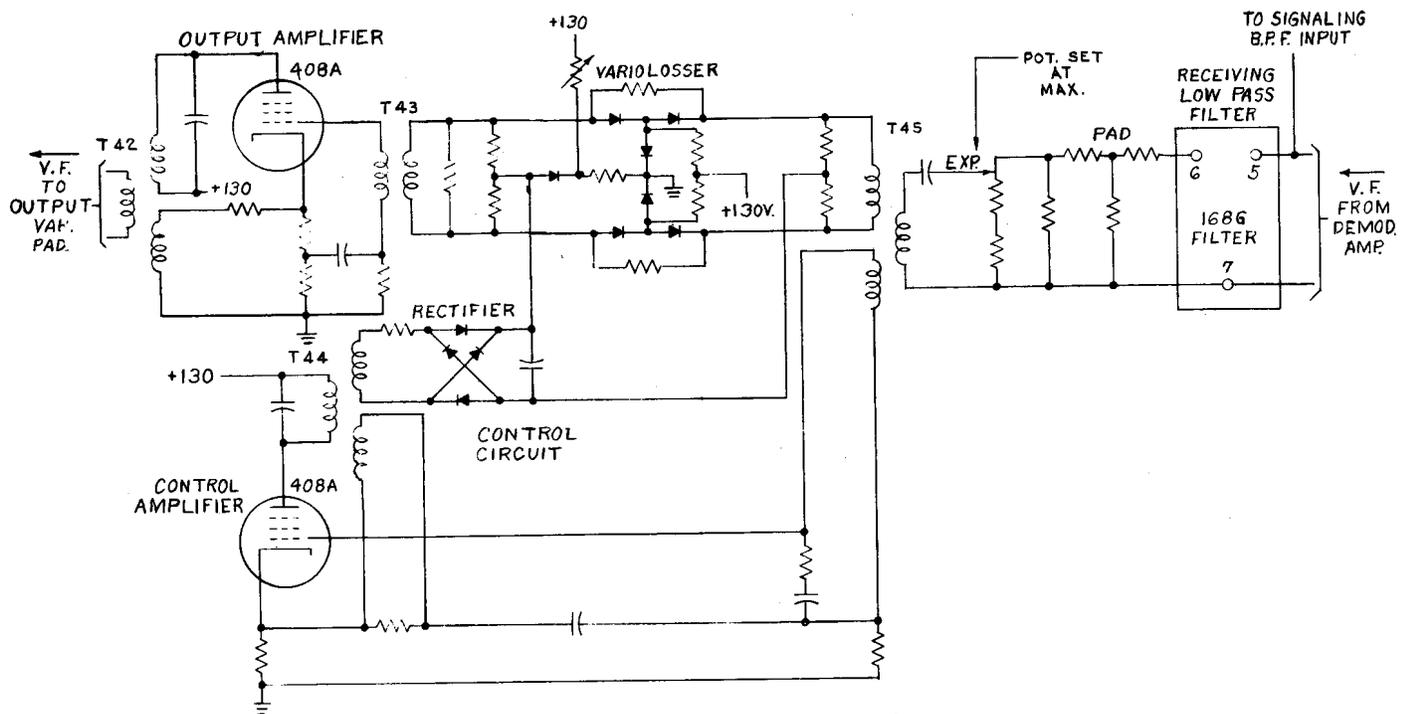


Fig. 21 - Expander Schematic

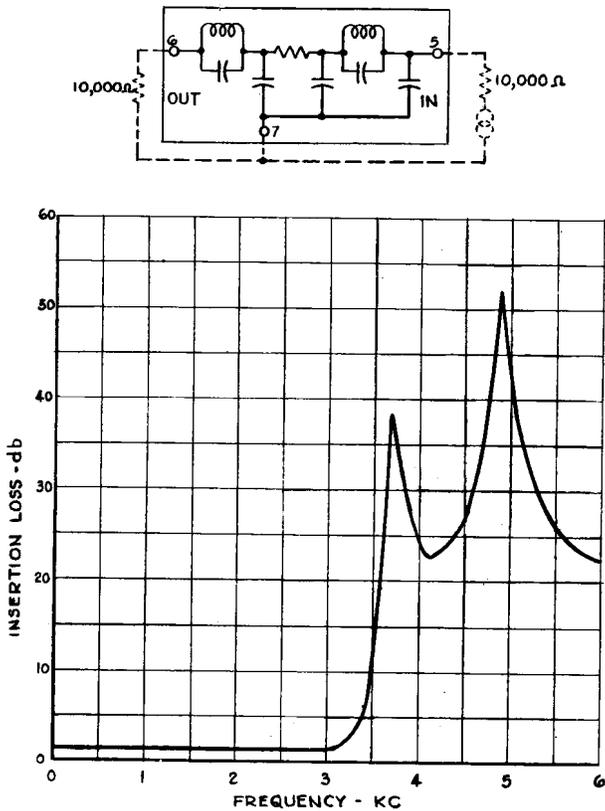


Fig. 22 - Schematic and Loss-Frequency Characteristic of Receiving Low-Pass Filter 168G

the vario-losser and control circuit which effect 2:1 volume expansion of the speech signals to restore their original volume range, and an output amplifier which provides sufficient gain to give +10 db level maximum (with respect to the transmitting switchboard) at the 4-wire output. As discussed in 2.08, a potentiometer in the compressor subassembly provides means for adjusting the 4-wire output level. In type O carrier the input potentiometer EXP is set at its extreme clockwise or minimum loss position except in unusual circumstances.

2.16 The expander circuit consists essentially of a control circuit, a variable loss varistor network, and a 34 db-gain amplifier. Speech energy is applied to the control amplifier. The amplified signals are then rectified by a full wave germanium rectifier. The resulting dc current, as in the case of the compressor circuit, is proportional to the speech amplitude and is passed through the vario-losser to control its loss. Fig. 18 compares a typical expander 2:1 load characteristic with the ideal. It also shows how the expander characteristic tracks with the compressor characteris-

tic, discussed in 2.12, to give the desired over-all compandor load curve. The receiving low-pass filter schematic and loss-frequency characteristic are shown in Fig. 22. The expander loss-frequency characteristic exclusive of the filter, is shown in Fig. 23.

Signaling Keyer

2.17 A schematic of the signaling keyer circuit is shown in Fig. 24. The circuit which is part of the expander-signaling subassembly, turns the 3700-cycle signaling tone on and off under control of the M lead from the trunk circuit to transmit supervisory, ringdown, and dialing signals on each channel. The 3700-cycle tone from the common oscillator in the group oscillator circuit is applied to the keyer input. In the idle or on-hook condition, ground (or open circuit) on the M lead biases the germanium varistor in the keyer to low resistance so that 3700-cycle tone is transmitted through to the input of the channel modulator in parallel with the speech output of the compressor. When the channel is seized or a ringdown signal supplied, -48-volt battery is applied to the M lead to bias the varistors to high resistance so that the tone is turned off. Dial pulsing consists of turning the tone on and off in response to the opening and closing of the dial contacts. The M lead resistance is limited to 200 ohms maximum for ground potentials of 5 volts maximum. Where the built-in signaling circuit is not needed, the 3700-cycle tone is removed permanently by connecting -48 volts to the M lead at the IDF.

Signaling Receiver

2.18 The signaling receiver circuit, Fig. 25, which is also a part of the expander-signaling subassembly, receives ringdown, supervisory, and dialing information from the channel demodulator amplifier in the form of pulses of 3700-cycle tone and translates this information into opens and closures on the E lead for ringdown signaling, supervision or dial pulsing. Two wiring options are provided for E lead signaling:

1. Standard open and ground pulsing for terminal or through operation with pulse link circuits
2. Open and -48 volt battery pulsing for through operation at junctions of combination O to O or O to N circuits without pulse link equipment (signaling extension option)

2.19 The signaling receiver circuit consist first of a 3700-cycle band pass filter (169A) to accept a signaling tone and reject speech frequencies. Fig. 26 shows a schematic and a typical loss-frequency characteristic for this filter. Following the filter is an amplifier with adjustable feedback for controlling operating

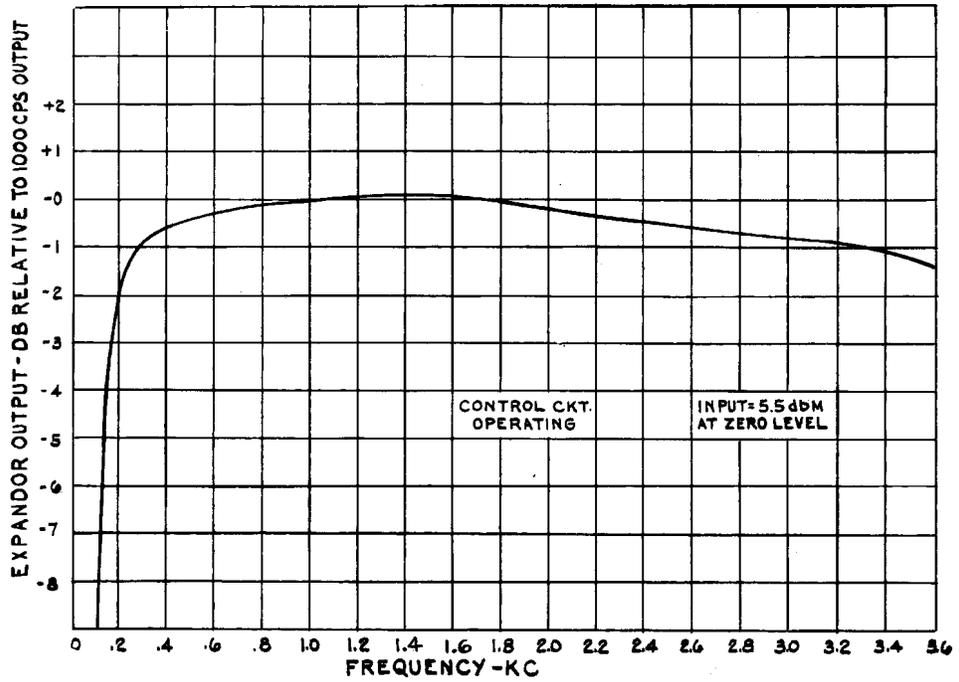


Fig. 23 - Typical Transmission Frequency Characteristic of Expander Circuit

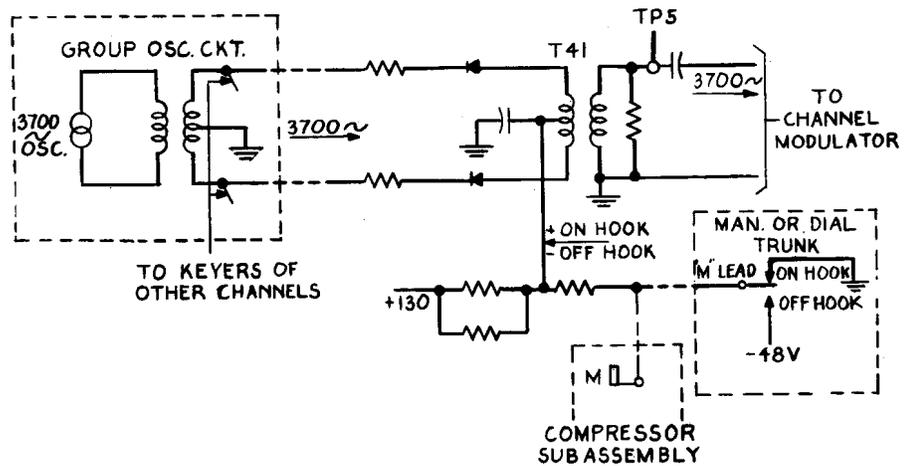


Fig. 24 - Signaling Keyer Circuit Schematic

SECTION 362-100-100

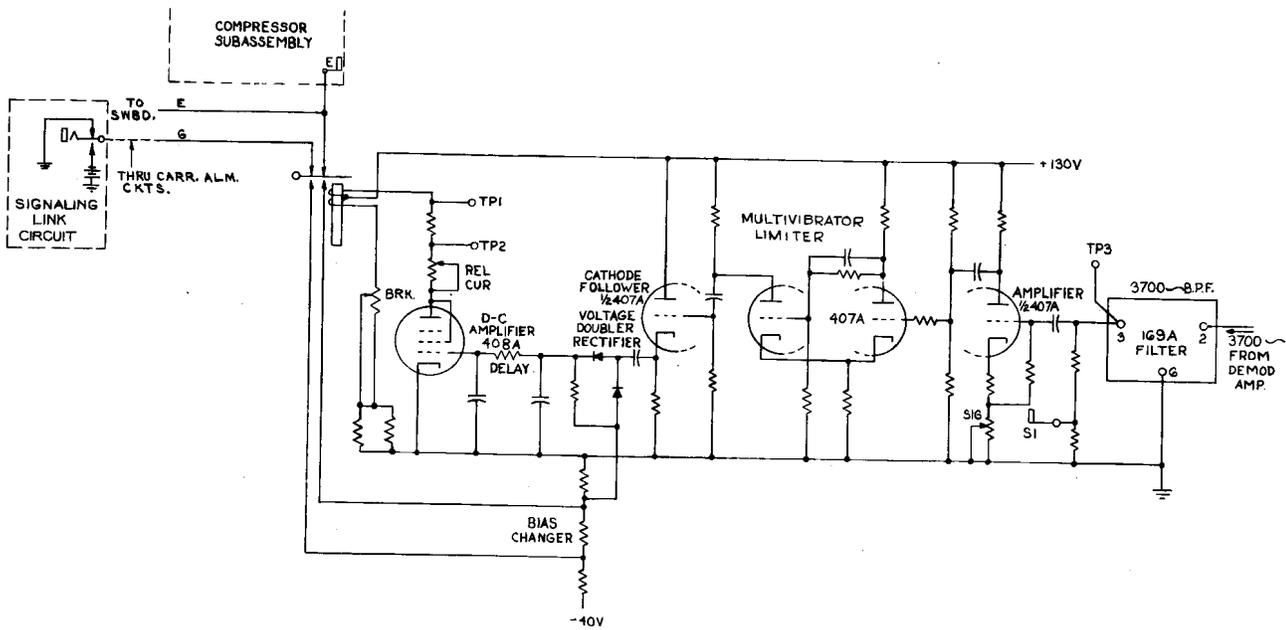


Fig. 25 - Signal Receiving Circuit Schematic

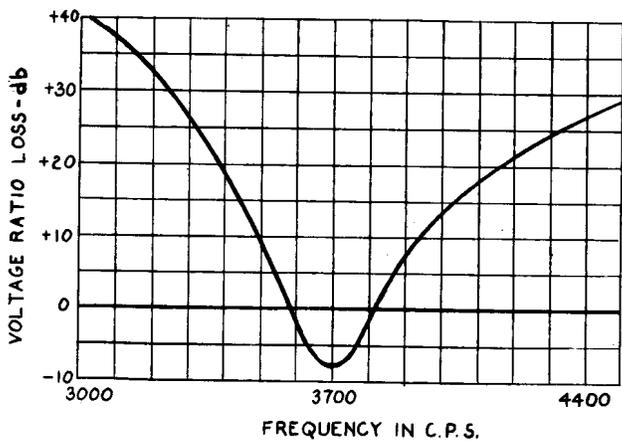
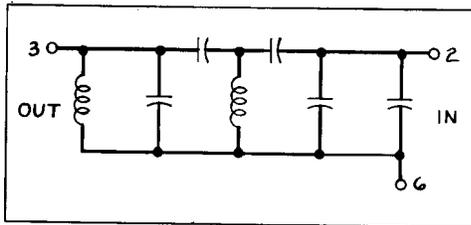
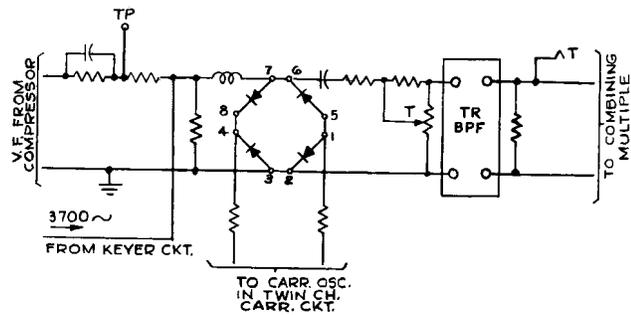
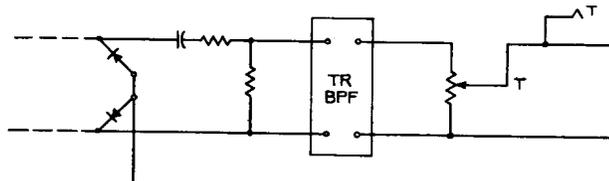


Fig. 26 - Schematic and Loss-Frequency Characteristic of 169A Signaling Filter



(A) 60 OHM FILTER TERMINATION



(B) 75 OHM FILTER TERMINATION

Fig. 27 - Channel Modulator Schematic

margin. Next is a multivibrator-limiter which converts the input 3700-cycle sine wave into a 3700-cycle square wave whose amplitude is constant over a wide range of input amplitudes. Following this is a cathode-follower stage which, by virtue of its high input impedance and low output impedance, affords means for interconnecting the high-impedance multivibrator to a low-impedance voltage doubler rectifier which converts the 3700-cycle square wave into dc. The dc from the rectifier is transmitted through a resistance-capacitance delay network which passes desired supervisory signals and dial pulses while rejecting comparatively short duration noise bursts and line transients. The dc signals from the delay circuit are applied to the grid of a dc amplifier with a sealed mercury contact polarized relay in its plate circuit. The dc amplifier is biased beyond cut-off so that with no 3700-cycle input to the circuit the relay is held in the nonoperated condition by action of steady current in its biasing winding so that the E lead to the switchboard is closed through the relay back contacts. When 3700-cycle tone is applied the dc amplifier conducts and its plate current operates the relay to open the E lead. Potentiometers are provided in series with the two relay windings for adjusting operate current and per cent break. The ground (or -48V battery when using the signaling extension option) is supplied to the "E" lead through contacts of relays in the alarm circuit.

Channel Modulator

2.20 The channel modulator circuit is part of the carrier frequency subassembly, which also contains the channel demodulator. It receives compressed speech frequencies from the compressor circuit and 3700-cycle signals from the signaling keyer and after modulation transmits them to the group transmitting circuit via the combining multiple in the terminal mounting as a single sideband at channel frequency.

2.21 A schematic of the channel modulator is shown in Fig. 27. It includes a voice frequency input pad which matches the 4500-ohm compressor output impedance to the 1000-ohm modulator, a shunt-type balanced varistor modulator where the compressed speech and 3700-cycle signaling tone modulates with the carrier supplied from the carrier oscillator in the twin-channel unit, a matching pad and potentiometer which permits adjustment of output power for initial line-up and maintenance, and the transmitting channel band filter which rejects the unwanted sideband and gives further suppression to the small amount of carrier leak coming from the modulator due to imperfect balance. Following the filter is a termination for the filter and a jack for measuring output power. Part A of Fig. 27

shows the circuit arrangement provided after January 1st, 1953; part B, the arrangement prior to that date. The change was made to provide a constant 60-ohm termination for the TRBPF filter, thereby improving the channel characteristic. The modulator operates with either a 184-kc or a 192-kc carrier which is supplied by an oscillator in the twin-channel carrier circuit.

2.22 The space in the carrier frequency spectrum allocated to the output of a channel modulator circuit depends upon the channel number and type of terminal. The channel frequency allocation, both transmitting and receiving, is given in the following table:

Chan. No.	Filter	LGT Term.		HGT Term.	
		Trans. KC	Rec. KC	Trans. KC	Rec. KC
1	529A	180	192	192	180
		to 184	to 196	to 196	to 184
2	529B	184	188	188	184
		to 188	to 192	to 192	to 188
3	529B	188	184	184	188
		to 192	to 188	to 188	to 192
4	529A	192	180	180	192
		to 196	to 184	to 184	to 196

The transmitting and receiving band filters for one channel are both contained in one plug-in filter can. The orientation of this can in its socket determines which section is used for transmitting and which is used for receiving. Because of the dual relationship between channels 1 and 4 and between channels 2 and 3, only two channel band filter codes are needed, 529A for channels 1 and 4 and 529B for channels 2 and 3. A channel may be changed from HGT to LGT operation, or vice versa, simply by unplugging its band filter, rotating it 180 degrees, and plugging it back in. Correct orientation of the filter in its socket is obtained when the visible information on its cover corresponds to the appropriate channel number and type of terminal. A schematic drawing and typical loss-frequency characteristics of the channel band filters are shown in Fig. 28. The schematic for only one filter is shown since both are identical in configuration.

Combining Multiple

2.23 The combining multiple, by means of which the four channel sidebands from the channel circuits and the two carriers from the twin-channel carrier circuits are combined for transmission to the input of the group transmitting circuit, is shown in

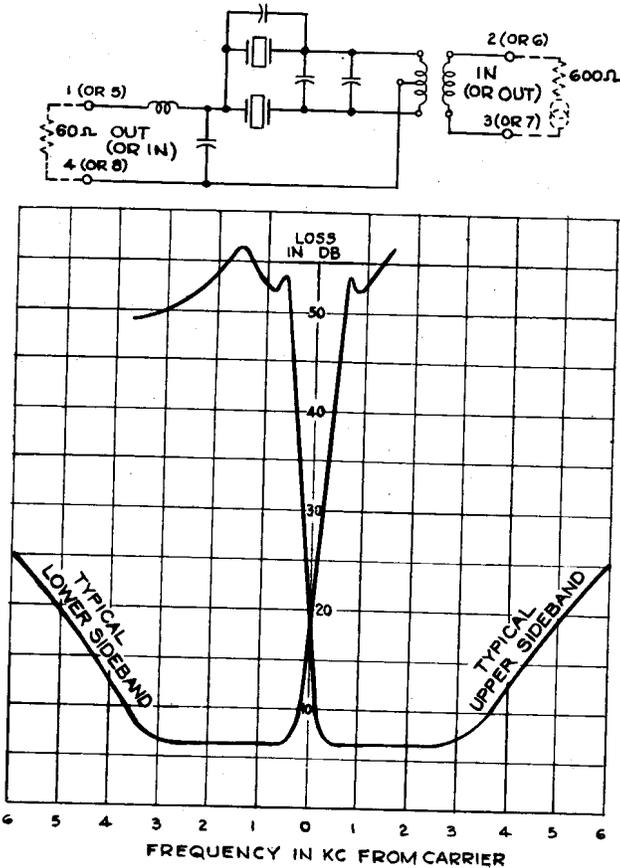


Fig. 28 - Schematic and Loss-Frequency Characteristic of Channel Band Filter

simplified form in Fig. 30. The resistors are mounted between two plastic strips at the left side of the space between the shelves of the terminal mounting. The combining multiple provides impedance matching between the transmitting channel band filters and the input of the group transmitting circuit. The combining pad loss between channels is 40 db so that the impedance effect of any channel filter upon the transmission of any other channel is negligible.

Channel Demodulator

2.24 A schematic drawing of the channel demodulator, which is part of the carrier frequency subassembly, is shown in Fig. 31. It selects from four carrier sidebands and two carriers at its input the appropriate sideband, converts this to voice frequency and 3700-cycle signals, and amplifies and transmits both to the expander and signaling detector circuits.

2.25 The demodulator circuit consists of the following: the receiving channel band filter which selects one channel sideband and rejects the other three; a shunt-

type balanced varistor modulator where the message and signaling sidebands are demodulated against the carrier to voice frequencies; and an amplifier, with a gain control potentiometer (R) at its input, for amplifying the voice frequencies received from the modulator before transmitting them to the input of the expander and 3700-cycle signal detector circuits. The demodulator amplifier has a maximum gain of about 28 db with sufficient feedback for stability.

2.26 The demodulator operates with either a 184-kc or 192-kc carrier. The carrier is selected by the pick-off filter in the twin-channel circuit, amplified, and fed to the demodulator over a pair of leads separate from those through which the sideband energy is transmitted.

2.27 The receiving band filter, as discussed in 2.22, is part of the plug-in filter unit which also contains the transmitting channel band filter. The details of frequency allocation, etc. are given in that paragraph. The schematic and frequency characteristics of this filter are the same as for the transmitting filter (see Fig. 28).

Through Channel Circuit

2.28 Where an O carrier channel is to be connected permanently (by cross-connection) in tandem with a channel in another O system or an N system, a relatively simple through channel unit may be substituted for the channel unit previously described. This through channel unit (see Fig. 29) consists of the usual carrier subassembly combined with a simplified through voice frequency subassembly in place of the compressor subassembly and expander and signaling subassembly. The through channel unit is plugged into the terminal mounting in place of the normal channel unit. Each through voice frequency subassembly provides level adjustment and amplification on the receiving side and impedance matching on the transmitting side. Separate level adjustments are provided for the message power and the 3700-cycle signaling power. By switches the unit may be conditioned for use in an N or O terminal and for connection to an N or O channel in another system. The through channel unit is fully described in CD-95191-01.

C. Twin-Channel Carrier Circuits

2.29 Each twin-channel carrier circuit performs four functions. On the transmitting side it supplies the common carrier (184 or 192 kc) to the modulators of two channels; also the same carrier is supplied to the combining multiple for eventual transmission over the line. On the receiving side it selects the complementary incoming common carrier and amplifies it for supplying the associated demodulators and at the same time provides a nearly constant output level

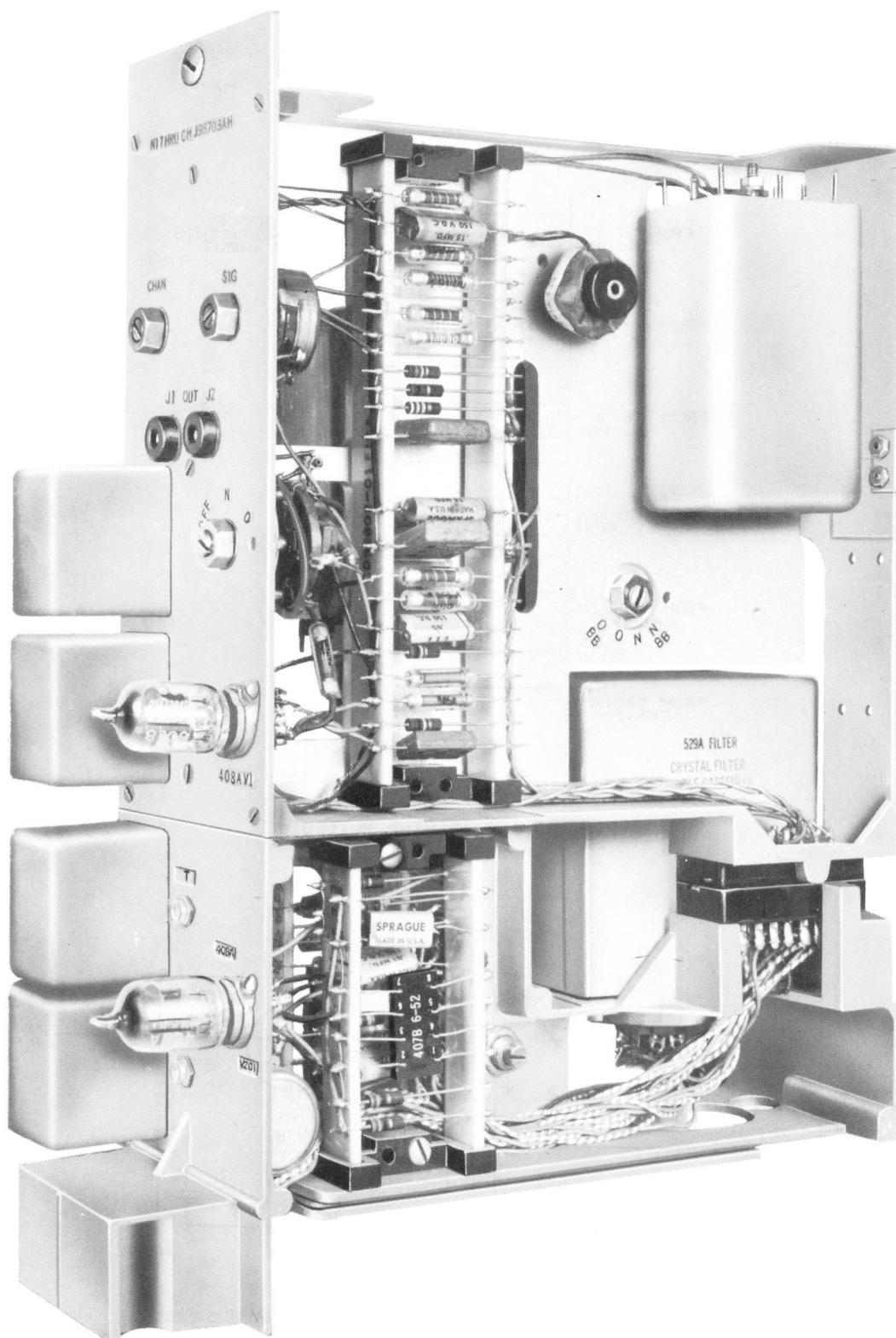


Fig. 29 - Through Channel Unit

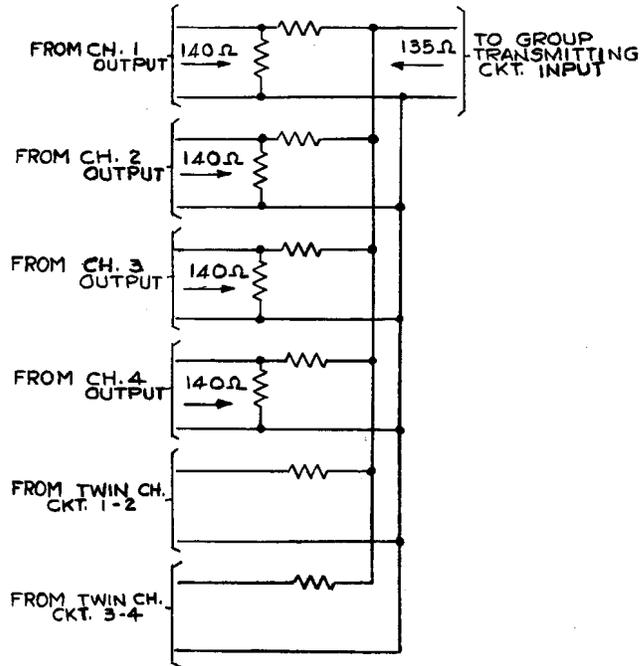


Fig. 30 - Combining Multiple

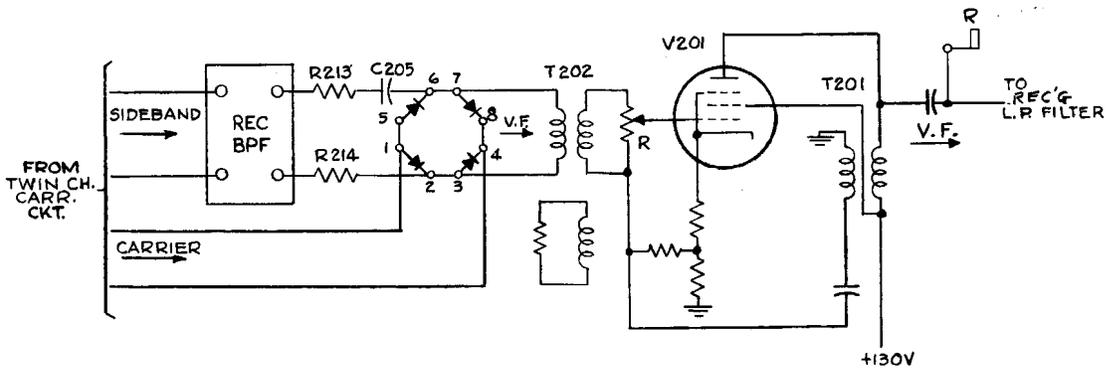


Fig. 31 - Channel Demodulator and Amplifier Schematic

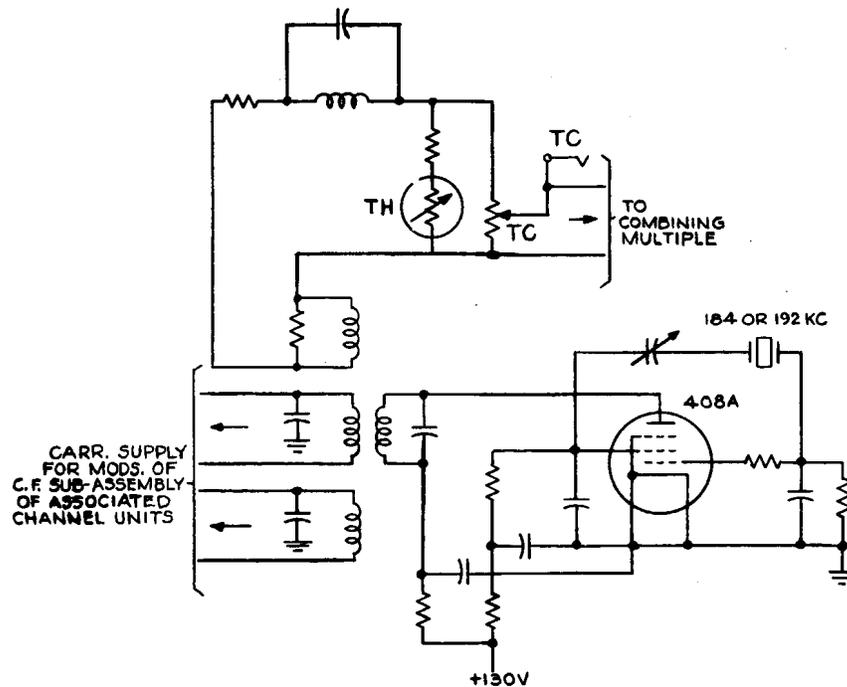


Fig. 32 - Twin-Channel Carrier Schematic - Transmitting Side

of the associated sidebands thus supplementing the regulation of the group receiving circuit. These functions are carried out at the channel frequencies, 180 to 196 kc.

2.30 The group receiving circuit regulates the four incoming channels as a group. The control circuit is flat and the total power output is about +9 dbm. However, one carrier and consequently its two associated channels may be several db lower in level than the other carrier and its two associated channels because of slope of the line attenuation characteristic across the band. Because of changing weather conditions this difference between the two carriers changes. The twin-channel carrier circuits practically remove this changing difference by regulating each carrier and its associated pair of channels to an approximately constant output.

2.31 Reference to Fig. 146 (on page 114), the O1 terminal block schematic, shows that the two twin-channel carrier circuits are identical except for the frequencies of the oscillators and the frequencies of the carrier pick-off filters. To change a terminal from LGT to HGT it is only necessary to interchange the two twin-channel carrier units in the terminal mounting. The same kinds of twin-channel carrier units are used for all of the O1 terminals. The received carriers at an O1 terminal which connects through an open-wire line to an ON

junction (described in Section 362-100-150) may have wider frequency variations due to the possible large number of frequency frogging points in an ON system. For this reason, type O1 terminals which are associated with an ON1 junction use twin-channel units which have wider band pick-off filters (see Fig. 35).

2.32 Fig. 32 is a schematic of the transmitting side of the twin-channel carrier circuit. The carrier oscillator uses the control grid, cathode, and screen grid of the tube. The crystal acts as the inductance in the tuned circuit coupling the three tube elements together. A capacitor in series with the crystal provides means for factory adjustment of the oscillator frequency. The output is taken from the plate of the tube by electron coupling for the purpose of isolation and stabilization. Two low-impedance windings of the oscillator output transformer supply carrier for the channel modulators of the associated channel units. Capacitors on one side of each of these windings compensate for their capacitance unbalance. The transmitted carrier, which is applied to the combining multiple, is taken from the third low-impedance winding of the transformer and is filtered in order to reduce harmonic content, which would produce interference in other O systems, and also to permit accurate measurement with a nonselective vacuum tube voltmeter. A potentiometer designated TC

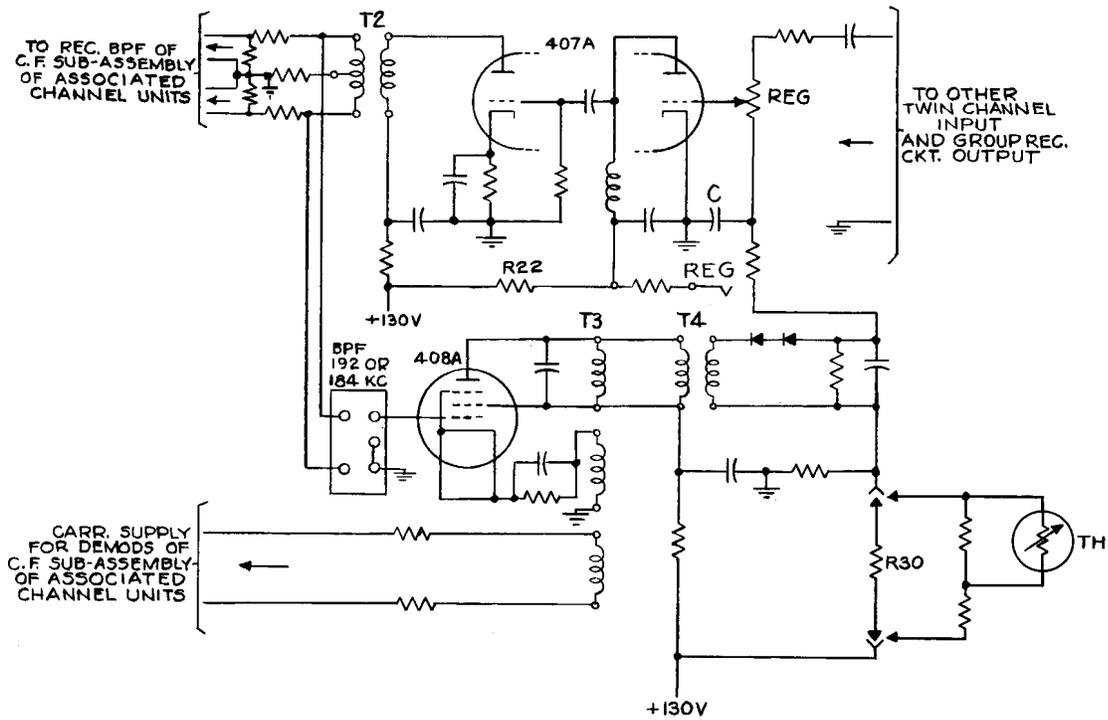


Fig. 33 - Twin-Channel Carrier Schematic - Receiving Side

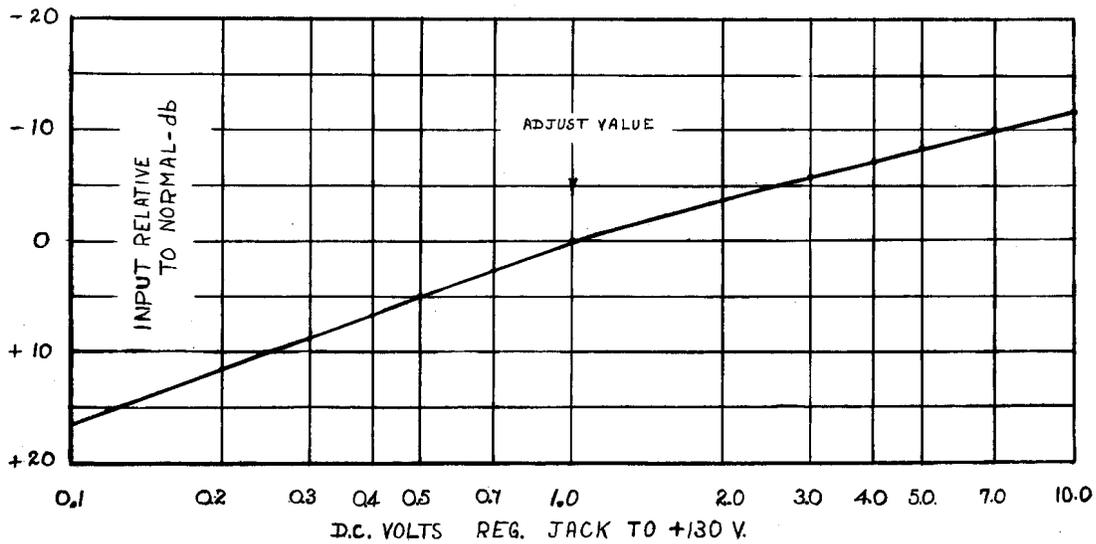


Fig. 34 - Twin-Channel Carrier Regulating Amplifier Input vs. Regulating Test Voltage

(transmitted carrier) permits adjustment of the transmitted carrier to the required value, which is measured at the pin jack TC. Because of the loss introduced by the combining multiple the second carrier applied to another branch of the multiple does not affect the reading significantly.

2.33 The receiving side of the twin-channel carrier circuit (shown in Fig. 33) consists of a variable gain amplifier and its control circuit. The inputs of the two twin-channel circuits are connected in parallel, and to the output of the group receiving circuit. Consequently, all four channel sidebands and both carriers are present in both twin-channel circuits. A crystal band pick-off filter (532A or 532B for type O systems, 532D or 532E for type O1 terminals forming part of ON systems) bridged at the output of the amplifier picks off one of the carriers associated with one pair of channels,

and applies it to a control circuit which regulates the amplifier gain to hold that particular carrier and the associated two channels constant at the amplifier output.

2.34 The variable gain amplifier consists essentially of a double triode, of which only the first section has variable gain, with impedance interstage coupling, an input potentiometer REG, and an output transformer T2. The input carriers and sidebands are attenuated considerably by the potentiometer to reduce modulation in the variable gain stage. At the same time the potentiometer permits adjustment of the regulator operating point. The output transformer, with a low side center-tap connected through a resistance to ground, acts as a hybrid coil providing balance between the two outputs so that the out-of-band impedance of one channel band filter does not affect the transmission through

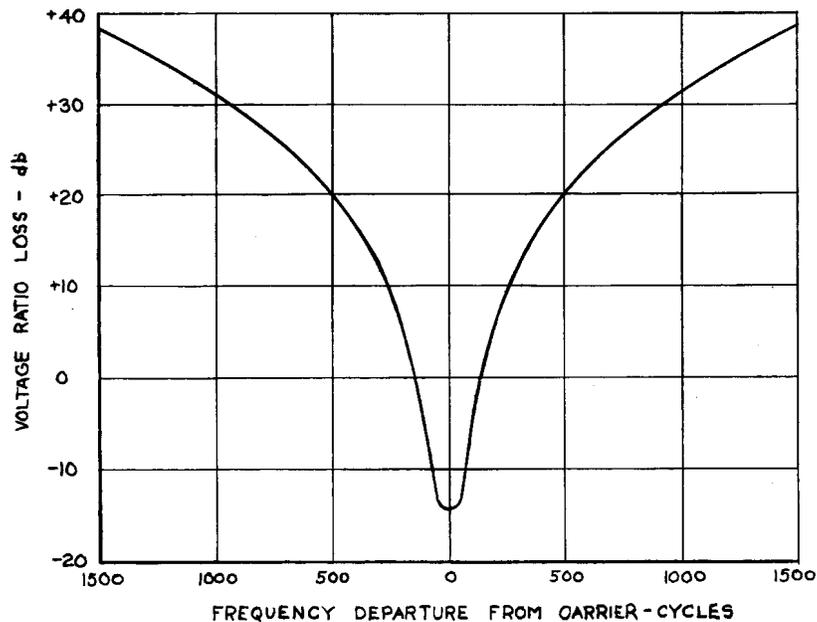
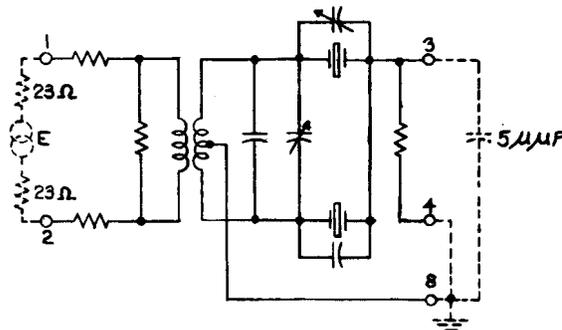


Fig. 35 - Typical Loss vs. Frequency Characteristic of Carrier Pick-off Filter

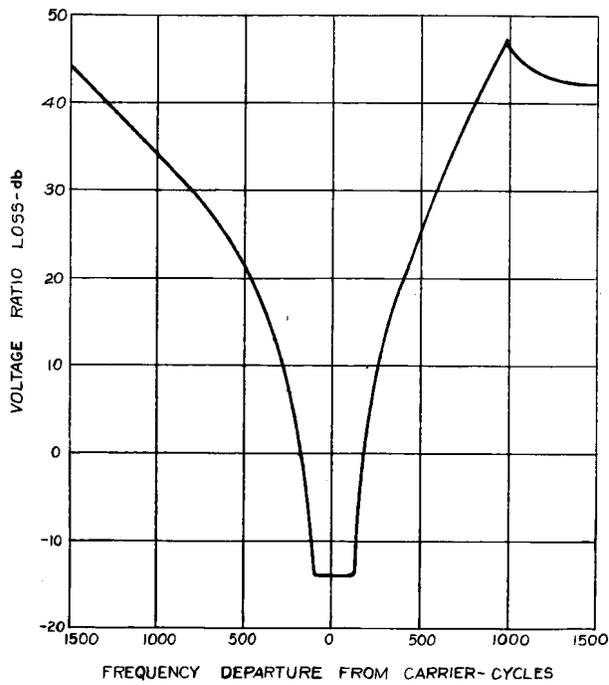
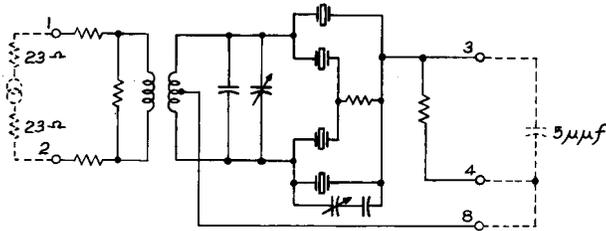


Fig. 36 - Carrier Pick-off Filters 532D or 532E

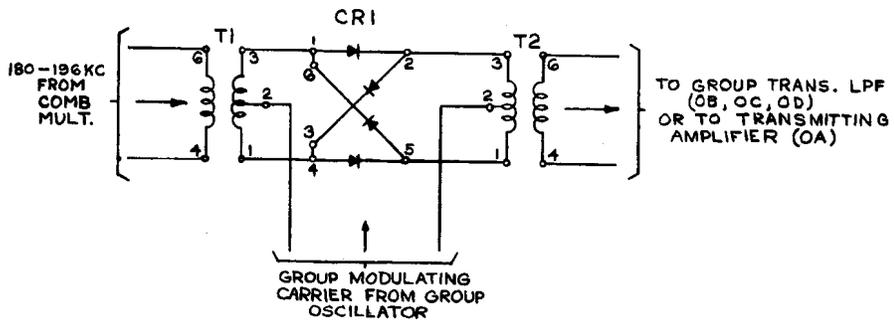


Fig. 37 - Group Transmitting Modulator Schematic

the other. A small pad in each output circuit further minimizes interaction effects between the band filters. This pad was changed in units produced in 1953 and thereafter to present an impedance of 60 ohms to the REC BPF filter instead of 75 ohms formerly, to improve the channel transmission characteristic.

2.35 The gain of the first section of the double triode is varied by means of a changing negative bias on the grid which is applied by the control circuit across capacitor C. Fig. 34 shows how the dc voltage across resistor R22 (a measure of plate current) varies with input. The bias is the resultant of a positive reference voltage derived from the 130-volt supply and of the larger negative voltage produced by the control circuit. A larger carrier output results in a larger negative control circuit output and therefore a reduced gain of the first stage of the variable gain amplifier. Similarly, a lower carrier results in a smaller negative control which increases the regulating gain. The net effect is to provide an output change of only 1 db when the input is changed 10 db.

2.36 A schematic and typical frequency characteristic of a pick-off band filter for a type O system is shown in Fig. 35 and a typical characteristic for a pick-off band filter used in an O1 terminal when it is part of an ON system in Fig. 36. Each filter includes a transformer stepping up the selected carrier voltage to the control grid of the 408A tube shown in Fig. 33. The primaries of two transformers T3 and T4 are in parallel in the plate circuit of the tube, the combination being broadly tuned to 188 kc. Transformer T4 applies the proper voltage to the germanium rectifiers. Aging effects are reduced by the low-output impedance. One of the low windings of T3 provides the shunt output feedback. There is about 20-db feedback in the control circuit to provide gain stability and a low-output impedance. The rectified dc output of the control circuit is applied to the variable gain amplifier through a resistor and capacitor C, which determine the regulation time constant. The thermistor and resistance network shown as TH on Fig. 33 compensate for the change in flat loss of the receiving channel band filter. As the flat loss of the filter rises with temperature the thermistor introduces an offsetting change in the grid bias on the variable gain amplifier. This change is being introduced about the middle of 1954. Another low winding of T3 supplies carrier power to the associated channel demodulators. Because of the low tube output impedance the change in carrier level on one demodulator when the other demodulator is removed is minimized.

2.37 The carrier oscillator frequency is adjusted in the factory and the only

field adjustment required is that of the potentiometer TC (Fig. 32) to adjust the transmitted carrier to the required level, as measured at the TC pin jack. The receiving side is lined up by adjusting the potentiometer REG (Fig. 33) to give a specified plate current in the first section of the double triode, as measured by the voltage between +130 volts and pin jack REG.

2.38 Performance of the twin-channel carrier circuit is covered in Parts 4C, Regulation, and 4D, Transmission Performance.

D. Group Transmitting Circuit

2.39 The group transmitting circuit performs three functions. It shifts the four sidebands and two carriers at the channel frequencies to the line frequencies, amplifies them to obtain the proper line level (provision is made for lowering the output line level for coordination purposes or reduction of interaction crosstalk) and provides a noise generator, the output of which is introduced into the transmission path of the group receiving circuit for masking intelligible crosstalk.

2.40 For OAL terminals the same group transmitting unit is used for LGT and HGT terminals; the only change required in the unit in going from one to the other type of terminal is a change of a strap on an inter-stage inductor. For OBL, OCL, and ODL terminals a different group transmitting unit is used. This unit is used unchanged for all these terminals, either LGT or HGT. This is feasible because the bands of the low-pass filter and transmitting amplifier can be made wide enough to accommodate all frequencies between 40 and 156 kc. The carrier supplied to the modulator from the group oscillator unit is different for each type of terminal in order to obtain the proper line frequencies.

Group Modulator

2.41 The output of the combining multiple is applied to the group modulator, a schematic of which is shown in Fig. 37. It is the double-balanced-type consisting of a copper oxide varistor CR1 connected between transformers T1 and T2. A perfect balance is not achieved practically but the input signal is suppressed about 20 db and the carrier about 40 db. Transformer T1 has an impedance ratio of 135 ohms to 135 ohms while T2 has a step-up ratio of 135 ohms to 3000 ohms. Transformer T2 in the OAL group transmitting unit is different from the one in the OBL, OCL, ODL unit since one transformer could not be used to cover the whole frequency range from 2 to 156 kc.

Group Transmitting Filter

2.42 In the OBL, OCL, ODL group transmitting unit a low-pass filter (540A)

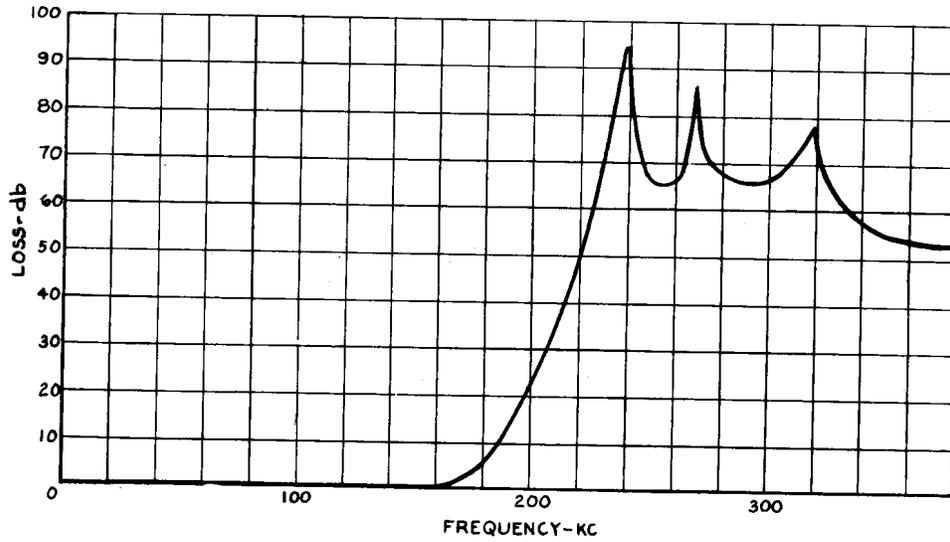
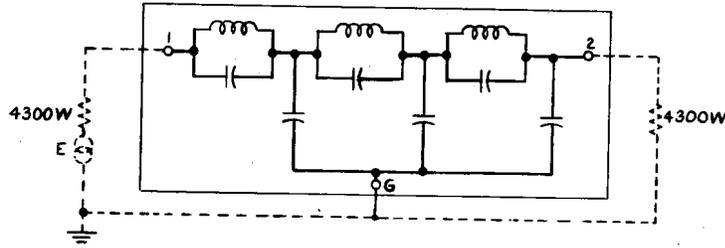


Fig. 38 - OBl, OC1, OD1 Group Transmitting Low-Pass Filter (540A)

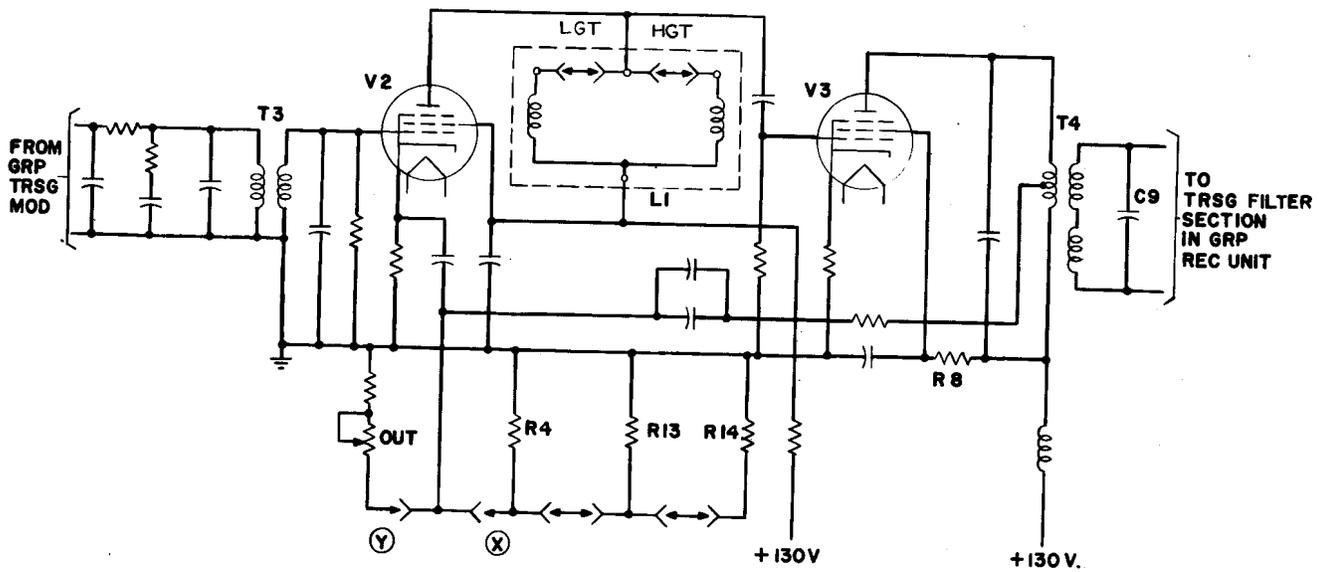


Fig. 39 - OA Group Transmitting Amplifier Schematic

passes the lower sideband produced by the modulator, to which it is connected, and rejects the group modulating carrier, the upper sideband, and all other products. Its configuration and characteristics are shown in Fig. 38. It is apparent that the filter transmits the OB, OC, and OD line frequencies.

2.43 In the OAl group transmitting unit the modulator connects to the transmitting amplifier through a combination of resistors and capacitors (see Fig. 39). The combination of these components with the modulator transformer T2, the transmitting amplifier input transformer T3, and the amplifier output transformer T4 provide sufficient discrimination to the group modulating carrier, the upper sideband, and other unwanted products from the modulator to eliminate the need for a low-pass filter such as used in the OBl, OC1, OD1 unit. This is possible because of the large frequency space between the highest wanted frequency in the OA high group (36 kc) and the lowest frequency to be rejected (low-group modulating carrier of 198 kc).

Transmitting Amplifier

2.44 Since the bands of frequencies that the transmitting amplifiers of the OAl group transmitting unit and the OBl, OC1, OD1 group transmitting unit must amplify are quite different (2 to 36 kc versus 40 to 156 kc), the size of the components used is different. However, their circuit configurations are similar; Figs. 39 and 40 show the circuit schematics.

2.45 In the OAl unit the output of the modulator is applied to the input of the amplifier through a combination of resistors and capacitors. The amplifier consists of two 408A pentode tubes impedance-coupled. The input transformer has an impedance ratio of 3000 ohms to 20,000 ohms and couples the 3000-ohm output of the modulator to the grid of the first tube providing step-up of the signal voltages present at the modulator output. The interstage network is a simple impedance-coupled circuit consisting of an inductor in the plate circuit, a grid leak resistor and a coupling capacitor between them. As shown in the schematic, strapping on the interstage inductor (V or W) determines which one of two values of inductance are used in the interstage according to the use of the unit in an HGT or LGT terminal. This provides a maximum amount of feedback over either the OA low-group or OA high-group frequency bands. The plate of the second tube is connected to hybrid transformer T4 which couples the amplifier output to the line and to the feedback circuit. Transformer T4 has an impedance ratio of 19,050 + 950 ohms to 600 ohms. The output impedance of the amplifier is a nominal 600 ohms

and is controlled by resistor R8 in conjunction with the turns ratio of the transformer.

2.46 In the OBl, OC1, OD1 unit the output of the low-pass filter is applied to the input of the amplifier. The amplifier consists of two 408A pentode tubes impedance-coupled. The input transformer has an impedance ratio of 3000 ohms to 20,000 ohms and couples the 3000-ohm output of the group filter to the grid of the first tube providing step-up of the signal voltages present at the filter output. The interstage network is a simple impedance-coupled circuit consisting of an inductor in the plate circuit, a grid leak resistor and a coupling capacitor between them. In this unit a single value of inductance in the interstage circuit is satisfactory for the complete OB, OC, and OD band. The plate of the second tube is connected to hybrid transformer T4 which couples the amplifier output to the line and to the feedback circuit. Transformer T4 has an impedance ratio of 18,000 + 2,000 ohms to 135 ohms. The output impedance of the amplifier is a nominal 135 ohms and is controlled by resistor R8 in conjunction with the turns ratio of the transformer.

2.47 In both the OAl and the OBl, OC1, OD1 group transmitting units the feedback amplifier may be either a fixed gain or an adjustable gain amplifier, on an optional basis. The amount of voltage fed back to the first tube controls the gain of the amplifier. For "X" wiring the feedback voltage is under the control of resistors R4, R13, and R14 arranged so that by strapping, manufacturing gain requirements can be met. For "Y" wiring the feedback voltage is under the control of the OUT potentiometer. It is only used when reduced output levels are required for coordination with other systems or reduction of interaction crosstalk. The feedback voltage is essentially applied across the cathode of the first tube resulting in a voltage which is in series and out-of-phase with the signal voltage applied to the grid.

2.48 The output of the group transmitting circuit is connected through the terminal mounting wiring to the transmitting side of the directional filter located on the group receiving unit. The output impedance is nominally 600 ohms for the OAl unit and 135 ohms for the OBl, OC1, OD1 unit. Capacitor C9 is bridged across the low side of T4 in order to provide impedance correction. When the group transmitting unit is plugged into an OBl terminal, wiring on the mounting will connect capacitor C13 in parallel with C9.

Noise Generator

2.49 The noise generator consists of a neon tube and a variable gain ampli-

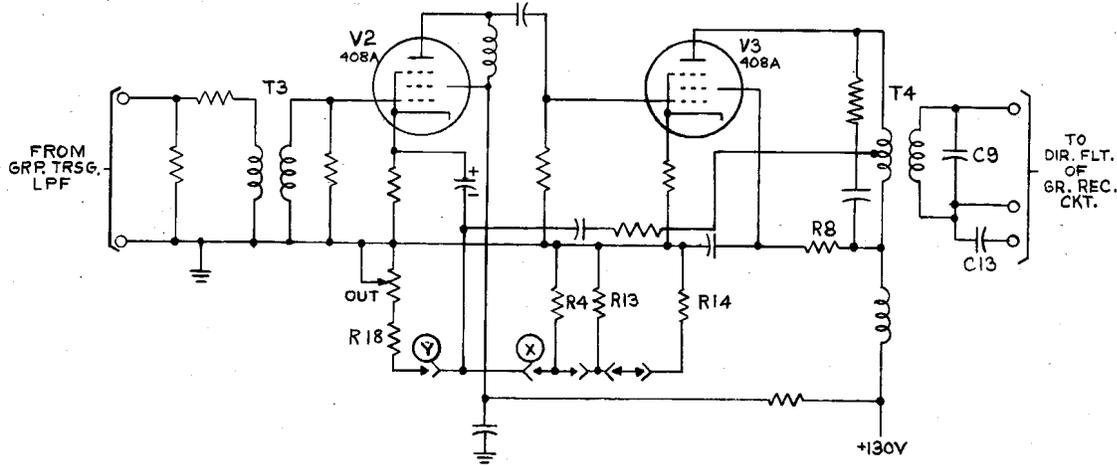


Fig. 40 - OB, OC, and OD Group Transmitting Amplifier Schematic

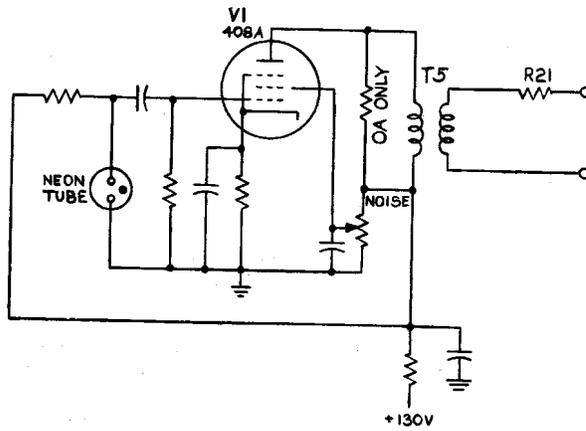


Fig. 41 - Noise Generator Schematic

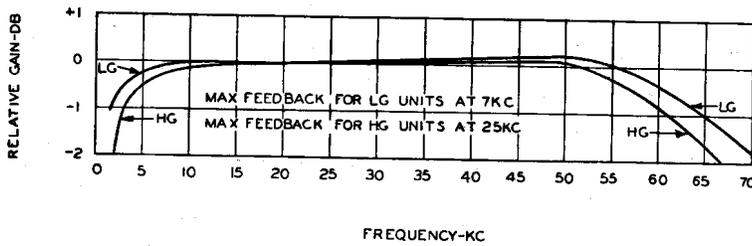


Fig. 42 - Typical Frequency Characteristic - OAl Group Transmitting Amplifier

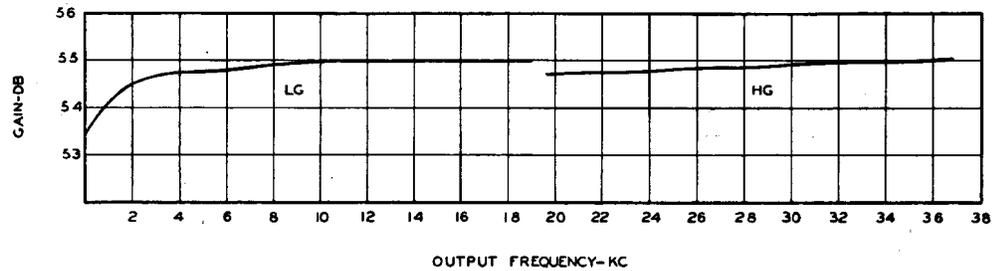


Fig. 43 - Over-all Frequency Characteristics - OAl Group Transmitting Circuit

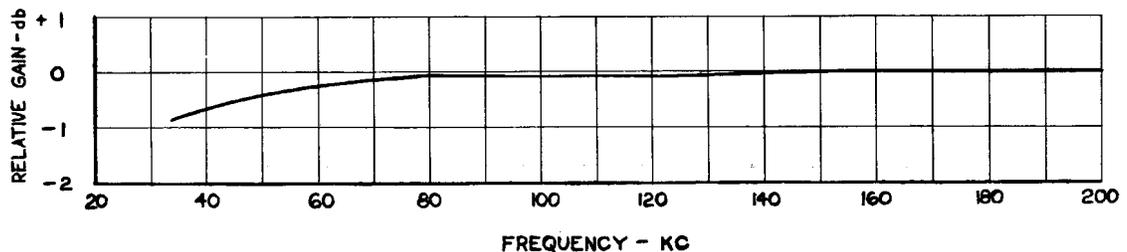


Fig. 44 - Typical Frequency Characteristic - OBl, OC1, OD1 Group Transmitting Amplifier

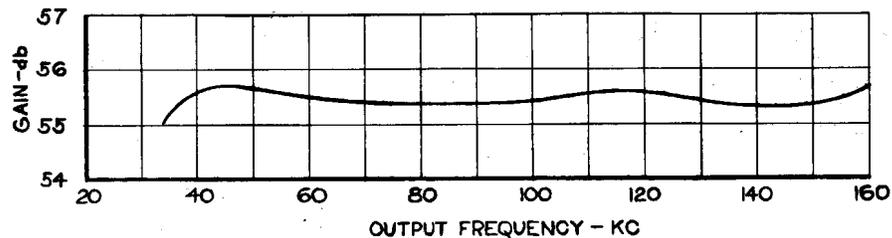


Fig. 45 - Over-all Frequency Characteristic - OBl, OC1, OD1 Group Transmitting Circuit

fier tube as shown in Fig. 41. Thermal-type noise is generated by conduction in the neon tube and coupled to the grid of the amplifier tube. The amplified noise appears across the low-impedance winding of transformer T5, which has an impedance ratio of 20,000 to 3,000 ohms. Resistor R21 provides a suitable level and output impedance of the noise source for the OBl, OC1, OD1 unit. In the OAl noise generator another resistor is shunted across the high side of transformer T5 to provide a suitable source impedance. The amount of noise output is adjustable by means of the noise potentiometer which varies the gain of the amplifier by changing its screen potential. The noise output is fed through the terminal mounting wiring into the group receiving circuit at a point between the modulator and the group band filter. The noise output can be adjusted to give at least +25 dba at a zero level point at the expander output.

Transmission Performance

2.50 The level of each carrier at the line is adjusted to a nominal value of +6 dbm by the TC controls of the two twin-channel carrier circuits. The nominal level of the 3700-cycle signaling sidebands at the same point is 0 dbm. For the on-hook condition of all four channels (3700-cycle tones on) the total power on the line is +10.8 dbm. For the off-hook condition the 3700-cycle tones are removed. For the OA group transmitting unit, the nominal gain of the transmitting amplifier is 63 db; the loss of the input circuit including the modulator is 8 db, so that the over-all nominal gain of the group transmitting unit is 55 db. The gain-frequency characteristics of the amplifier for both low-group and high-group strappings of the interstage inductor are shown in Fig. 42, and the characteristics of the over-all circuit in Fig. 43. For the

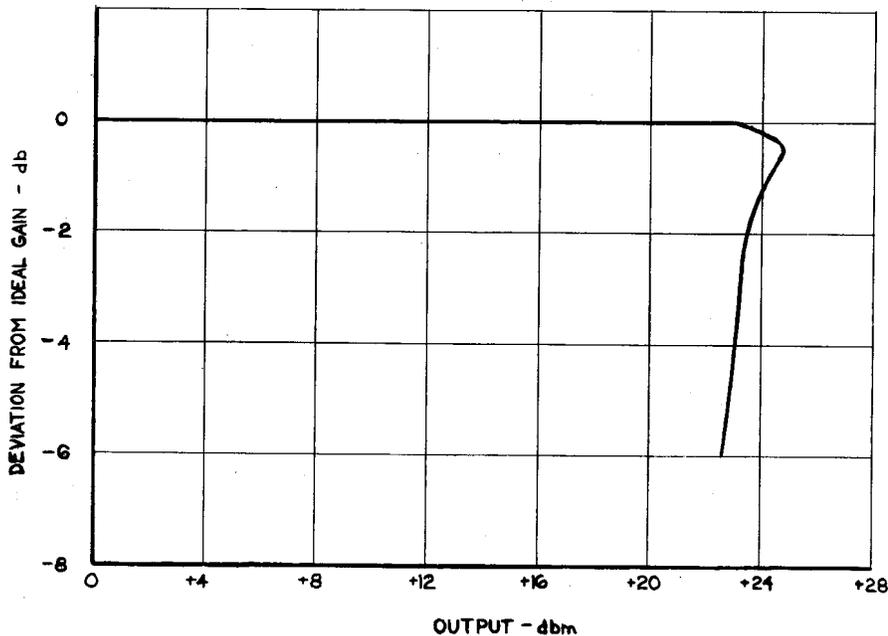


Fig. 46 - Amplifier Load Characteristic Group Transmitting or Group Receiving Circuit

OBl, OC1, OD1 group transmitting unit the nominal gain of the transmitting amplifier is 62 db and the nominal modulator loss including the group low-pass filter is 7 db so the nominal over-all group transmitting circuit gain is also 55 db. The gain-frequency characteristic of the amplifier is shown in Fig. 44 and that of the over-all circuit in Fig. 45.

2.51 Both amplifiers can deliver a power of +23 dbm into a matched load (600 ohms for the OAl unit, 135 ohms for the OBl, OC1, OD1 unit) as shown in Fig. 46. Typical modulation characteristics for the OAl unit are shown in Fig. 47, and for the OBl, OC1, OD1 unit in Fig. 48. Modulation in the preceding part of both circuits is negligible. Also shown in Fig. 48 are third order modulation characteristics for the 530A (OB), 530B (OC), and 530E (OD) directional filters for products falling into the same group as the fundamentals. Modulation in the directional filter (530H) for the OA system is negligible.

E. Group Receiving Circuit

2.52 The group receiving circuit performs five functions. A directional filter separates the two directions of transmission on the line. The low-level incoming line frequencies are amplified. The incoming line frequencies are group modulated to the range of the channel band filters, 180 to 196 kc. In addition the flat gain supplied is automatically controlled to compensate for line loss, including changing weather conditions. This regulation does not of

course compensate for line slope or change in line slope. Finally, provision is made for operating an alarm circuit if the received carriers are lost.

2.53 The terminal block schematic (see Fig. 146 on page 114) shows that the group receiving circuit can be changed from LGT to HGT or vice versa in the OB system by rotating the 530A directional filter 180 degrees and replacing the 530R or 531C filter by the 530P or 531B filter or vice versa. The 530R and 530P filters replace the 531B and 531C filters which are no longer in production. The carrier frequency supplied to the modulator by the group oscillator circuit must also be changed, by strapping, in the latter circuit. This is also true for the other O systems, with different filters being involved, as shown in Fig. 146 on page 114 for the OC and OD systems, and in Fig. 145 on page 110 for the OA system. Moreover, the same basic unit is used for the OBl, OC1, and OD1 group receiving units, it being necessary only to plug in the proper filters to obtain the desired unit.

Directional Filter

2.54 The directional filters are plug-in units consisting of two filters housed in a single container. One passes the low-group and one passes the high-group frequencies of a system. In the OA system the directional filter is a high-pass, low-pass combination, while in the OB, OC, and OD systems they are band-pass combinations. Characteristics and schematics of the filters are shown in Figs. 49, 50, 51, and 52.

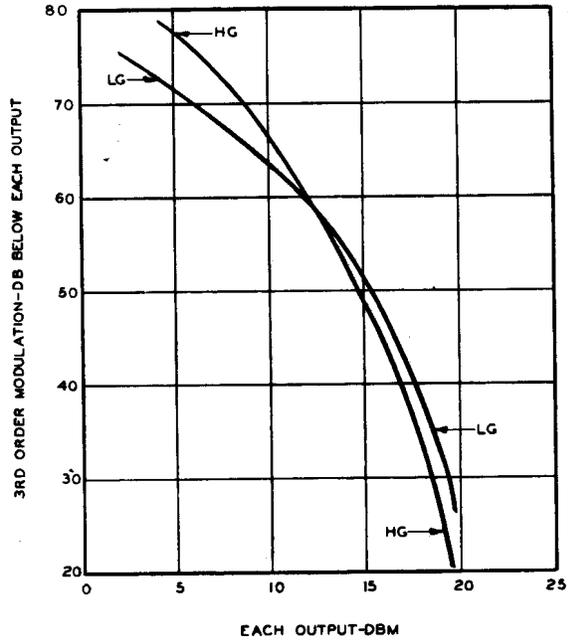


Fig. 47 - Third-Order Modulation OAl Group Transmitting Amplifier

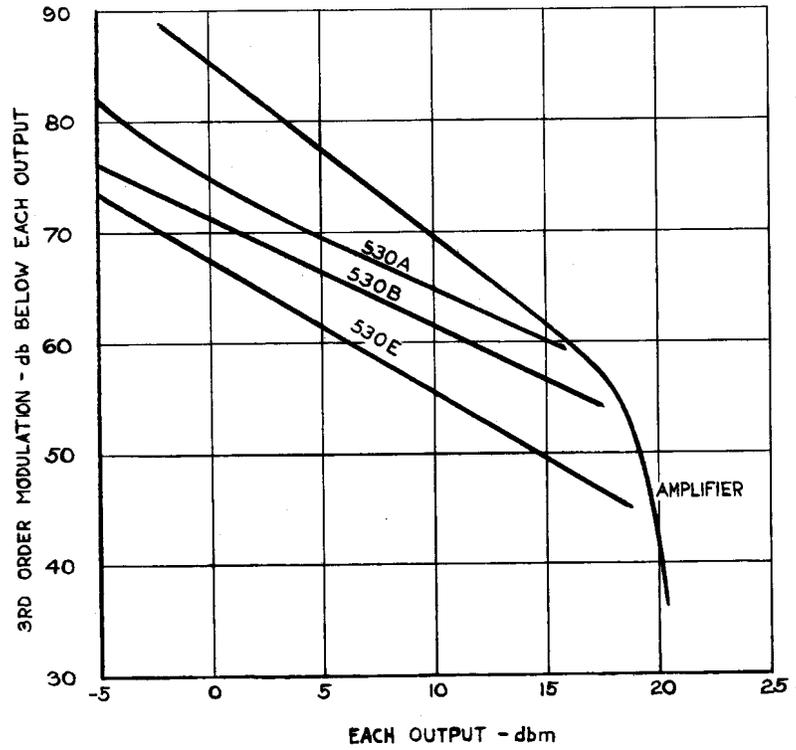


Fig. 48 - Third Order Modulation - OB, OC, OD Group Transmitting Amplifier and Directional Filter

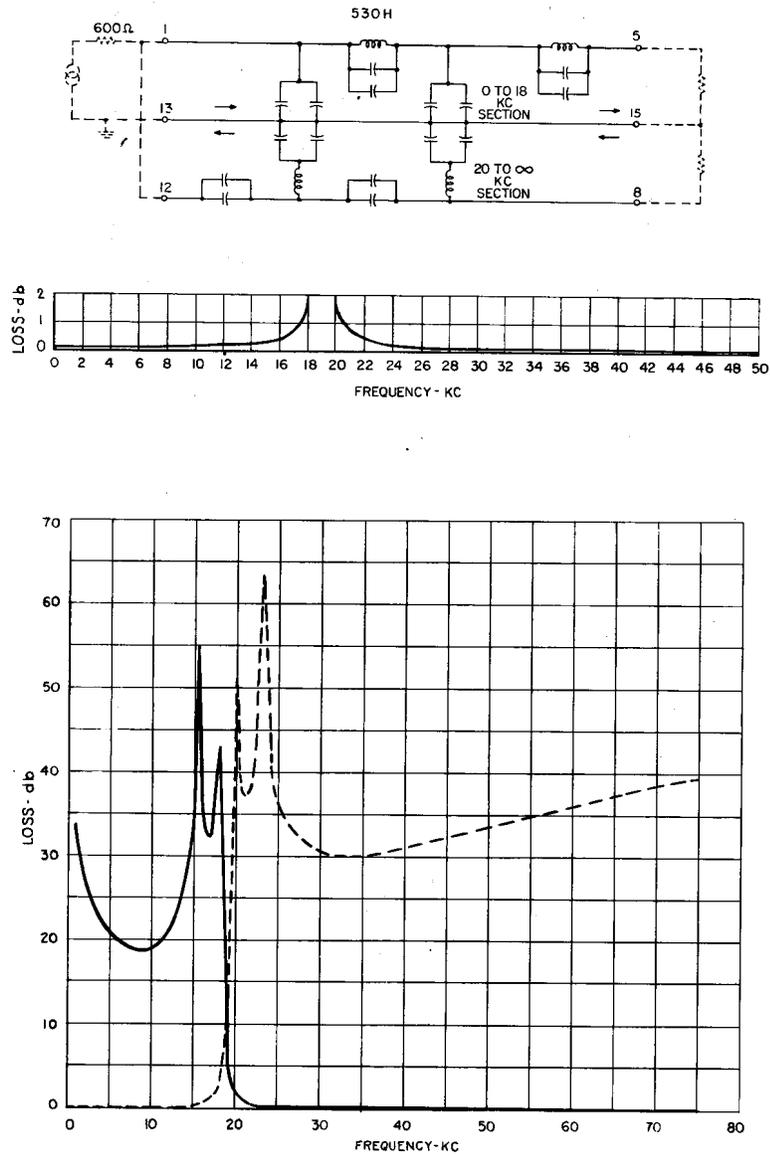


Fig. 49 - Schematic and Loss-Frequency Characteristic of 530H Directional Filter

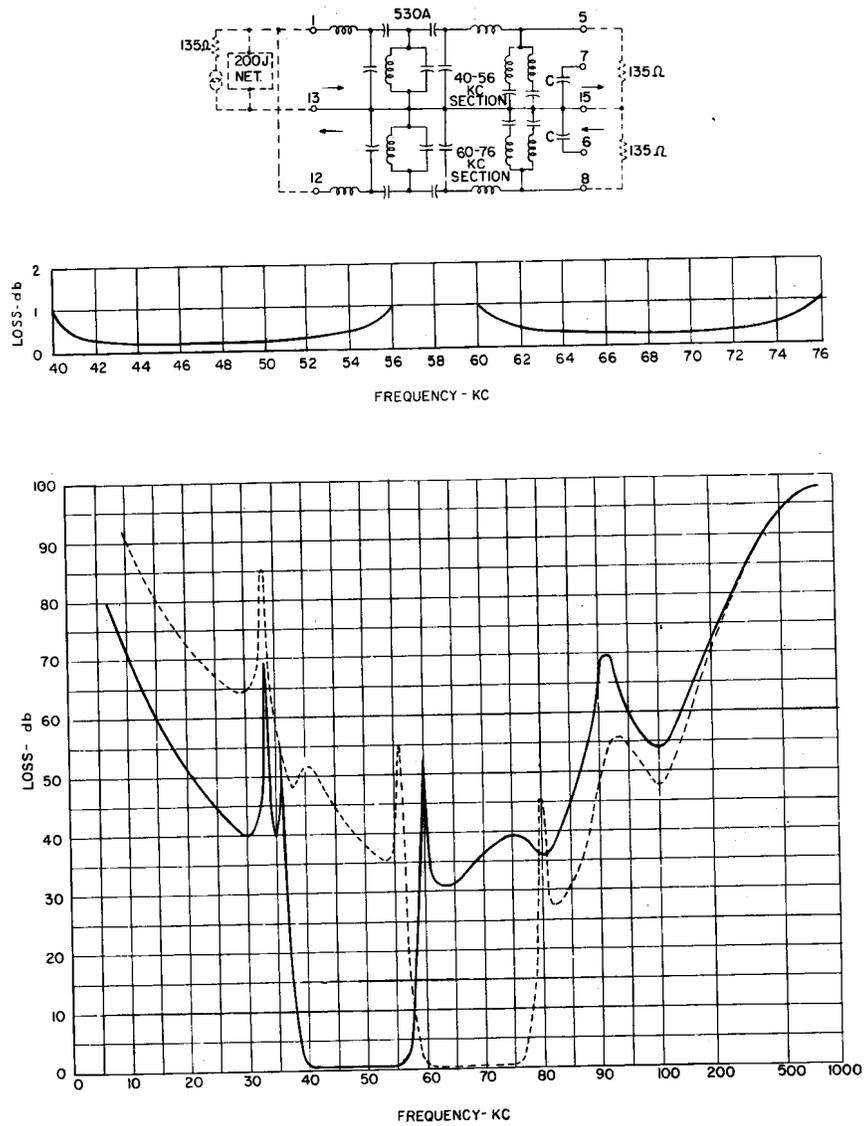


Fig. 50 - Schematic and Loss-Frequency Characteristic of 530A Directional Filter

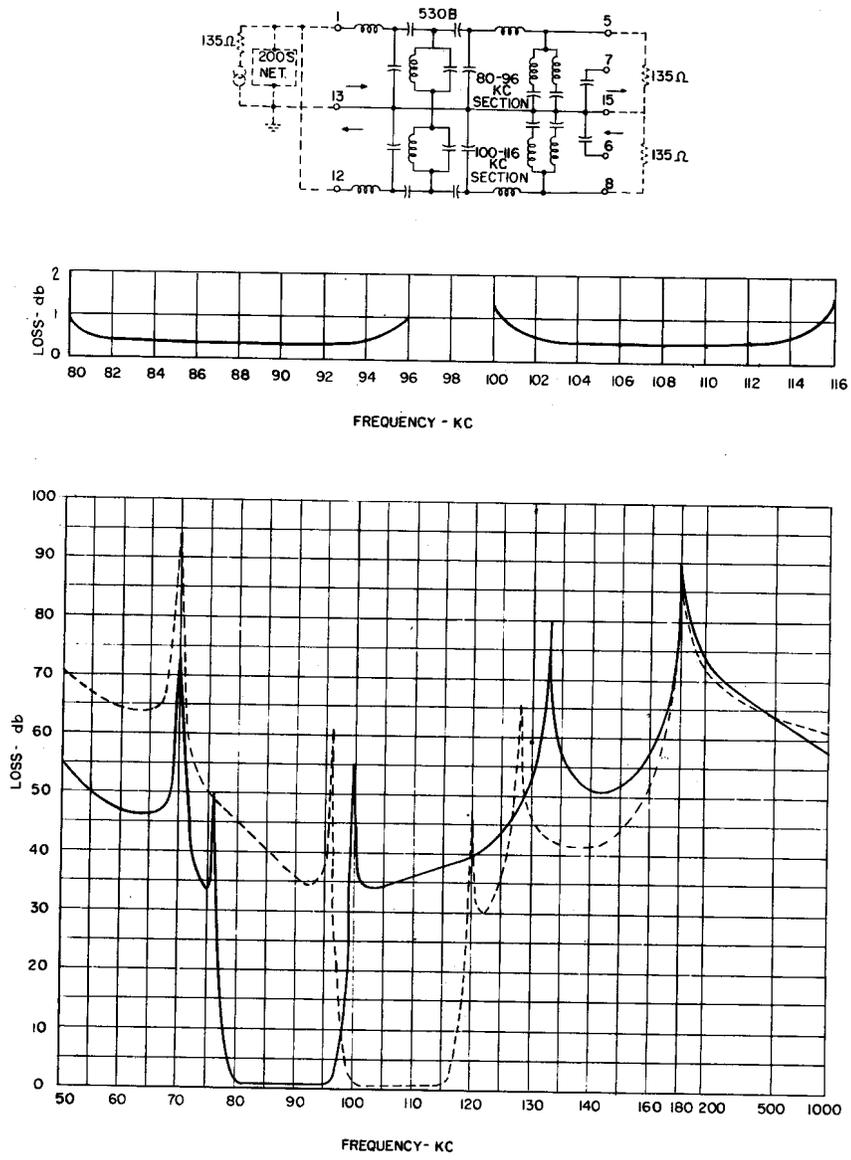


Fig. 51 - Schematic and Loss-Frequency Characteristic of 530B Directional Filter

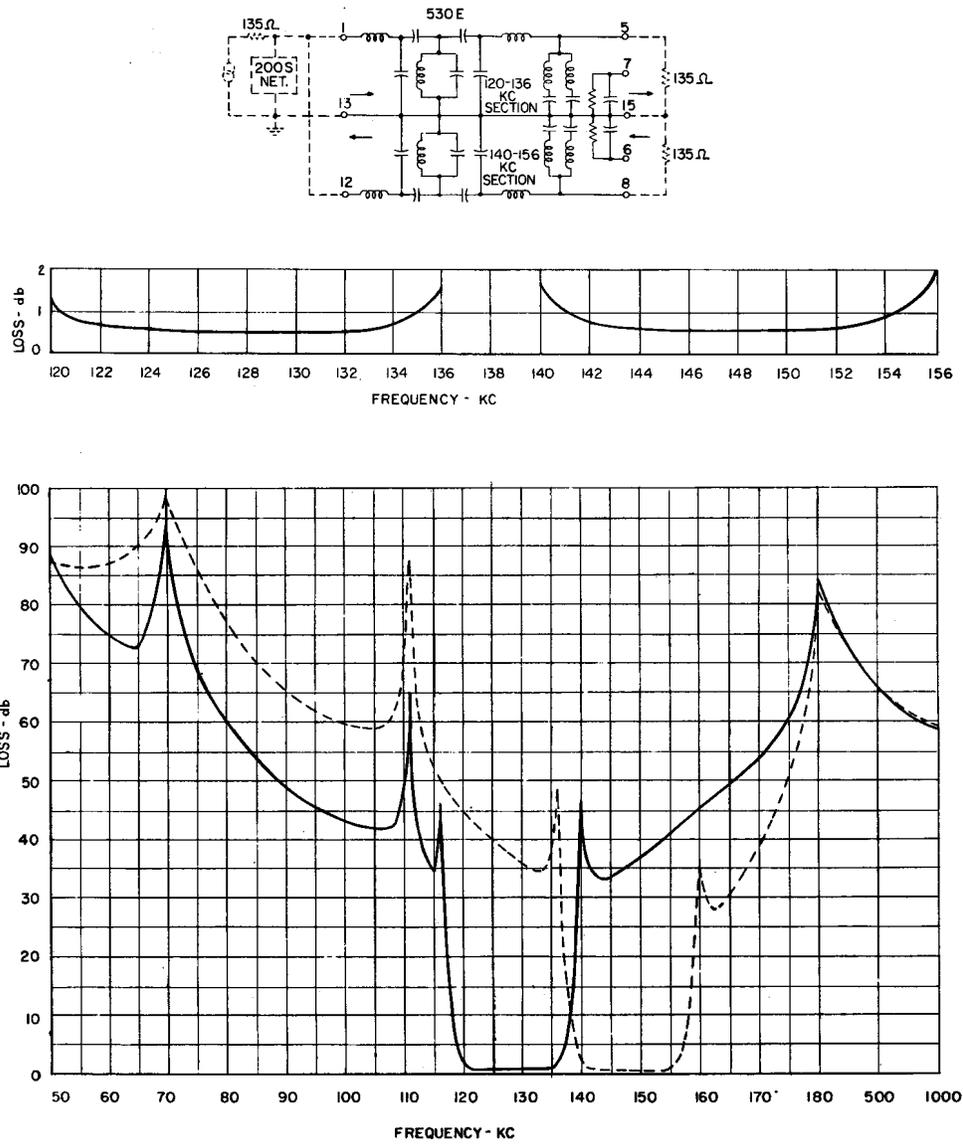


Fig. 52 - Schematic and Loss-Frequency Characteristic of 530E Directional Filter

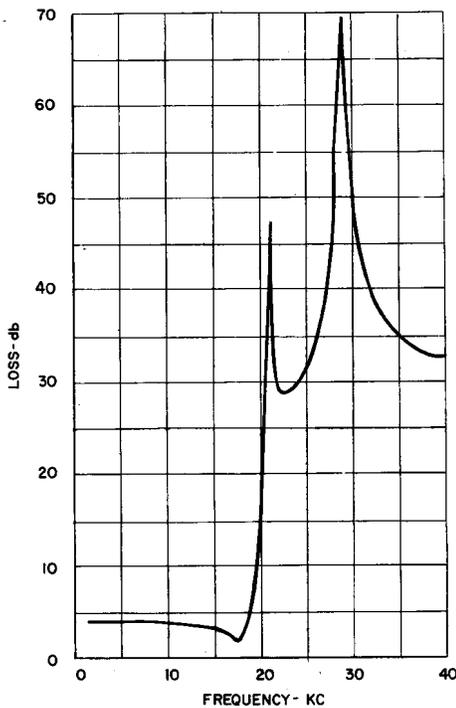
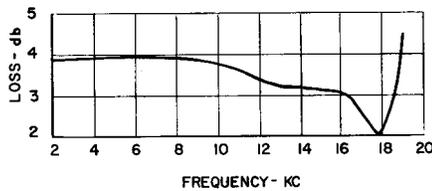
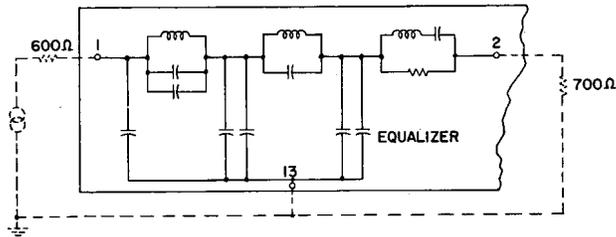


Fig. 53 - Schematic and Loss-Frequency Characteristic of 530J Filter - OAl Auxiliary Filter

In use the received frequencies from the line are passed through one filter to the group receiving input, and the transmitted frequencies from the associated group transmitting unit are passed through the other filter to the line. Each of the OBl, OC1, and OD1 filters has two impedance-correcting capacitors (and resistors in the OD1 filter) which are connected to the filter jacks in such a manner that one or the other of the capacitors (and resistors in the OD1 filter) is connected across transformer (T1) depending on the orientation of the filter. The OBl, OC1, and OD1 directional filters were designed to be used with directional filters for the adjacent frequency bands multiplied on the line side.

Transformer T1 and Input Pad

2.55 In the OAl group receiving circuit transformer T1 (see Fig. 145 on page 110) is the line transformer. It isolates the balanced line from the unbalanced directional filter. The input pad and equalizer which follow the filter, together with additional attenuation in the auxiliary filter, attenuate the input signals to a level suitable for the regulating amplifier input. They also match the 600-ohm impedance level of the directional filter to the 700-ohm impedance of the auxiliary filter. The equalizer is adjustable by means of a switch to introduce a slope of 0, 5, or 10 db in either the high group or low group, whichever is being received. This provides compensation for line characteristic slope in the OA system, where there is no frogging or inversion.

2.56 In the OBl, OC1, OD1 group receiving circuit, transformer T1 (see Fig. 146 on page 114) isolates the line transformer and directional filter ground, from the grounds of the individual group receiving circuits. This arrangement eliminates ground loops that could result in noise or crosstalk difficulties when more than one of the OB, OC, or OD systems are operated on the same carrier line. Since the OBl, OC1, and OD1 terminals are multiplied together at the line side of the directional filters (the OA system is separated from the OB, OC, and OD systems at terminals and repeaters by a line filter), one line transformer serves all three terminals and hence is not mounted on the OBl, OC1, OD1 group receiving unit as it is on the OA unit. The input pad attenuates the input signals 22 db to a level which is suitable for the regulator input and matches the 135-ohm output impedance of the transformer to the 3000-ohm impedance of the auxiliary filter.

Auxiliary and Group Receiving Filters

2.57 Following the input pad of the group receiving unit is an auxiliary filter

which supplements the receiving side of the directional filter, providing additional attenuation to unwanted frequencies. This is a band-pass filter for all groups except for the low group of the OA band, where it is a low-pass filter. The auxiliary filters of the OAl units include pads, which further reduce the input signals to a suitable level for the regulator input, and components which equalize for the loss characteristics near 18 and 20 kc of the 530H directional filters at both the transmitting and receiving terminals. The other filter in the circuit is the group receiving filter which passes the wanted sideband from the modulator (180 to 196 kc) and suppresses other products. Attenuation peaks in this filter occur at or near the frequency of the group modulating carrier. Both the auxiliary filter and the group receiving filter are part of a single plug-in filter. The code of the filter which is used at a particular terminal is given in Figs. 145 and 146 (pages 110 and 114). Characteristics and schematics of the filters are given in Figs. 53, 54, 55, and 56 for the OA system, Figs. 57, 58, 59, and 60 for the OB system, Figs. 61, 62, 63, and 64 for the OC system, and Figs. 65, 66, 67, and 68 for the OD system.

Regulating Amplifier

2.58 In the OBl, OC1, OD1 and high-group receiving OAl group receiving units, the regulating amplifier is a double triode 407A tube operated as a two-stage, resistance-coupled, variable gain amplifier, (see Figs. 69 and 70). In the low group receiving OAl unit, the first stage of the amplifier is strapped out in order to reduce the gain and thus lessen the effects of microphonics in the tube that occur in the OA low-group frequency range. Since this reduces the over-all regulation range, an input potentiometer REG is provided in order to adjust the input to the optimum part of the regulation range. This point is set by the space current in the second stage of the amplifier, as measured by the voltage drop across the plate filter resistor. When used at an LGT terminal, both stages of the regulator are used and the REG potentiometer set at the top of its range.

2.59 Automatic gain control in the regulating amplifiers is obtained by amplifying and rectifying a portion of the group receiving circuit output, comparing it to a dc reference voltage, and applying the resultant voltage as bias to the grids of both stages of the regulator. Regulation is obtained as follows: an increase in signal input to the unit increases the output of the unit which results in more dc output of the rectifier. This makes the bias on the grids of the regulating amplifier tubes more negative, reducing the regulator gain and restoring the output of the unit close to its former value. A decrease in input will

result in the opposite effect; therefore, the regulating amplifier tends to maintain a fixed output and, consequently a fairly constant level at the modulator input. The time constant of the regulator is controlled by resistor R9 and capacitors C2, C3, and C4.

Group Modulator

2.60 In the group modulator (Figs. 69 and 70) the regulated signals are shifted from the line frequencies to the 180- to 196-kc baseband. The modulator is the double-balanced-type in which both the input and modulating carrier frequencies are suppressed in the output. The output of the noise generator, located in the group transmitting circuit, is introduced into the circuit at the output of the group modulator (see Figs. 145 and 146 on pages 110 and 114). In the OBl, OC1, OD1 unit the bridging loss of the noise generator output impedance is one arm of a 4.3 db pad used to reduce the effect of the modulator impedance on the group receiving filter.

Amplifier

2.61 The amplifier circuit is a 2-stage feedback amplifier similar to the amplifier of the group transmitting circuit described in Part 2D. The simplified schematic of the amplifier is shown in Fig. 71 and except for the following, its operation is identical to the amplifier described in 2.44.

- (a) Input transformer T4 has an impedance ratio of 135 to 20,000 ohms.
- (b) The feedback circuit differs in that there is no option for variable gain and there is 8 db more feedback.
- (c) Some of the energy present in the plate circuit is fed to the control amplifier for amplification and rectification in order to obtain a dc voltage which is proportional to the output level of the group receiving unit.

The output of the amplifier, the group receiving circuit output, is fed to the high-impedance inputs of the two twin-channel circuits in parallel. The output impedance of the amplifier is a nominal 135 ohms. A 135-ohm terminating resistor for the amplifier output is located in the terminal mounting. Capacitor C20 provides impedance correction of the output transformer. Capacitor C19 is not present in the OAl amplifier, and is used at repeaters in the OBl, OC1, OD1 unit. Impedance correction for input transformer T4 is provided in the OBl, OC1, OD1 unit by a capacitor in the plug-in filter.

Control Amplifier and Rectifier

2.62 The control amplifier is a 408A tube employing cathode feedback, the out-

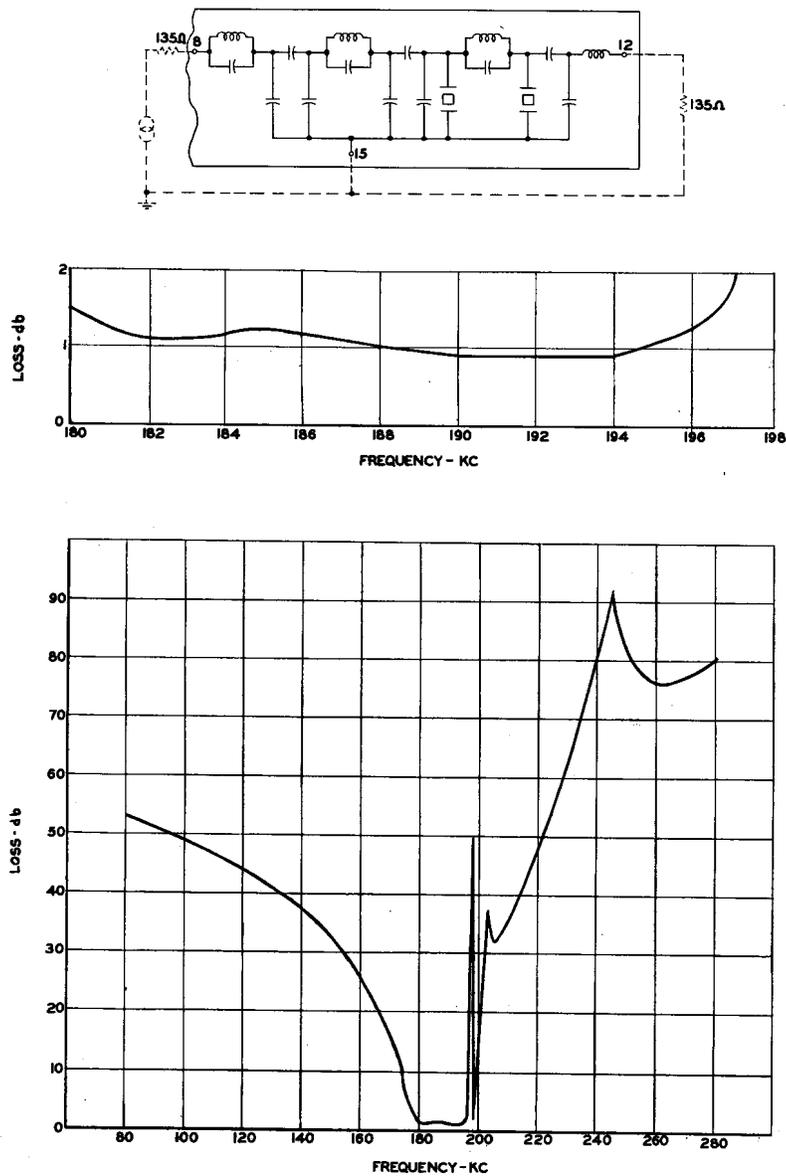


Fig. 54 - Schematic and Loss-Frequency Characteristic of 530J Filter - OAl Group Receiving Filter

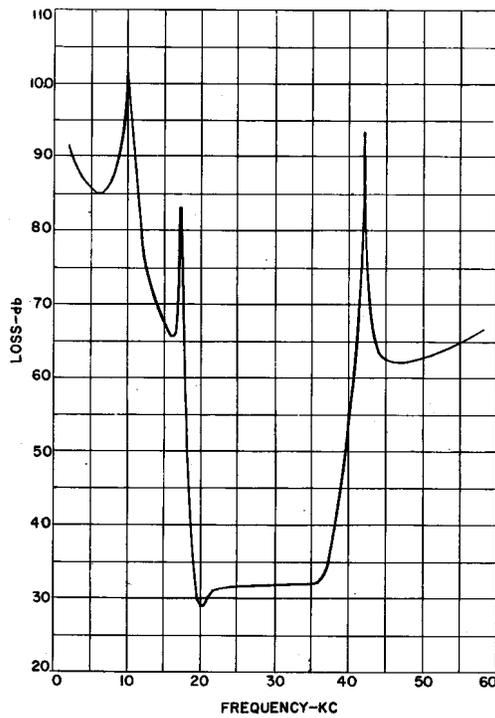
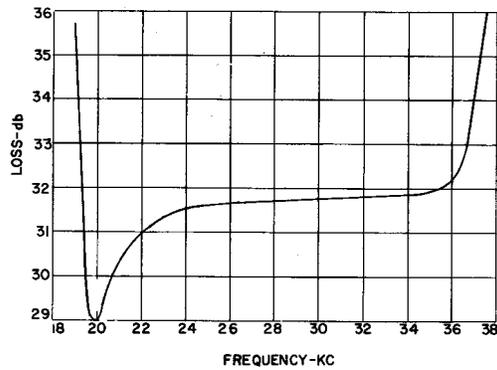
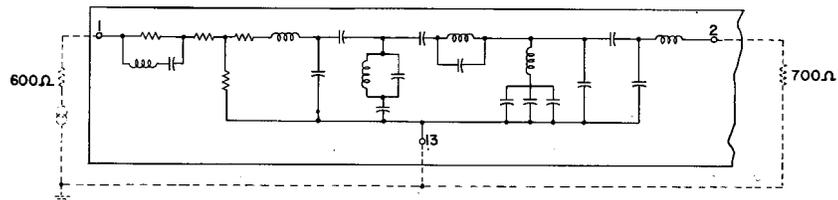


Fig. 55 - Schematic and Loss-Frequency Characteristic of 531F Filter - OAI Auxiliary Filter

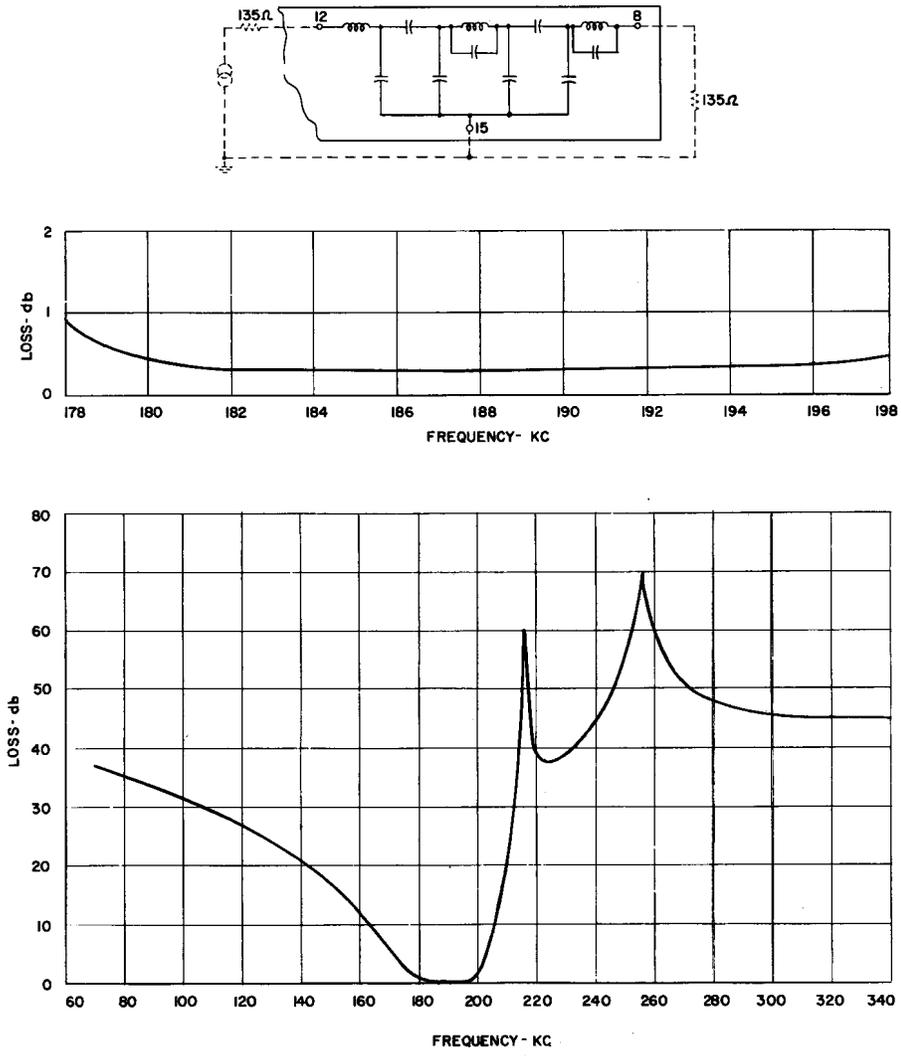


Fig. 56 - Schematic and Loss-Frequency Characteristic of 531F Filter - OAl Group Receiving Filter

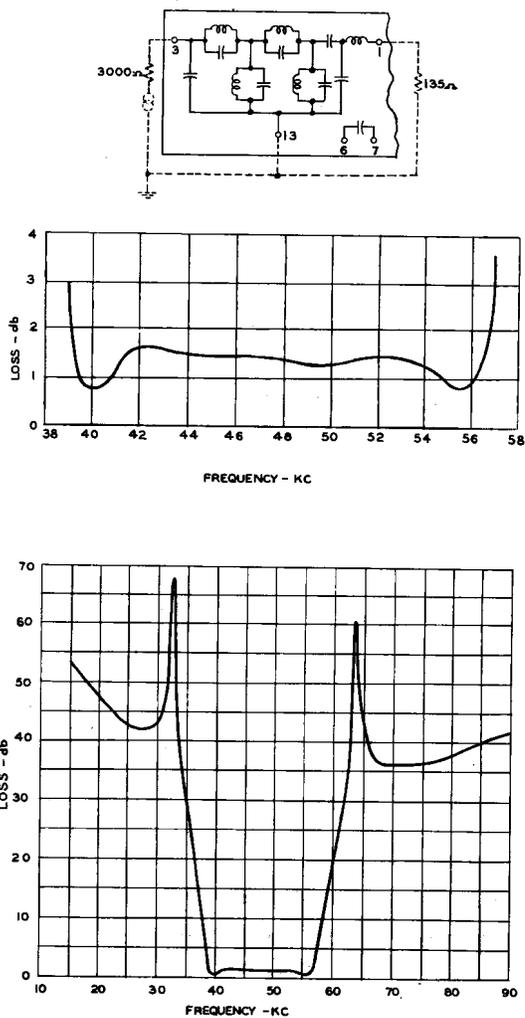


Fig. 57 - Schematic and Loss-Frequency Characteristic of 531B or 530P Filter - OBI Auxiliary Filter

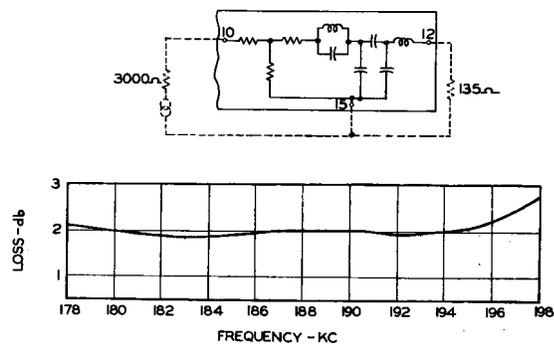
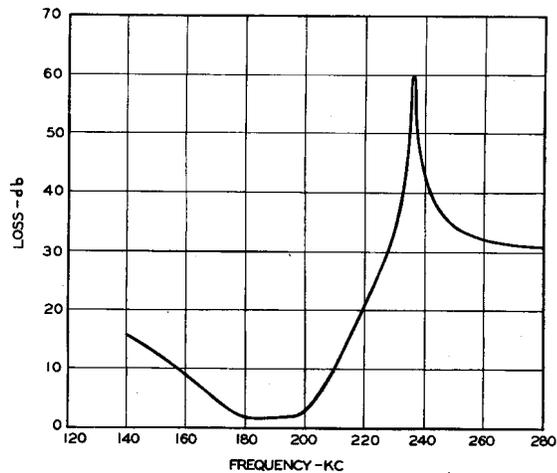
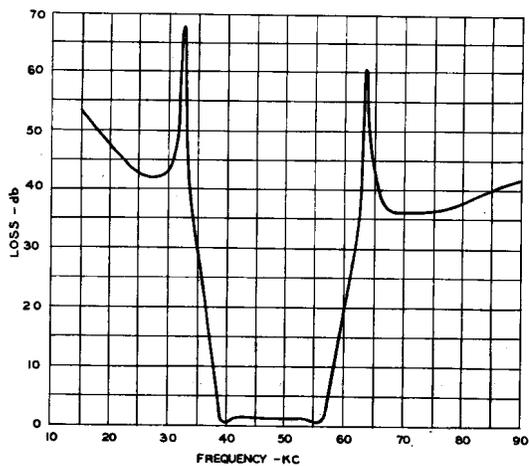


Fig. 58 - Schematic and Loss-Frequency Characteristic of 531B or 530P Filter - OBI Group Receiving Filter



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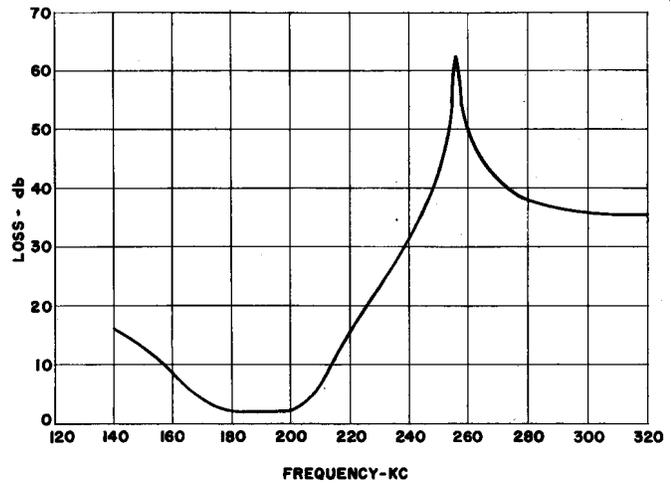
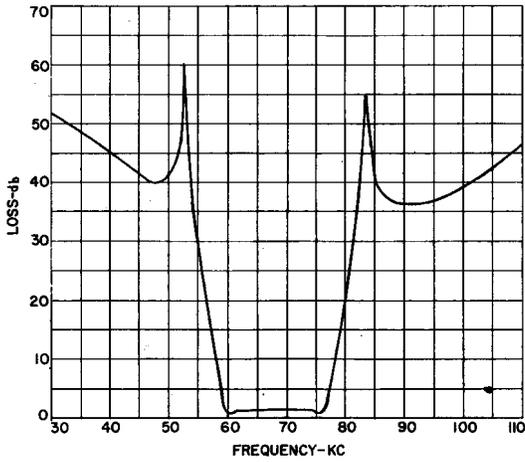
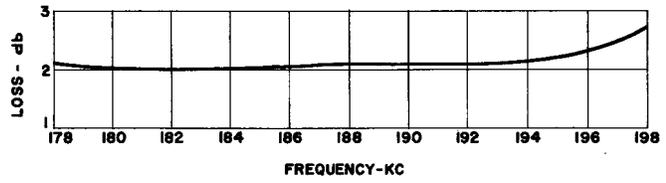
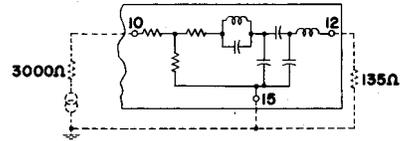
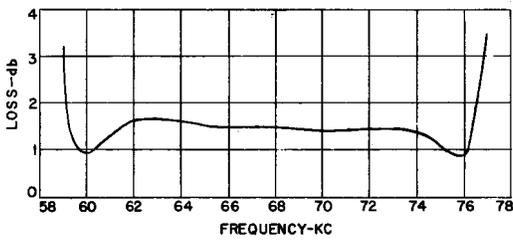
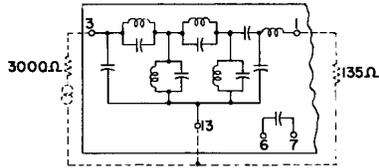


Fig. 59 - Schematic and Loss-Frequency Characteristic of 531C or 530R Filter - OBI Auxiliary Filter

Fig. 60 - Schematic and Loss-Frequency Characteristic of 531C or 530R Filter - OBI Group Receiving Filter

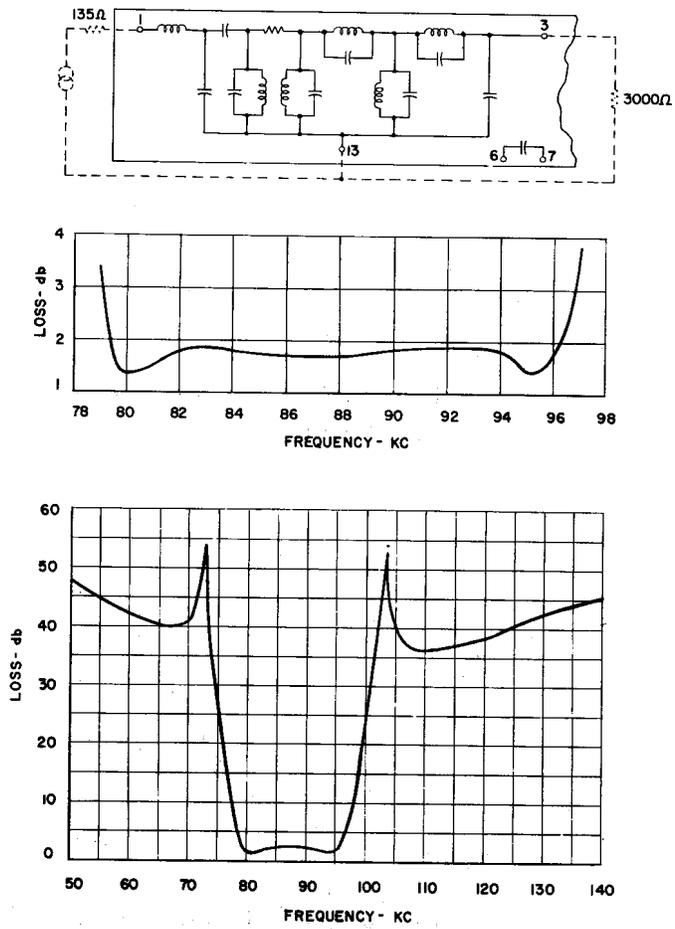


Fig. 61 - Schematic and Loss-Frequency Characteristic of 530C Filter - OCl Auxiliary Filter

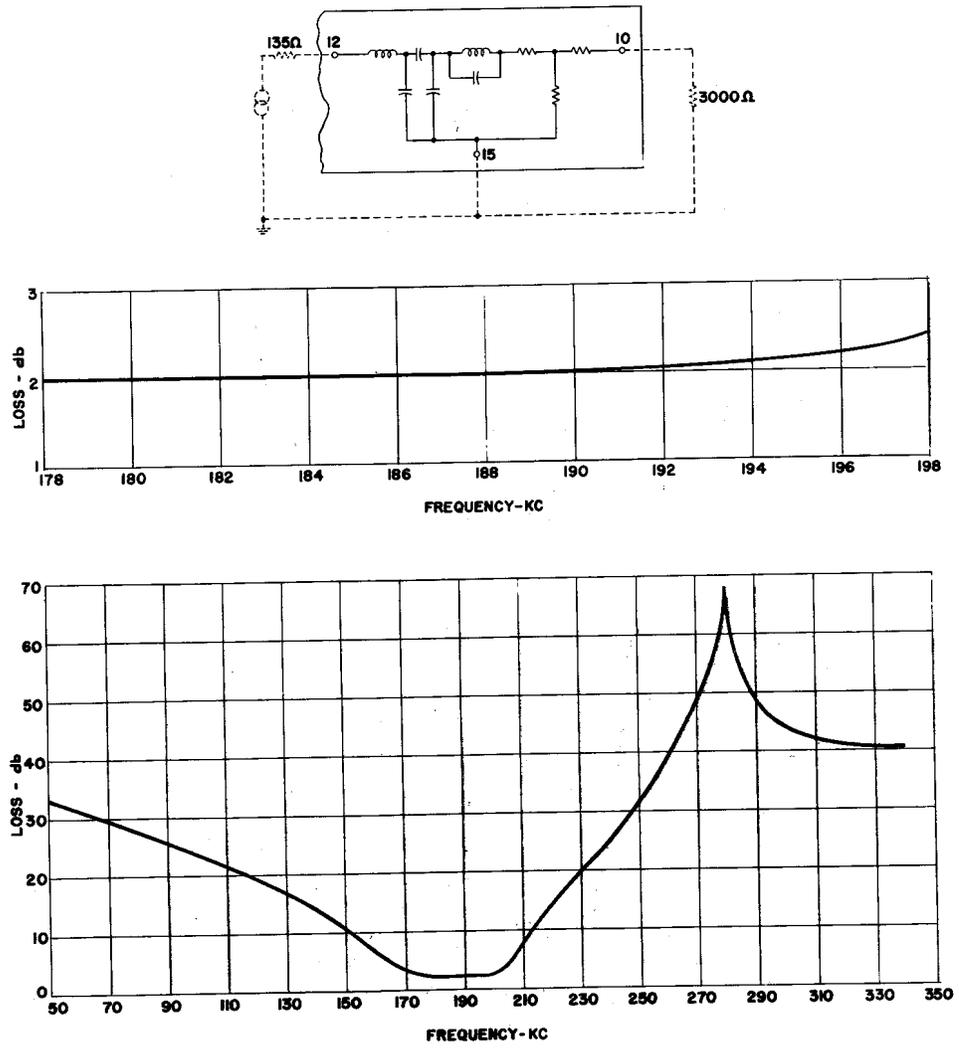


Fig. 62 - Schematic and Loss-Frequency Characteristic of 530C Filter - OCl Group Receiving Filter

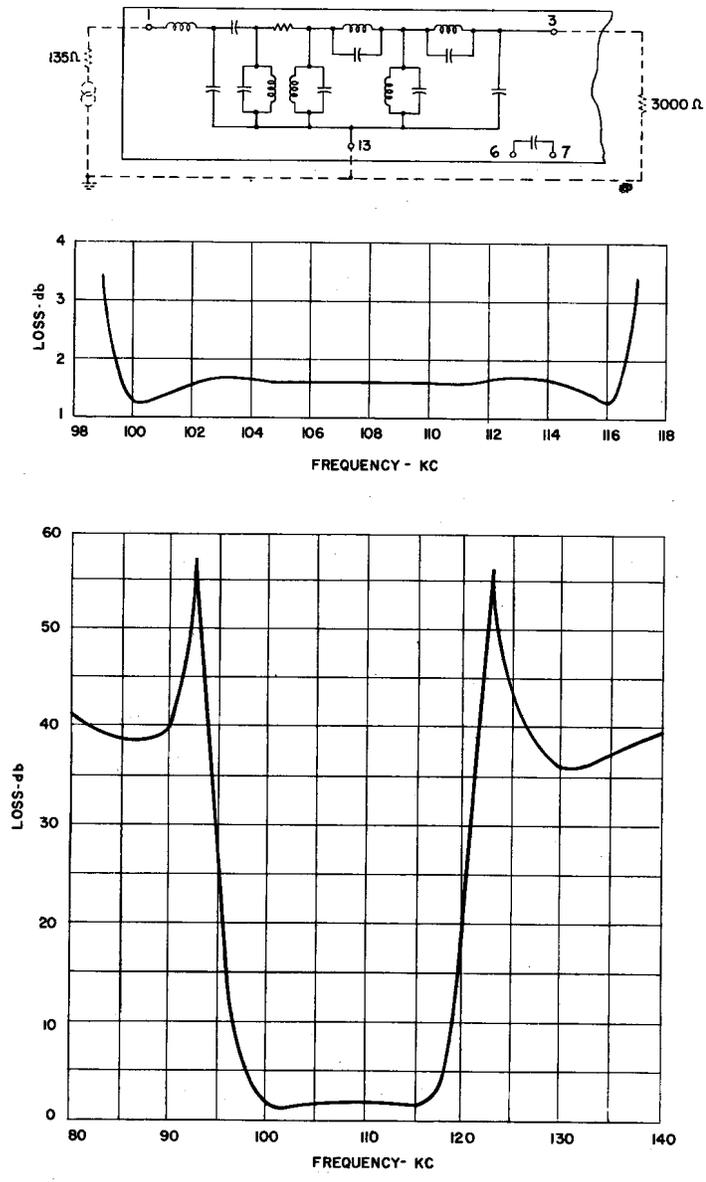


Fig. 63 - Schematic and Loss-Frequency Characteristic of 530D Filter - OCl Auxiliary Filter

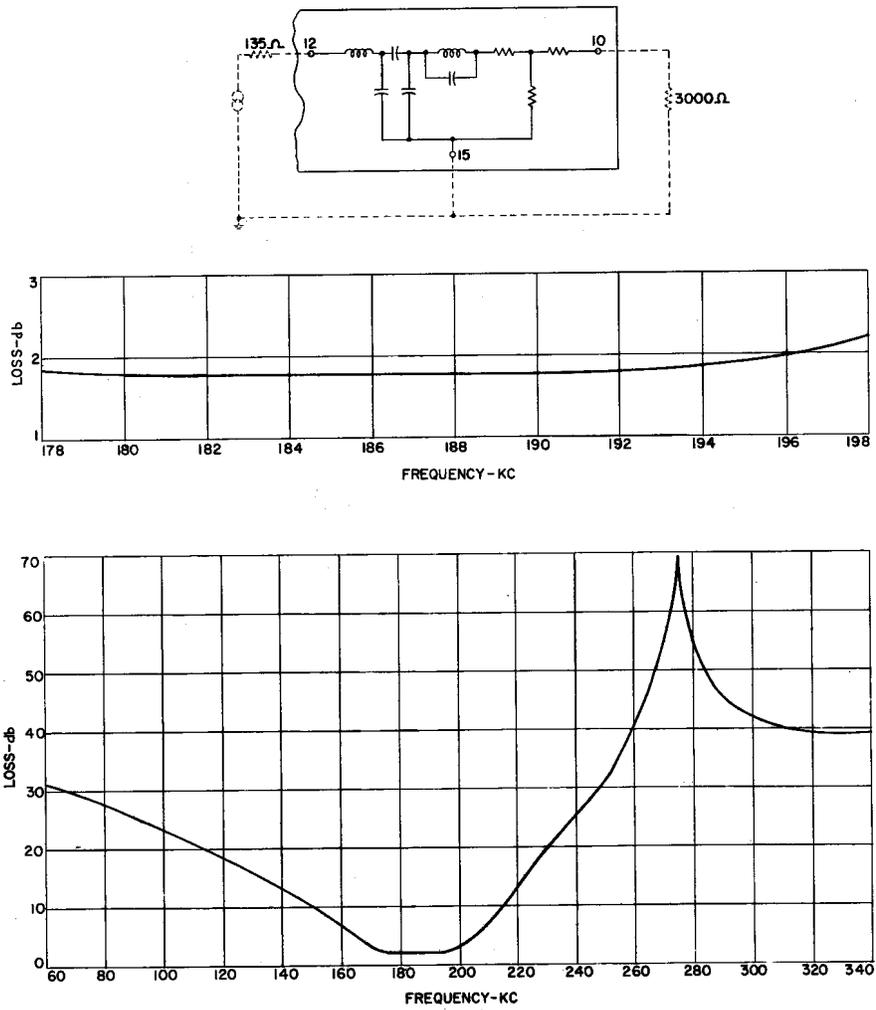


Fig. 64 - Schematic and Loss-Frequency Characteristic of 530D Filter - OC1 Group Receiving Filter

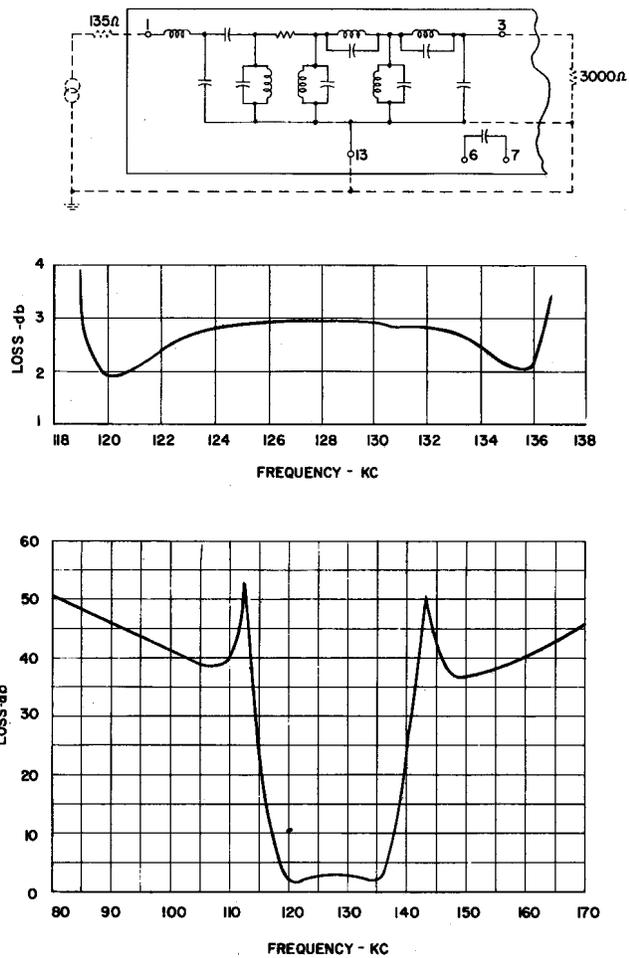


Fig. 65 - Schematic and Loss-Frequency Characteristic of 530F Filter - OD1 Auxiliary Filter

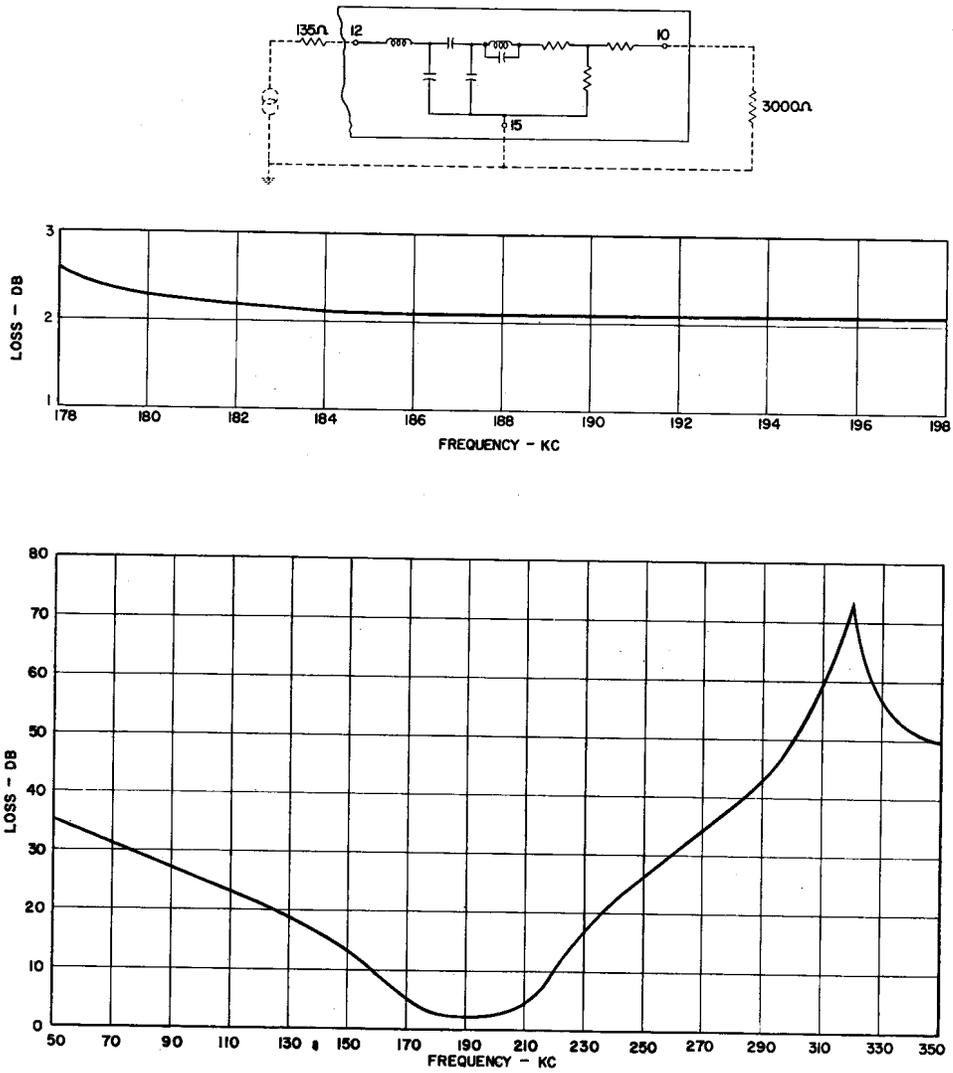


Fig. 66 - Schematic and Loss-Frequency Characteristic of 530F Filter - OD1 Group Receiving Filter

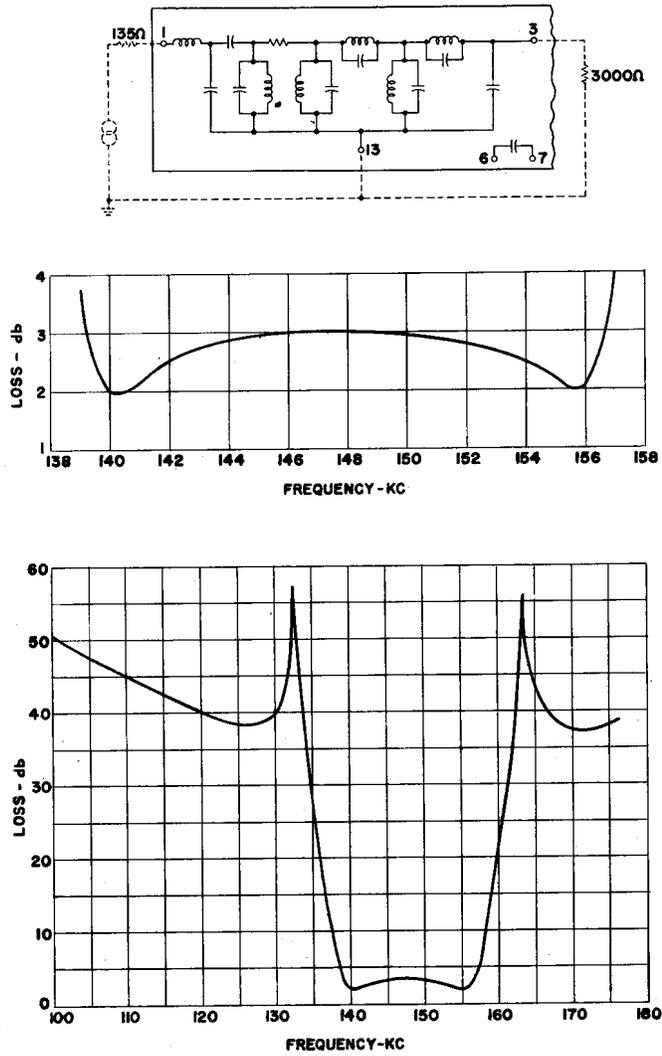


Fig. 67 - Schematic and Loss-Frequency Characteristic of 530G Filter - OD1 Auxiliary Filter

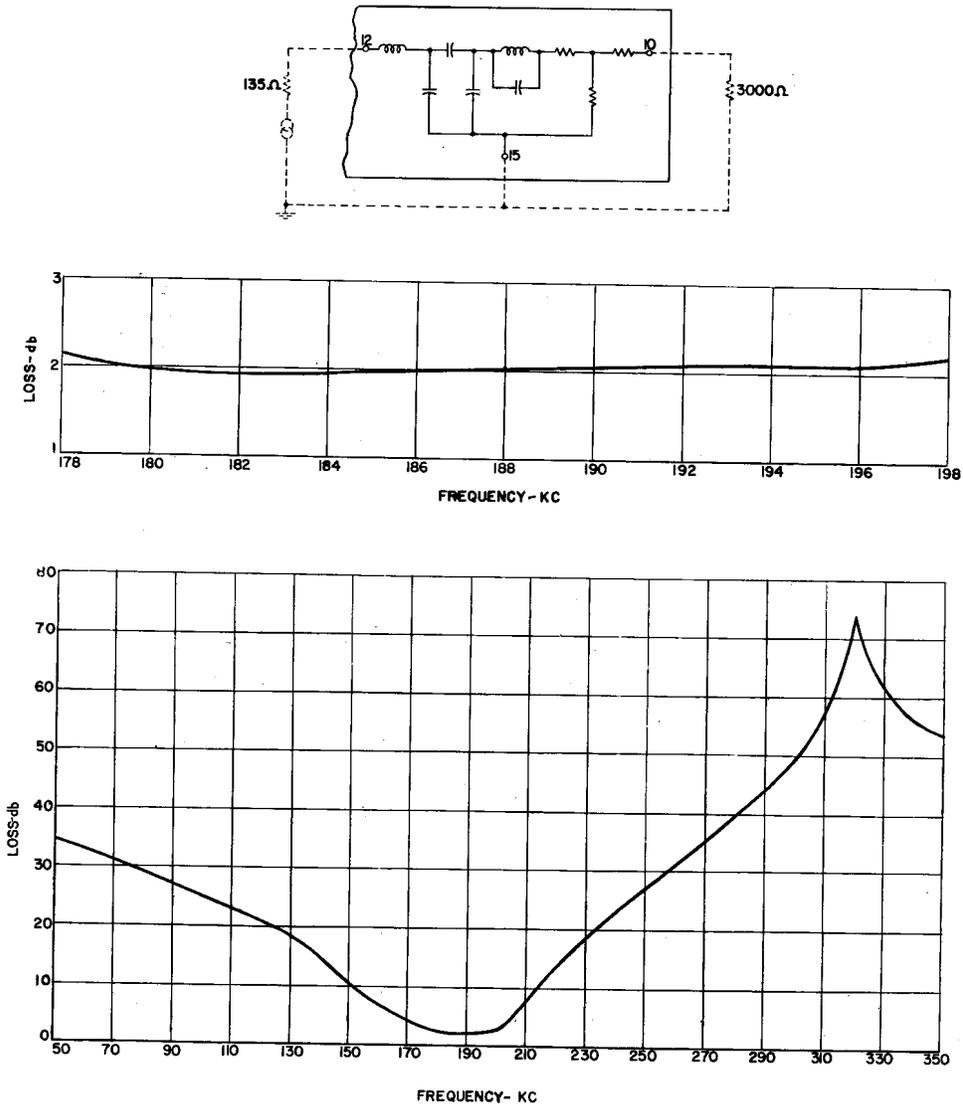


Fig. 68 - Schematic and Loss-Frequency Characteristic of 530G Filter - OD1 Group Receiving Filter

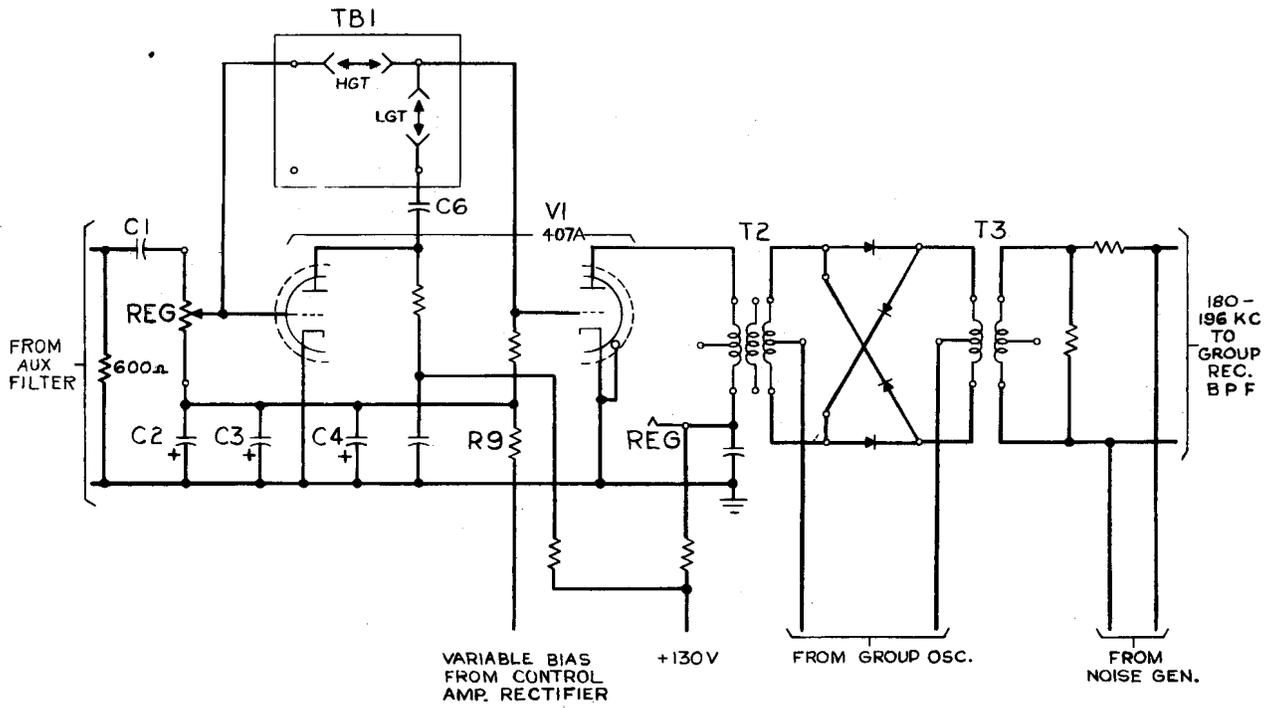


Fig. 69 - Regulating Amplifier and Modulator - OAl Group Receiving Circuit

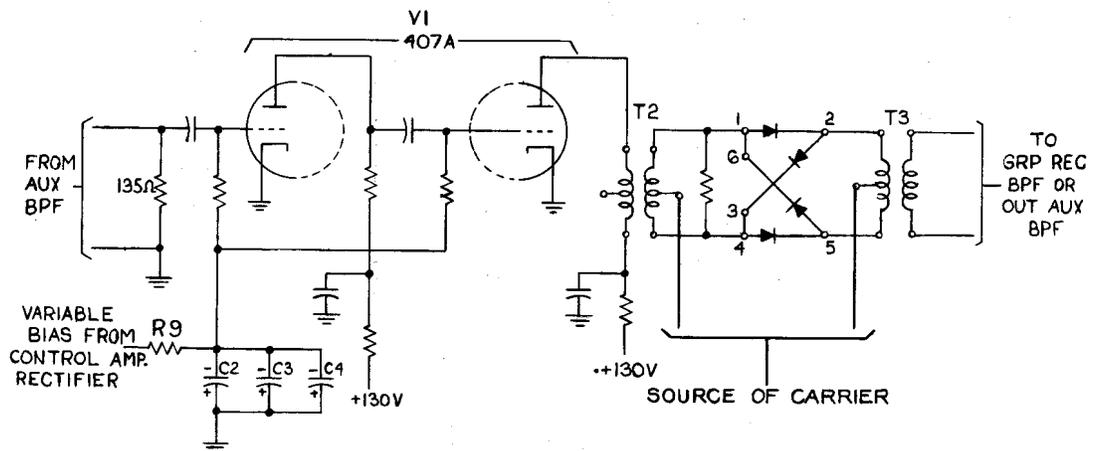


Fig. 70 - Regulating Amplifier and Modulator of OBl, OC1, OD1 Group Receiving Circuit or Repeater

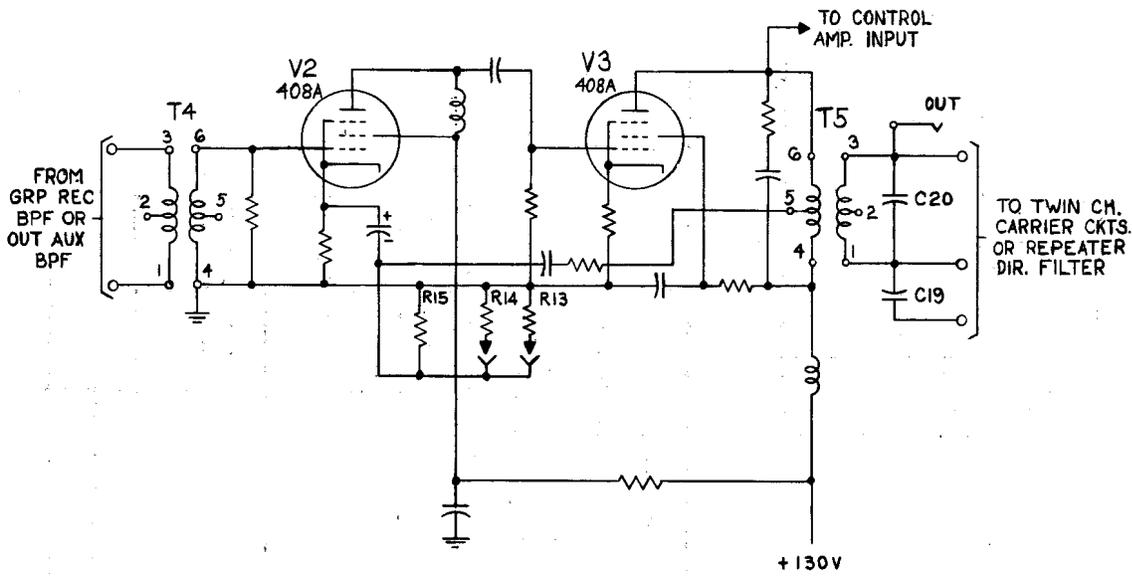


Fig. 71 - Amplifier of OBI, OCI, ODI Group Receiving Circuit or Repeater

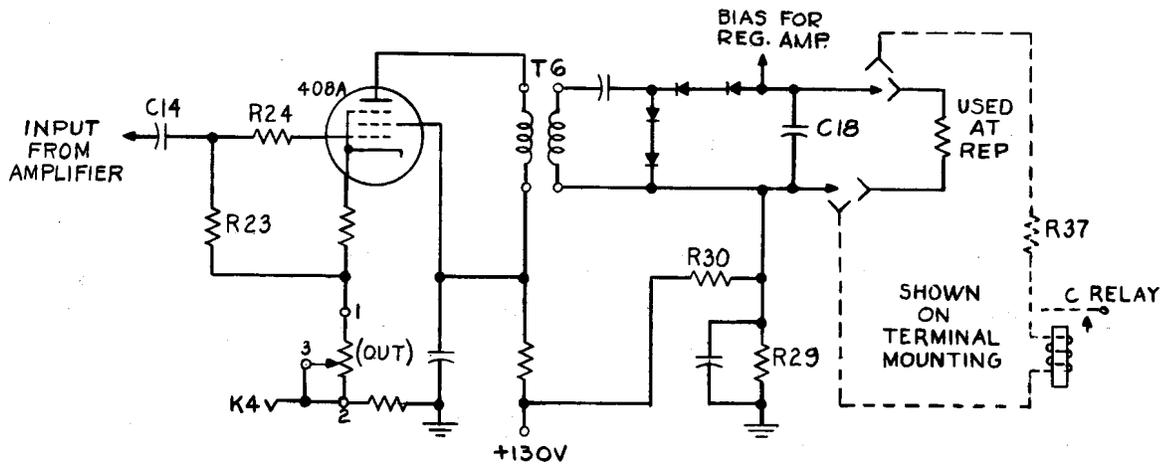


Fig. 72 - Control Amplifier and Rectifier of OI Group Receiving Circuits and of OBI, OCI, ODI Repeater

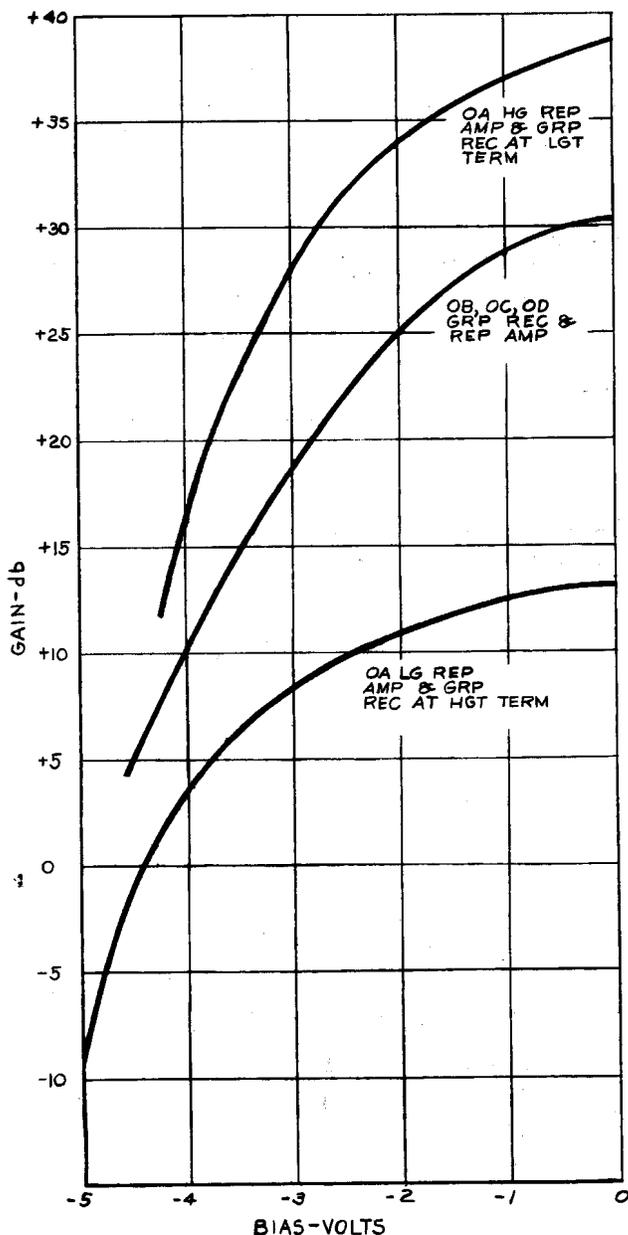


Fig. 73 - Typical Gain vs. Bias Characteristics of Regulating Amplifiers

put of which is rectified by a voltage doubler as shown in Fig. 72. The rectifier load is resistance R37 in series with the C relay, both located in the terminal mounting. So long as the incoming carriers are present the C relay will be held operated, but failure of the carriers releases the relay and results in an alarm. Bias for the regulating amplifier is obtained from the negative end of capacitor C18 but the net bias is the difference between the recti-

fier output and the positive reference voltage obtained from the voltage divider R30 and R29.

2.63 The input of the control amplifier (Fig. 72) is coupled to the plate circuit of the group receiving amplifier by capacitor C14. Resistor R24 prevents a sudden increase in input from causing an overloaded locked-up condition of the group receiving unit.

2.64 The output level at which the group receiving unit regulates is adjusted by means of potentiometer OUT. Changing this potentiometer changes the feedback and hence the gain of the contact amplifier, which in turn changes the bias on the regulating circuit. Lower contact amplifier gain reduces this bias and raises the group receiving circuit output level.

Performance

2.65 The steady state regulation characteristics of the group receiving circuits are shown in Part 4C. The group receiving amplifier has a nominal gain of 54 db for the OBl, OC1, OD1 unit and 55 db for the OA1 unit. The modulator loss including the group band filters and the effect of the noise generator is about 10 db. The gain versus bias characteristics of the regulating amplifiers are shown in Fig. 73. Because of wide variations in tubes at high negative biases, these characteristics are subject to wide variations in the low-gain regions. These variations do not appreciably affect the performance of the regulator.

2.66 The frequency characteristic of the group receiving amplifier is the same for the OBl, OC1 and OD1 units as that shown in Fig. 44. The amplifier for the OA unit has less gain below the 180- to 196-kc baseband, otherwise being similar to that of Fig. 44. Typical frequency characteristics of the regulating amplifiers are shown in Fig. 74 for the OA1 unit, and in Fig. 75

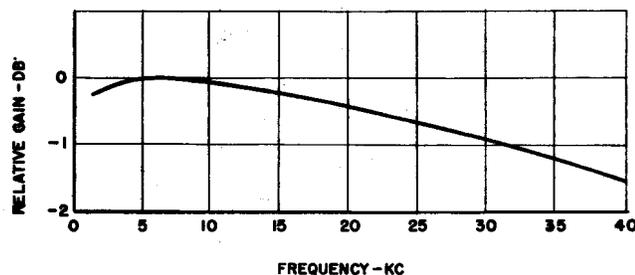


Fig. 74 - OA1 Regulating Amplifier - Frequency Response

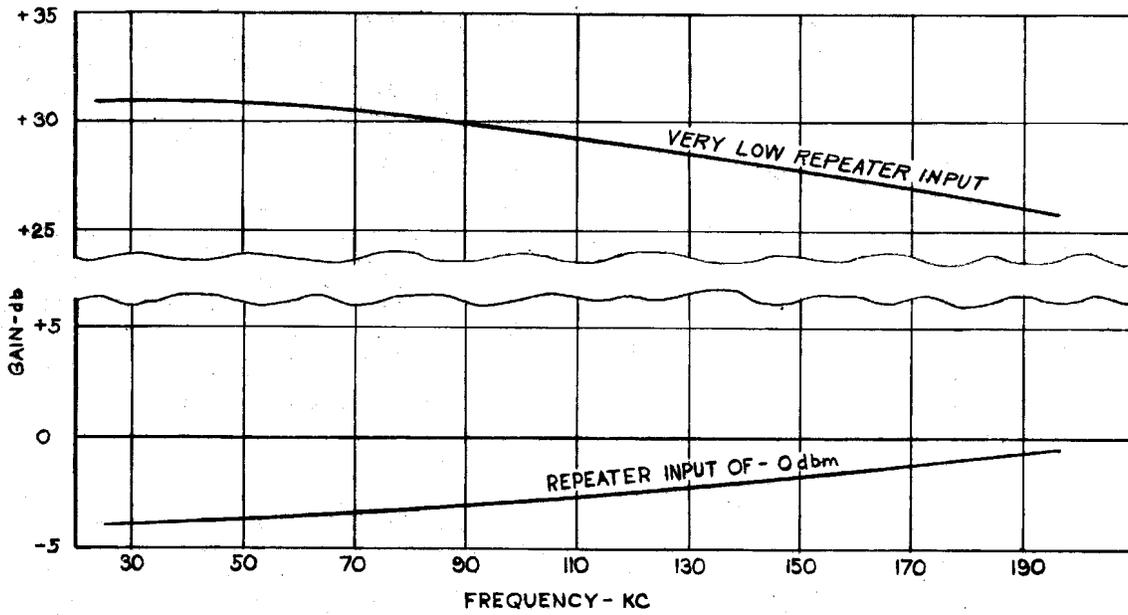


Fig. 75 - OBl, OC1, OD1 Regulating Amplifier - Gain-Frequency Characteristics

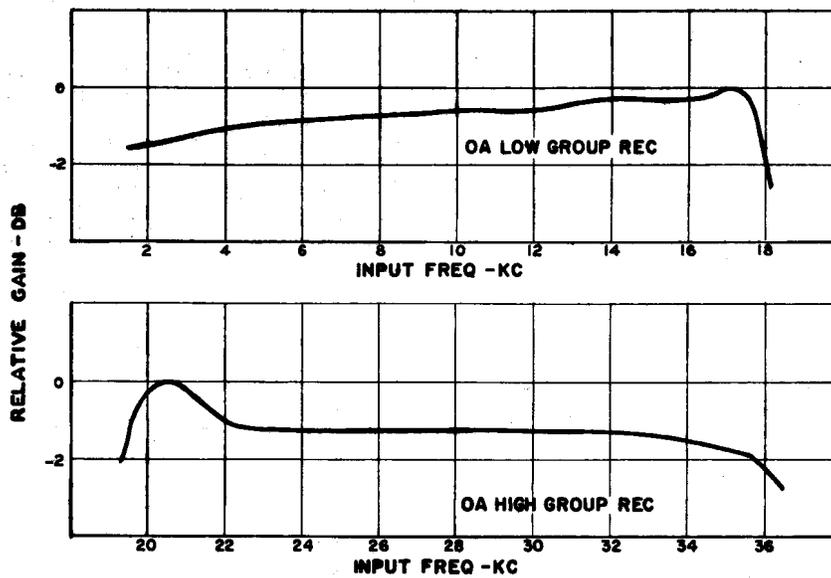


Fig. 76 - OA Group Receiving Circuit - Over-all Gain-Frequency Characteristics - Zero-Slope Adjustment

for the OBl, OC1, OD1 unit. In the latter figure two curves are given to show the effect of grid bias on the frequency characteristic.

2.67 Figs. 76, 77, 78, and 79 show the overall gain-frequency characteristics of the group receiving units with a fixed bias on the regulating amplifier. The gain peaks near 18 and 20 kc in the curves for the OAl unit provide equalization for the directional filter at the transmitting terminal. A single curve is shown for each of the OBl, OC1, and OD1 units since characteristics for the low-group receiving and high-group receiving units for each system are so similar. Two frequency scales are shown to show the actual input frequencies in each case.

2.68 Because of the frequencies being used in the OB, OC, and OD systems, second order modulation products cannot fall into the same group as the frequencies being transmitted. In the OA system, however, the frequencies in the low group are low enough to permit second order products to fall in the same group. Third order products in all the systems may fall in the same group. Because of the expander advantage and the small level differences between channels, the magnitude of modulation components falling in the same group is tolerable. Figs. 80 and 81 show modulation performance for the low-group OAl and the OBl, OC1, OD1 regulating amplifiers. The OAl HG regulating amplifier has third order modulation of about 75 db below each fundamental over its operating range. Fig. 82 shows third order modulation of the final amplifier for all of the units. The 12 db difference between the modulation curves for the amplifiers of the group transmitting circuit and the group receiving circuit is accounted for by the fact that there is 12 db less feedback in the 180- to 196-kc band than in the group transmitting amplifier in the 40- to 76-kc band where the modulation product was measured in the latter circuit. The single frequency load characteristic of the final amplifier is shown in Fig. 46 in Part 2D.

F. Group Oscillator Circuit

2.69 The group oscillator unit comprises three oscillators: an RC thermistor-controlled oscillator generating 3700 cycles per second which supplies the signaling tone for the four channels, and two crystal oscillators, one of which supplies carrier to the modulator of the group transmitting circuit and the other to the modulator of the group receiving circuit. The frequencies of the crystal oscillators are 198 and 216 kc for the OAl group oscillator, 236 and 256 kc for the OBl, 276 and 296 for the OC1, and 316 and 336 kc for the OD1 unit. Provision is also made for supplying direct current, rectified from the 3700-cycle output, to an alarm relay located in the ter-

minal mounting. Failure of the 3700-cycle output brings in an alarm.

Group Carrier Oscillator

2.70 The terminal block schematic, Fig. 146, on page 114, shows that the oscillator circuit can be changed from LGT to HGT or vice versa by interchanging the outputs of the two crystal oscillators. This is accomplished by resoldering straps.

2.71 Fig. 83 is a simplified schematic of a typical carrier oscillator. All components of the oscillators are the same except for capacitors C11 and C19, and crystal Y1. This is an electron-coupled crystal oscillator. The screen and control grid of the 408A pentode, together with capacitors C11, C7, crystal Y1, and capacitor C19 form an oscillator with the crystal acting as an inductance. Variable capacitor C7 is used to adjust the frequency at the factory to 6 cycles above nominal at room temperature for all the oscillators except the 198-kc oscillator, which is set at the nominal frequency. The frequency offset makes the frequency variation of the manufactured product symmetrical over the expected temperature range.

3700-Cycle Signaling Oscillator

2.72 Fig. 84 is a simplified schematic of the 3700-cycle oscillator. The oscillator is essentially a 2-stage feedback amplifier with an RC bridge connected between the output and input terminals of the 2-stage amplifier so that the bridge is included in the feedback loop. This bridge controls the frequency and output (by means of thermistor RT1 together with potentiometer R2) of the oscillator, allowing the two tube sections to operate on the linear portion of their characteristics. This obviates tuning the output transformer or employing other filtering to insure a good waveform. Adjustment of potentiometer R2 has little effect on frequency. The frequency is adjusted by means of capacitor C5, at the factory.

G. Line Transformer and Network Circuits

2.73 In order to isolate the balanced line from the unbalanced directional filter of the terminal equipment, a line transformer is required. In the OAl terminal this transformer is mounted on the group receiving unit. In the OBl, OC1, and OD1 terminals the line transformer is mounted on a separate panel along with a network, or in case the terminal is connected to a carrier line in multiple with an OBl, OC1, or OD1 repeater, is part of a 200L network. Between the transformer and the line is a set of jacks, one facing each way, to permit access to the line and equipment for patching and maintenance purposes.

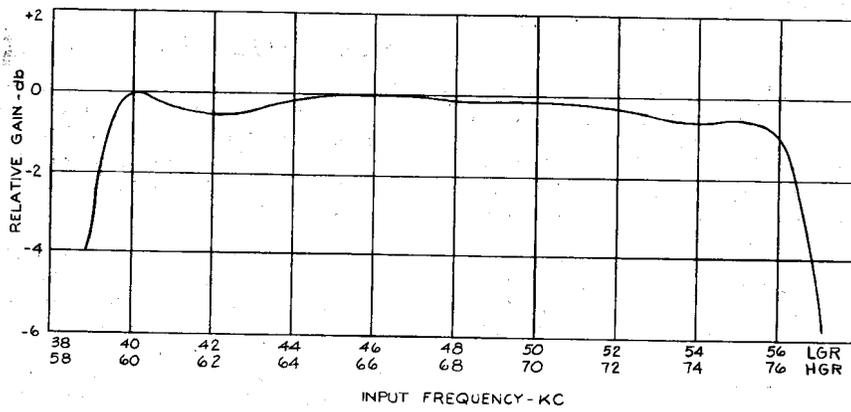


Fig. 77 - Over-all Gain-Frequency Characteristic - OBI Group Receiving Circuit

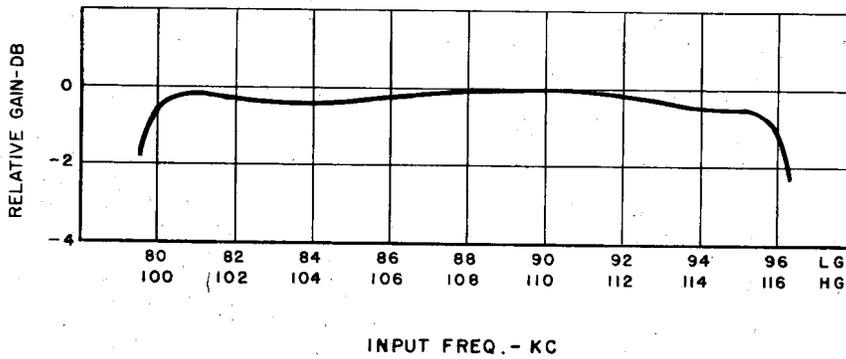


Fig. 78 - Over-all Gain-Frequency Characteristic - OCI Group Receiving Circuit

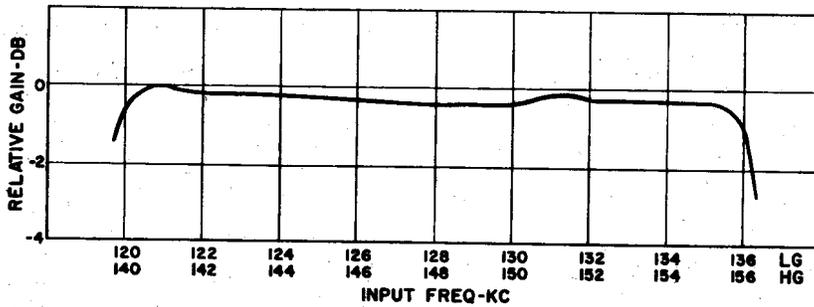


Fig. 79 - Over-all Gain-Frequency Characteristic - ODI Group Receiving Circuit

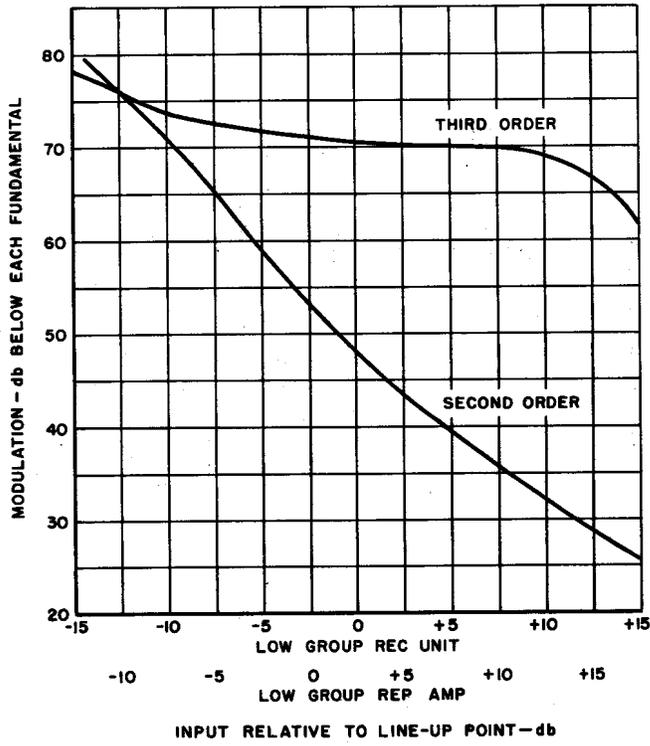


Fig. 80 - Modulation in Regulating Amplifier of OAl Low-Group Repeater and Low-Group Receiving Unit

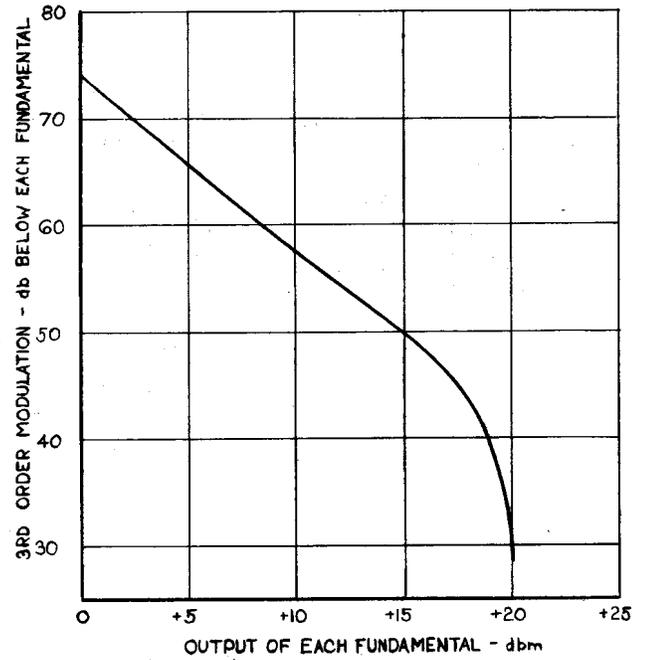


Fig. 82 - Third Order Modulation of Final Amplifier of Group Receiving Circuit

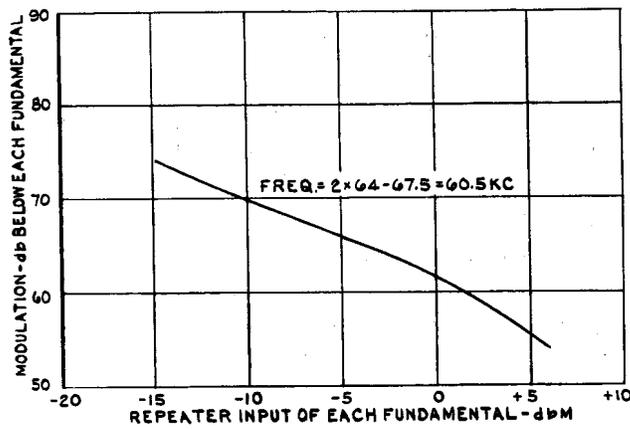


Fig. 81 - Third Order Modulation of OBl, OC1, OD1 Regulating Amplifier Falling Into Same Group

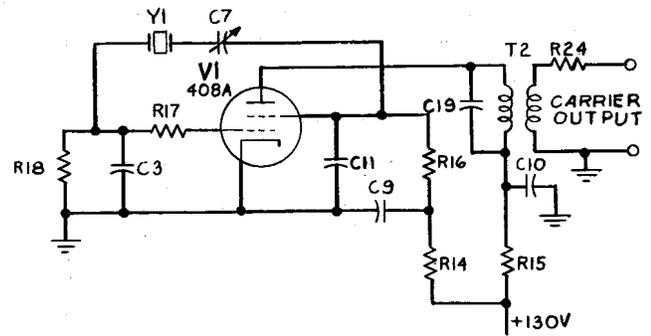


Fig. 83 - O1 Group Carrier Oscillator Schematic

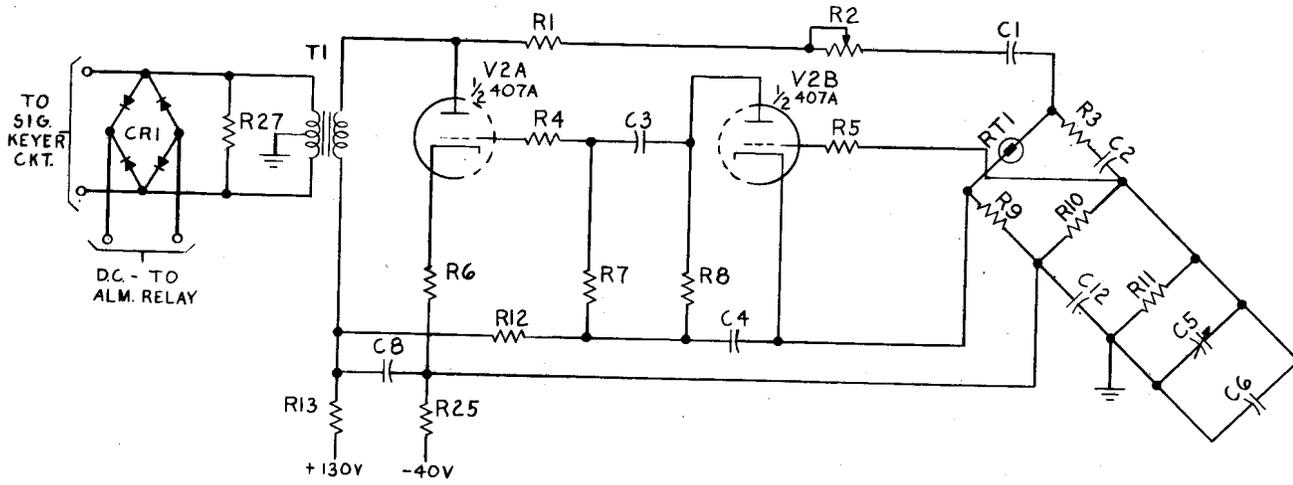


Fig. 84 - O1 3700-cycle Signaling Oscillator Schematic

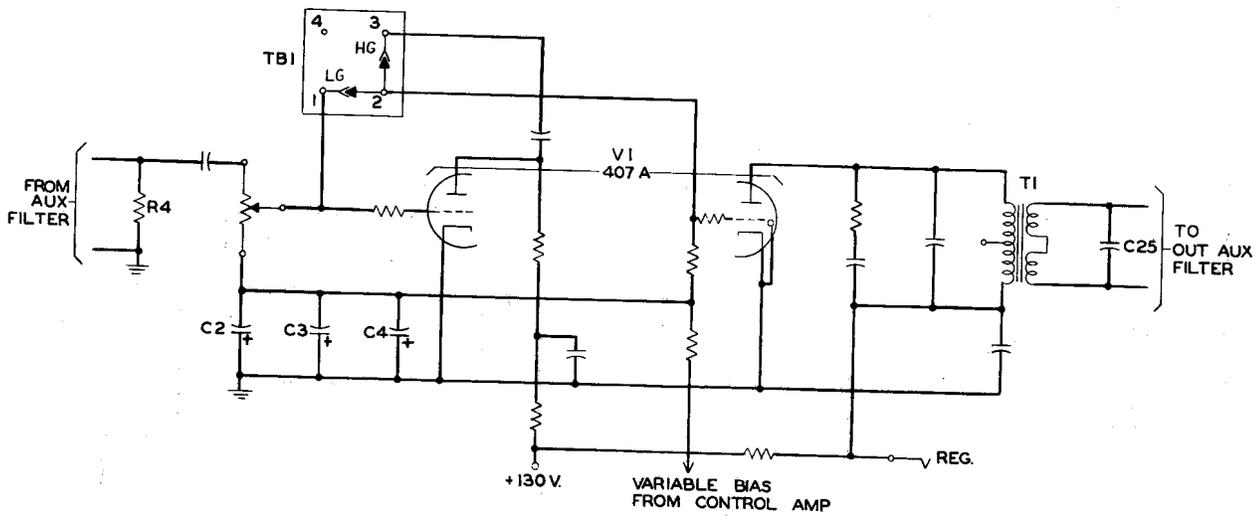


Fig. 85 - OAl Repeater - Regulating Amplifier

2.74 The type of network which is mounted on the panel with the line transformer (or 200L network) at an OBl, OC1, or OD1 terminal (or repeater) depends upon the particular combination of OB, OC, or OD systems to be put on the pair. This network, which may be a 200J, 200S, or 200T network, provides impedance and transmission correction for the directional filters. Each network consists of four series-resonant arms bridged across the filter side of the line transformer (or 200L network), two permanently connected and two on an optional basis. Each series resonant arm is designed to provide impedance and transmission correction for either the upper edge of the high group or the lower edge of the low group of a directional filter when the directional filter for the adjacent frequency band is not present. The directional filters provide this correction for each other when filters for adjacent groups are present. For example, when an OC system is the only one of the OB, OC, or OD systems on the pair, series-resonant arms in the 200S network provide the necessary correction for the OC1 directional filter in the absence of the OBl and OD1 directional filters. Such a network is not required for the OAl directional filter since it is a high pass-low pass type of filter.

2.75 The proper network for the various combinations of the OB, OC, and OD systems is given below.

Type O Systems Multiplied to Carrier Line	Network Used	Strap Terminals
OB only	200J or 200T	1-3-5 and 2-4-6
OC only	200S	1-5 and 2-6
OD only	200S or 200T	1-3 and 2-4 or 1-3-5 and 2-4-6
OB and OC	200J	1-5 and 2-6
OC and OD	200S	No straps
OB and OD	200T	1-3-5 and 2-4-6
OB, OC, and OD	200J or 200T	No straps

3. REPEATERS

A. General

3.01 The repeater used in the OA carrier system performs three basic functions. It separates the two groups of frequencies used for the two directions of transmission on the open-wire line, amplifies the signals and transmits them to the line, and automatically regulates the gain to compensate for changes in line loss. OBl, OC1, and OD1 repeaters perform an additional basic function. They translate and invert the in-

coming group by modulation to the opposite group. That is, they are "frequency frogging" repeaters.

3.02 An OAl repeater consists of a mounting, two networks on a line network panel, and three plug-in units: two repeater amplifiers and a dummy oscillator unit. Except for a plug-in auxiliary filter and strapping on a terminal block, the two repeater amplifiers are exactly alike. The dummy oscillator unit is used to complete the tube heater supply circuit. A block schematic of an OAl repeater is shown in Fig. 147 on page 115.

3.03 An OBl, OC1, or OD1 repeater also consists of a mounting, associated networks on a line network panel, and three plug-in units: two repeater amplifiers which are exactly alike, and a repeater oscillator. The same mounting is used for all the O1 repeaters, and except for the plug-in filters the same repeater amplifier is used for OBl, OC1, and OD1 repeaters as well as for OBl, OC1, and OD1 group receiving units at terminals. A block schematic of an OBl repeater is shown in Fig. 148 on page 116. Schematics of the OC1 and OD1 repeaters are identical to that of the OBl repeater except for the filters and frequencies involved. The filters and frequencies used are also given in Fig. 148 for the OC1 and OD1 repeaters.

3.04 An OAl, OBl, OC1, or OD1 repeater transmits the four message and signaling channels of the system on an equivalent 4-wire basis using two frequency groups, a low group and a high group for each system, for the two directions of transmission on the open-wire pair. The OAl repeater has a low-group (E-W) and a high-group (W-E) repeater amplifier, each transmitting in one direction. Each OBl, OC1, or OD1 repeater has two identical repeater amplifiers, since they are frequency frogging repeaters. The OBl, OC1, and OD1 repeater may be arranged for HL operation (high-low receives high-group and transmits low-group frequencies of the system) or LH operation (low-high receives low-group and transmits high-group frequencies of the system) by properly plugging the proper directional and auxiliary filters into the repeater amplifier unit. The basic performance of the HL and LH repeaters of the OB, OC, and OD systems is the same except for the frequencies being received and transmitted. The two arrangements (LH and HL) are used alternately along the high-frequency line for a particular system.

3.05 The OB, OC, and OD frequencies are separated from the OA frequencies or other lower frequencies on the line by a line filter. After passing through the line filter, the separated OA or OB, OC, and OD frequencies are transmitted through the line and equipment jack circuit (not furnished at

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pole-mounted repeaters) and the line network circuit.

B. Line Network Circuits

3.06 Three types of line network circuits are used. They are as follows:

(a) For OAL repeaters a 200R or 200P network is connected between the line and the W or E side of the repeater amplifiers, respectively. Each network contains a line transformer and a series-resonant circuit. The line transformers isolate the balanced lines from the unbalanced equipment, and the series-resonant circuits are bridged across the transmission paths to introduce suppression peaks in the cut-apart region between the high and low groups of the OA band to increase the repeater loop loss in this region.

(b) When OCl, and OD1 repeaters are not to be used on the pair, the line network circuit for OB consists of a 200K network connected between each line and the E or W side of the repeater amplifiers. This network contains a line transformer and three series-resonant circuits. The line transformer is used to isolate the balanced line from the unbalanced equipment. On the unbalanced side of the transformer are connected the three series-resonant circuits. Two of these circuits provide impedance and transmission correction of the directional filters. The third series-resonant circuit introduces a suppression peak at 58 kc to increase the repeater loop loss at filter crossover frequencies.

(c) The third type of line network circuit is designed to be used when an OC or an OD system is expected to be used on the pair and can be used with any combination of the OB, OC, and OD systems. It consists of a 200L network connected between each line and the E or W side of the repeater amplifiers with a 200J, 200S, or 200T network bridged across the unbalanced side of each 200L network. The 200L network contains the line transformer and three series-resonant circuits. These circuits introduce transmission suppression peaks at the cut-apart frequencies between the high and low groups of the OB, OC, and OD systems. These peaks occur at 58, 98, and 138 kc and provide additional repeater loop loss in the cut-apart regions. The 200J, 200S, and 200T networks provide impedance and transmission correction for the directional filters; their purposes and uses are the same as described in 2.74 and 2.75 for terminals.

3.07 The panel used to mount the networks for office-mounted repeaters will accommodate a maximum of eight networks in addition to the jacks which provide access

to the carrier lines and equipment at the E and W sides of the repeater. This includes the networks for two line network circuits. These two circuits may be any combination of the three types described in 3.06.

3.08 The panel used to mount the networks at a pole-mounted repeater will accommodate four networks. This includes the networks for one of the line network circuits involving:

A combination of OB, OC and OD systems on the same line pair,
two OA systems,
two OB only systems, or
one OB only and one OA system.

This panel is provided with plug and jack arrangements on the repeater side and screw-type terminals on the line side of the circuit for ease of installation and replacement.

C. Directional Filters

3.09 As shown in Figs. 147 and 148 on pages 115 and 116, directional filters are used at the E and W sides of the repeater to separate the two directions of transmission and to attenuate unwanted frequencies. The E and W directional filters are identical with each other and with the directional filters at the terminals for any particular type-O system. Characteristics and schematics of the filters are shown in Figs. 49, 50, 51, and 52.

3.10 A single ground is provided for all the directional filters paralleled at one point. This prevents noise and crosstalk that might occur from large circulating ground currents that would be possible if each directional filter had its own ground.

D. Repeater Amplifier

OAL Repeater Amplifier

3.11 The signals received from the line are transmitted through the 200P or R network (see 3.06) to the directional filter. After passing through the directional filter the signals are attenuated 10 db by the input pad (see Fig. 147 on page 115). This plus additional attenuation in the input auxiliary filter reduces the signals to a level suitable for the regulating amplifier input and also determines the maximum gain of the repeater amplifier.

3.12 The input auxiliary filter supplements the discrimination of the directional filter, helps to attenuate the received signals to a suitable level for the regulator input, and provides equalization near 18 kc for the low-group (LG) or 20 kc for the high-group (HG) repeater amplifier to compensate for the distortion of the two directional filters near these frequencies.

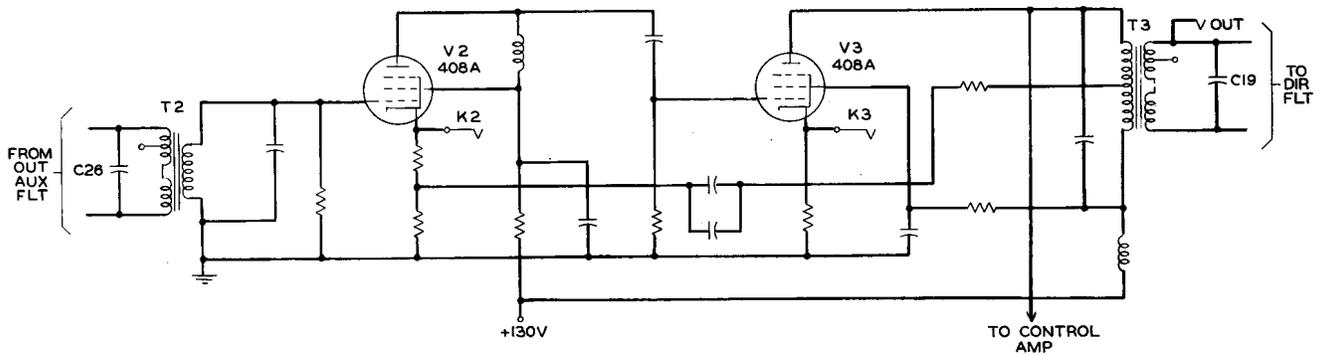


Fig. 86 - OAl Repeater - Line Amplifier Circuit

3.13 The output of the input auxiliary filter is applied to the input of the regulating amplifier (see Fig. 85). As in the group receiving unit this is a 2-stage, resistance-coupled, variable gain amplifier in the HG repeater amplifier; in the LG repeater amplifier the first stage is strapped out in order to reduce the gain and thus lessen the effects of microphonics in the tube that occur in the low-group frequency range. Since this reduces the overall regulation range, an input potentiometer REG is provided in order to adjust the input to the optimum part of the regulation range. This point is set by the space current in the second stage of the amplifier, as measured by the voltage drop across the plate filter resistor. When used in an HG repeater amplifier both stages are used and the REG potentiometer is set at the top of its range.

3.14 The output of the regulating amplifier is supplied at a nearly constant level to the output auxiliary filter. In the LG unit this part of the filter assembly is a strap which connects the regulating amplifier to the line amplifier input. In the HG unit this is a high-pass filter which suppresses microphonics and modulation products of the amplifier below the high-group band. Both the input and output auxiliary filters are contained in the auxiliary filter unit.

3.15 The output of the output auxiliary filter is amplified by the line amplifier (Fig. 86) to the correct level and transmitted through the directional filter, located on the other repeater amplifier, to the line. The amplifier has a nominal gain of 46 db and a single-frequency load characteristic as shown in Fig. 46. The gain-frequency characteristic of the amplifier is shown in Fig. 87. As shown in the figure, the amplifier band is wide enough to accommodate both the OA high and low groups.

3.16 The repeater output is automatically adjusted by amplifying and rectifying a portion of the output of the line amplifier in the control amplifier and rectifier (see Fig. 88), comparing this dc voltage to a reference dc voltage and supplying the difference to the regulating amplifier stages as bias. A change in repeater output results in a change in regulator bias which causes the regulating amplifier gain to change in such a direction as to offset, largely, the original change in output. The OUT potentiometer in the cathode circuit of the control amplifier provides an adjustment of repeater output by adjusting the operating point of the regulator.

OBl, OC1, OD1 Repeater Amplifier

3.17 Operation of the OBl, OC1, OD1 repeater amplifier is identical with that of the group receiving amplifier described in detail in Part 2E, except that no masking noise is provided at repeaters and the modulating frequency and auxiliary filters are different. The carrier applied to a repeater modulator is always 116 kc for an OBl repeater, 196 kc for an OC1 repeater, and 276 kc for an OD1 repeater, whether the repeater is LH or HL. Similarly, the plug-in auxiliary filter is the same for each system, whether the repeater is LH or HL.

3.18 After passing through the directional filter the signals are transmitted through a 22-db pad (see Fig. 148 on page 116) to the input auxiliary filter. For an LH repeater this filter will pass the low group and reject other frequencies. For an HL repeater the high group would be passed. The output of the filter is applied to the input of the regulating amplifier (see Fig. 70) which supplies the signals at a nearly constant level to the modulator.

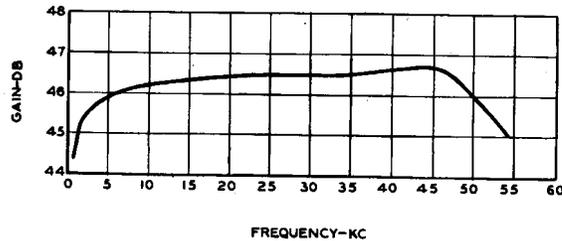


Fig. 87 - Typical Gain-Frequency Characteristic - OAL Repeater Line Amplifier

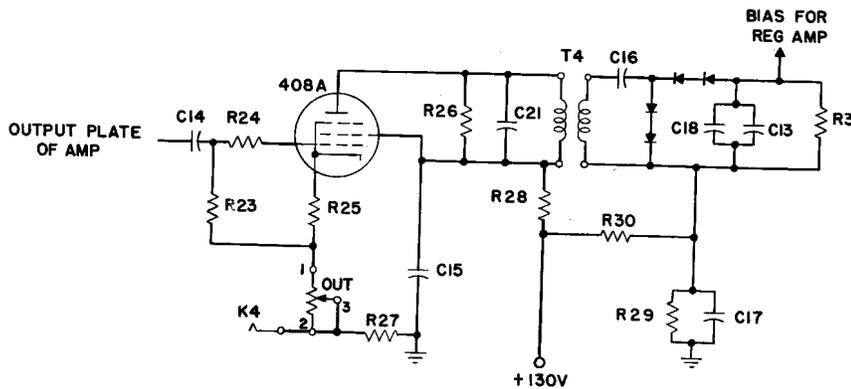


Fig. 88 - OAL Repeater Control Amplifier and Rectifier

3.19 In the modulator the input group of frequencies is modulated with the modulating carrier from the repeater oscillator to translate from low group to high group, or vice versa, of the particular system. The modulator is of the double-balanced type which provides suppression at the output of both the modulating carrier and the input signals.

3.20 The modulator output is passed through the output auxiliary filter which is part of the auxiliary filter unit. This differs from the filter used at the corresponding point in the terminal group receiving circuit. It passes either the low group (HL repeater) or high group (LH repeater), depending upon the orientation of the auxiliary filter, and rejects other frequencies.

3.21 The transmitted sideband is next amplified by the line amplifier (see Fig. 71) to the correct level and transmitted through the directional filter, located in the other repeater amplifier. This filter suppresses carrier leak and

unwanted frequencies. The amplifier gain is about 54 db. The maximum single-frequency output is about +23 dbm, as shown in Fig. 46. The frequency characteristic is shown in Fig. 44.

3.22 The output of the repeater is automatically controlled as explained for the OAL repeater in 3.16. A schematic of the control amplifier and rectifier is shown in Fig. 72.

E. Auxiliary Filters

3.23 The two auxiliary filters for the OAL repeater are not reversible and both are used at a repeater, the 530K in the LG repeater amplifier, and the 530L in the HG repeater amplifier. The 530L has both an input and an output auxiliary filter. The 530K has no output auxiliary filter; a strap connects the input and output terminals where the output auxiliary filter would ordinarily go. Schematics and characteristics of the filters are shown in Figs. 89, 90, and 91.

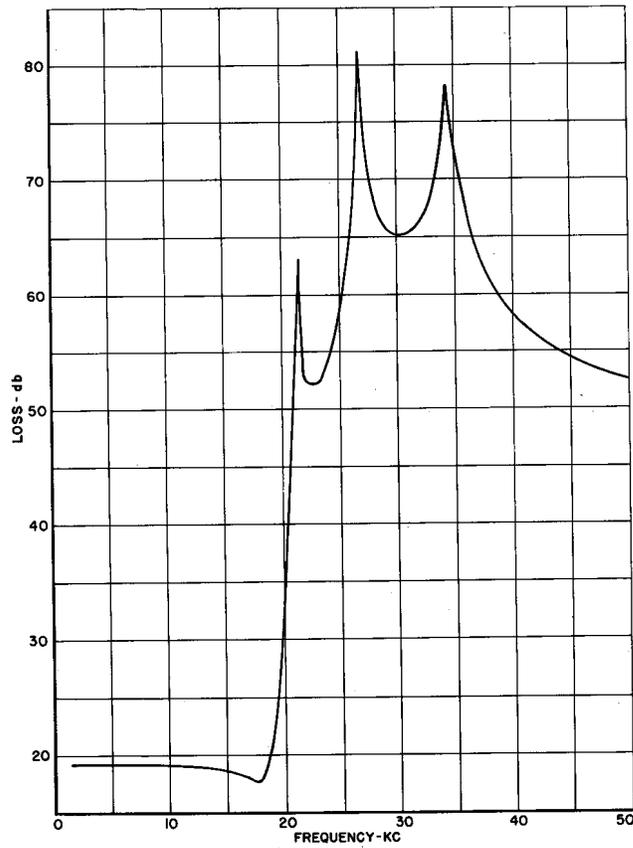
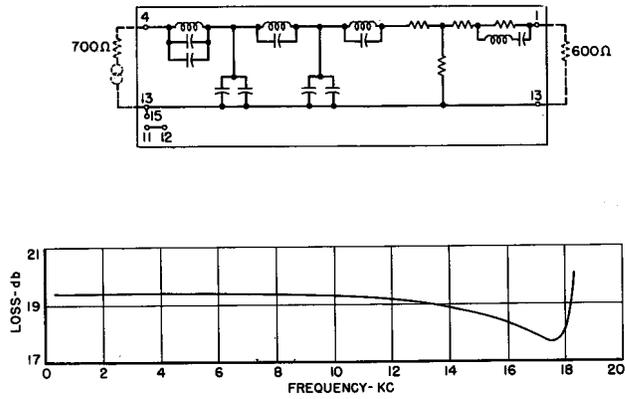


Fig. 89 - Schematic and Loss-Frequency Characteristic of 530K Input Auxiliary Filter

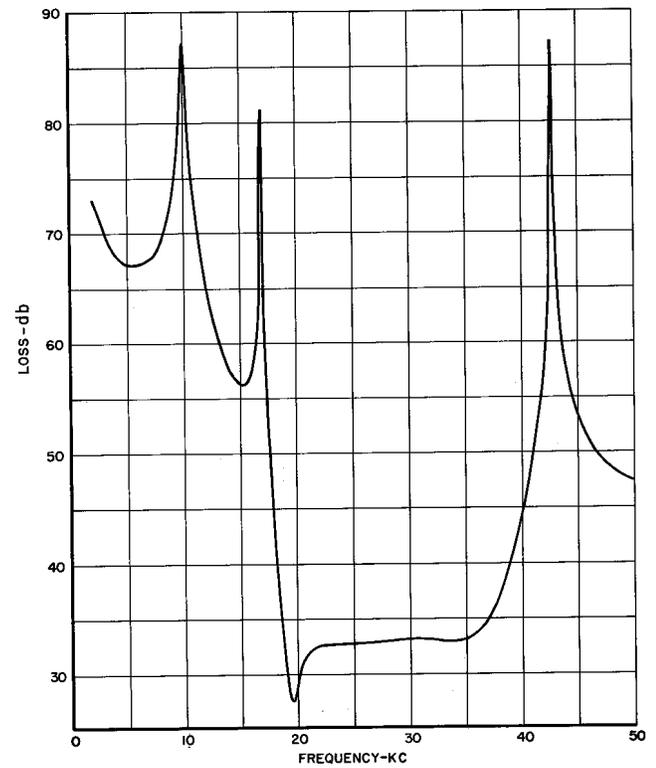
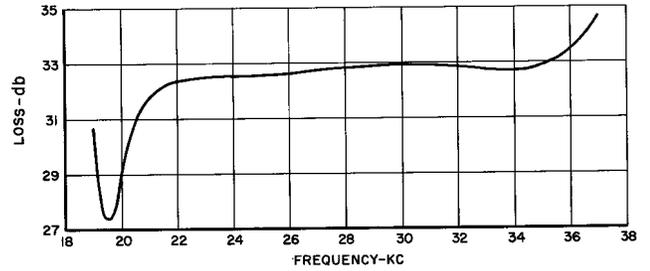
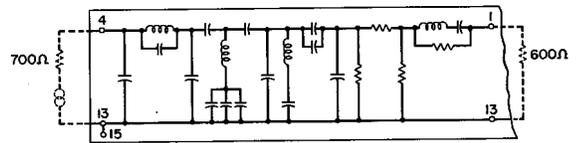


Fig. 90 - Schematic and Loss-Frequency Characteristic of 530L Input Auxiliary Filter

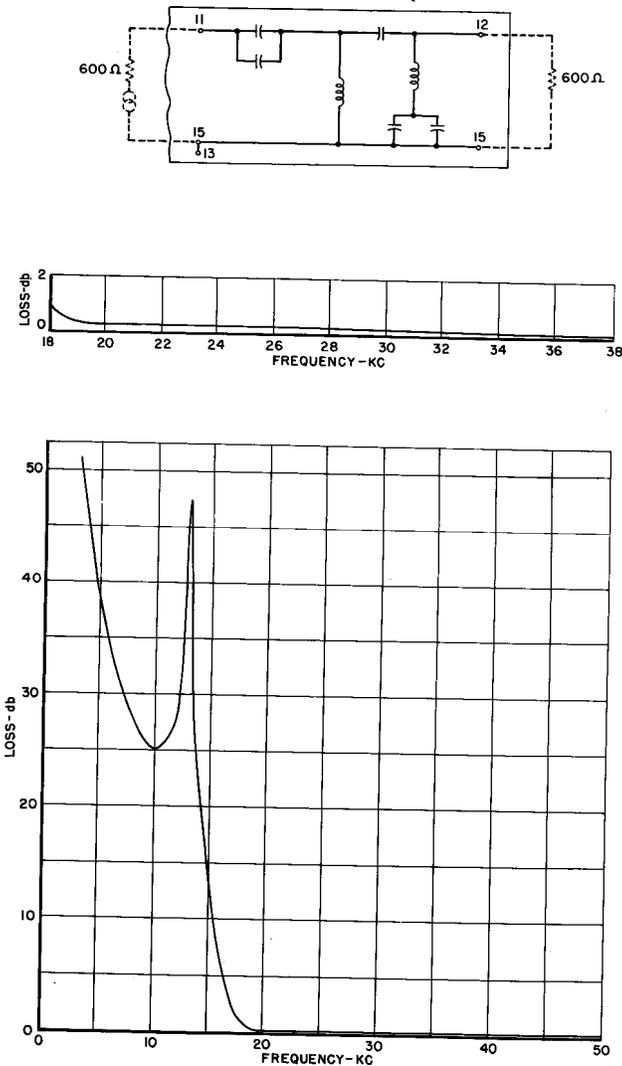


Fig. 91 - Schematic and Loss-Frequency Characteristic of 530L Output Auxiliary Filter

3.24 The auxiliary filters for the OBI, OC1, and ODI repeaters, each of which contains a low-group and a high-group filter for the particular system, are reversible plug-in units whose orientation in the socket determines which half is used at the input and which at the output. This filter is the 531A for OBI repeaters, 531D for OC1 repeaters, and 531E for ODI repeaters. The schematics and characteristics for the 531A filter are the same as shown for the filters in Figs. 57 and 59. For the 531D filter the schematics are the same and the characteristics are the same, except for minor differences in the passband, as those shown for the filters in Figs. 61 and 63. For the

531E filter the schematics are the same and the characteristics are the same, except for minor differences in the passband, as those shown for the filters in Figs. 65 and 67. All of the OBI, OC1, and ODI auxiliary filters have pads connected on the high-impedance side to provide a good impedance termination for the filter when connected between the modulator and the line amplifier. These pads have 3-db loss except in the 531E filter, which has 1.5-db pads. Capacitors are included to provide additional impedance correction when used between the modulator and line amplifier, and the 531E filter has resistors connected across the capacitors for still further correction.

F. Repeater Oscillator

3.25 The carrier frequency used at each OBI, OC1, or ODI repeater for group modulation is supplied by a crystal-controlled oscillator which is required to be very accurate in frequency so that the carriers will be translated the proper number of cycles in the process of frequency frogging. This is important to insure that when the carriers arrive at the terminal they will fall into the very narrow passbands of the pick-off filters of the twin-channel regulators. The carrier frequencies are 116 kc for OBI, 196 kc for OC1, and 276 kc for ODI repeaters. The three oscillators are identical except for the crystal and two capacitors. A schematic is shown in Fig. 92.

3.26 The repeater oscillator is an electron-coupled crystal-controlled oscillator similar to those in the group oscillator and twin-channel circuits. The cathode, screen, and control grid of a 408A pentode operate as a triode oscillator with a tuned circuit employing a crystal as a positive reactance connected between the screen grid and control grid. Capacitor C2 in series with the crystal provides a frequency adjustment of about +20 to -12 cycles per

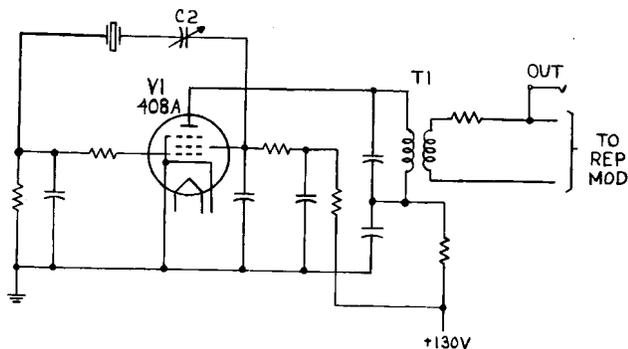


Fig. 92 - OBI, OC1, ODI Repeater Oscillator Circuit

second. Ordinarily this is adjusted in the factory only. Oscillations are coupled to the plate circuit of the pentode by the electron stream so that variations in modulator load have negligible influence on the oscillating circuit. The oscillations are transmitted from the plate to the modulator through an impedance-matching transformer which is tuned to improve the output waveform.

G. Repeater Performance

3.27 The OAL repeater provides regulated flat gain for each direction of transmission, up to a maximum of about 40 db for the high group and about 27 db for the low group. The OA low group does not require as much gain or regulating range because at these lower frequencies there is lower line attenuation and smaller change in attenuation with wet weather and sleet. Because of the limited regulation range of the low-group repeater amplifier, the input is adjusted to the optimum point of the regulation characteristic. It can be lined up with a maximum line attenuation at 6 kc of about 17 db, and has a regulating range of about 10 db above and below this point. The OBl, OC1, OD1 repeaters provide a regulated flat gain up to a nominal maximum of 40 db. Detailed regulation information, which will indicate maximum usable gains, is given in Part 4C. Transmission characteristics are given in Figs. 93, 94, 95, 96, and 97.

3.28 For OBl, OC1, and OD1 repeaters the transmission slopes (see Fig. 7 for example at OB frequencies) of successive repeater sections tend to compensate each other due to the frequency frogging that takes place at each repeater so that a gain of 40 db provides for a maximum line loss of 50 db at the top frequency in the high group of a system under sleet conditions. Equalization is not provided for the odd line sections or for differences in weather variation along the line. The residual slope across any one channel band is small, except under sleet conditions.

3.29 A limiting factor on the maximum gain that can be used in a repeater is the loop loss. If the total loop gain exceeds the total loop loss, the repeater will go into self oscillations. The loop loss characteristics for the type O1 repeaters at maximum gains are given in Figs. 98, 99, 100, and 101.

3.30 The unwanted modulation products of the repeater may be divided into two categories: (a) the products that fall back into the same group, and (b) the products that fall into the other group being transmitted in the opposite direction. Except in the low group of the OA system, the predominant products are third order

products, since the second order products generated in the repeater fall outside the band being transmitted and are attenuated by the auxiliary and directional filters. In the low group of the OA system, the frequencies are low enough to allow the second order products to fall into the same group.

3.31 The regulating amplifier, line amplifier, and directional filter may form products which fall into the same group. Because of the expander advantage and small level difference between channels, the requirements for modulation falling into the same group are relatively mild. The modulation due to the OAL directional filter is negligible. The third order modulation of the OAL HG regulating amplifier over its operating range is approximately 75 db below the fundamentals of +6 dbm at the repeater output. This is expected to be satisfactory. Second and third order modulation for the OAL LG regulating amplifier, which is the major source of modulation in the OAL repeater, is shown in Fig. 80. Third order modulation for the OBl, OC1, OD1 regulating amplifier is given in Fig. 81. Fig. 102 shows the third order modulation characteristics for products falling into the same group for the OBl, OC1, and OD1 directional filters and line amplifier. The directional filters are the predominant sources of this modulation except for repeater gains less than approximately 5 db for OD1 to 20 db for OBl, where the regulating amplifier becomes predominant. Fig. 103 shows the modulation of the OAL repeater line amplifier.

3.32 Another product in the OBl, OC1, and OD1 repeaters which may fall back into the group in which it originates is a fifth order product which is the result of the second harmonic of the transmitted signal (formed in the control rectifier) crosstalking into the regulating amplifier, and there modulating with the third harmonic of the incoming signal, forming the product 2C-3V. It is more than 50 db below a fundamental output of +6 dbm.

3.33 The only source of third order products falling into the group being transmitted in the opposite direction is the directional filter, since it attenuates any such products formed before it in the repeater. This modulation of the OAL directional filter is negligible; that for the OBl, OC1, and OD1 directional filters is shown in Fig. 104. The carrier leak at the output of an OBl repeater, which is at about -75 dbm, falls at the edge of the high group of the OC system (116 kc). Therefore, where an OBl repeater is multiplied to an HL OC1 repeater, an output of about -35 dbm at 80 kc (196 to 116) can be expected when the OC1 repeater is at maximum gain. This

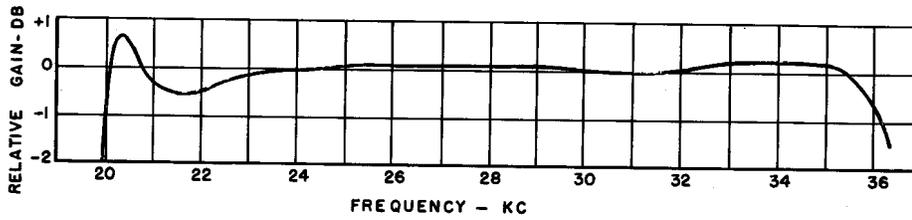


Fig. 93 - OAl High-Group Repeater - Over-all Gain-Frequency Characteristic

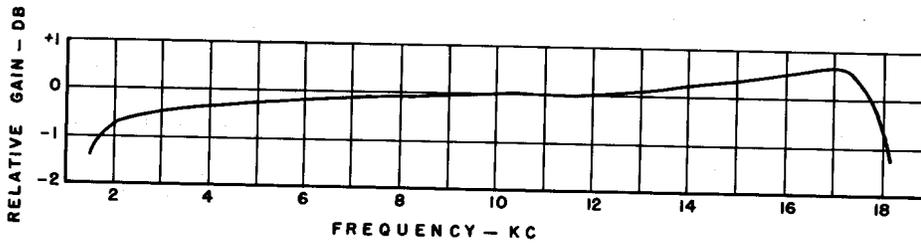


Fig. 94 - OAl Low-Group Repeater - Over-all High-Frequency Characteristic

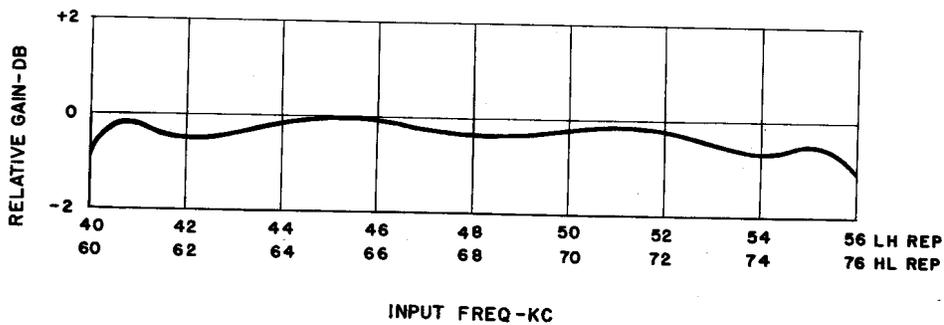


Fig. 95 - OBl Repeater - Over-all Gain-Frequency Characteristic

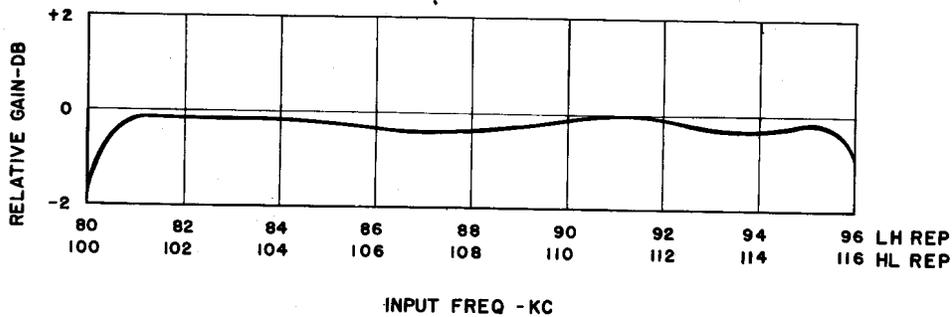


Fig. 96 - OCl Repeater - Typical Over-all Gain-Frequency Characteristic

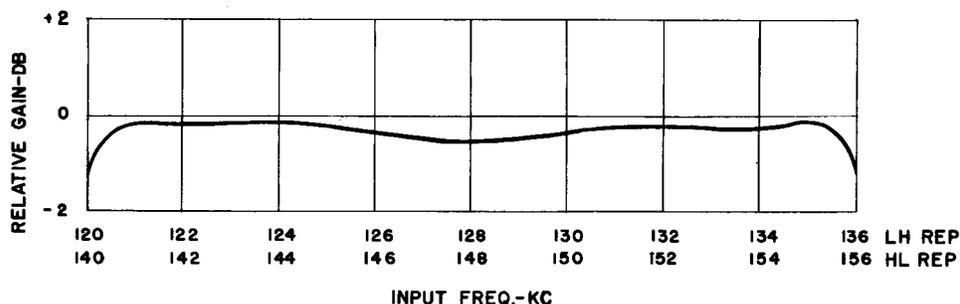


Fig. 97 - OD1 Repeater - Typical Over-all Gain-Frequency Characteristic

is not expected to be objectionable. The carrier leak of the OC1 and OD1 repeaters is outside any type O transmission band and is much lower than that for the OB1 repeater.

3.34 The noise in the repeater originates in the regulating amplifier (since it is at the lowest level in the circuit), and hence varies as the repeater gain changes due to line conditions. The maximum noise in a 3000-cycle band at the output of OA HG repeater amplifiers and OB1, OC1, OD1 repeaters is about -42 dbm and about -70 dbm for OAL LG repeater amplifiers, all at maximum gain.

4. SYSTEM

A. Terminal Levels

4.01 Fig. 149 on page 117 is a simplified schematic and level diagram of an OB1, OC1, or OD1 terminal. The same levels apply for an OAL terminal, but the impedances at the group transmitting unit output, terminal output, and group receiving unit input are 600-ohm instead of 135-ohm levels. Message circuit levels which are not within the compressed portion of the circuit have the usual reference to 0 db at the transmitting toll switchboard. Message levels between compressor and expander are subject to special interpretation as outlined in Part 1B. Carrier and signaling power is given in dbm and is not affected by compressor action.

4.02 All controls involved in line-up are shown in Fig. 149 in bold-face type,

except for the REG potentiometer and the slope contact switch of the equalizer in the group receiving unit of the OAL terminal (see Fig. 146 on page 114). The arrangement shown is for a 2-wire voice-frequency connection. Where desirable, the resistance hybrid of the channel unit may be strapped out to provide a 4-wire connection. In the latter case the transmitting level at the 4-wire input would be -16 db and the receiving level at the 4-wire output can be adjusted as required between +10 and -16 db.

4.03 On the transmitting side the COMP control is adjusted for proper message channel level at the compressor output and the T control for proper sideband level at the channel band filter output. The TC control in each twin-channel unit is adjusted to obtain the proper level of transmitted carriers. The OUT control in the transmitting group equipment is used only when required for crosstalk coordination.

4.04 On the receiving side assumed input levels are indicated. Actually, sufficient regulation range is provided in the receiving equipment to permit operation with input message levels as low as approximately -50 db for OB1, OC1, and OD1 terminals and -40 db for OAL terminals. The REG control in the OAL group receiving unit is used at an OAL HGT terminal to adjust the input to the optimum value for the regulator. This control does not exist at OB1, OC1, or OD1 terminals and is not used at an OAL LGT terminal. The OUT control in the group receiving unit is used to adjust the total carrier power in its output

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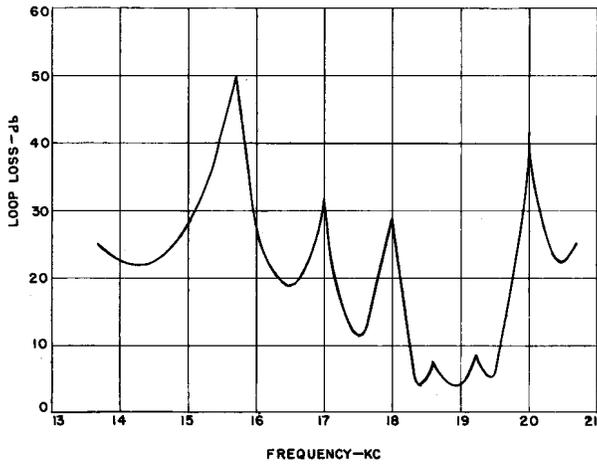


Fig. 98 - OAl Repeater Loop Loss

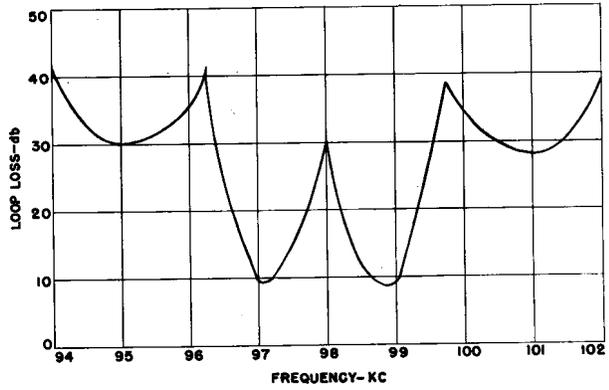


Fig. 100 - OC1 Repeater Loop Loss

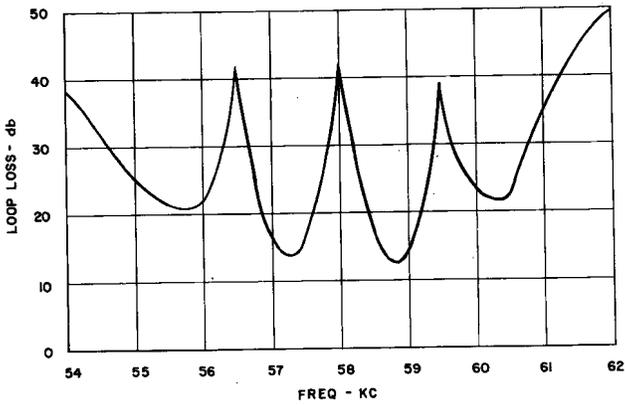


Fig. 99 - OB1 Repeater Loop Loss

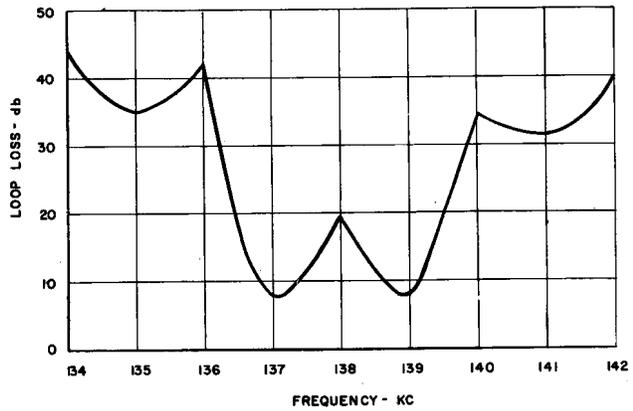


Fig. 101 - OD1 Repeater Loop Loss

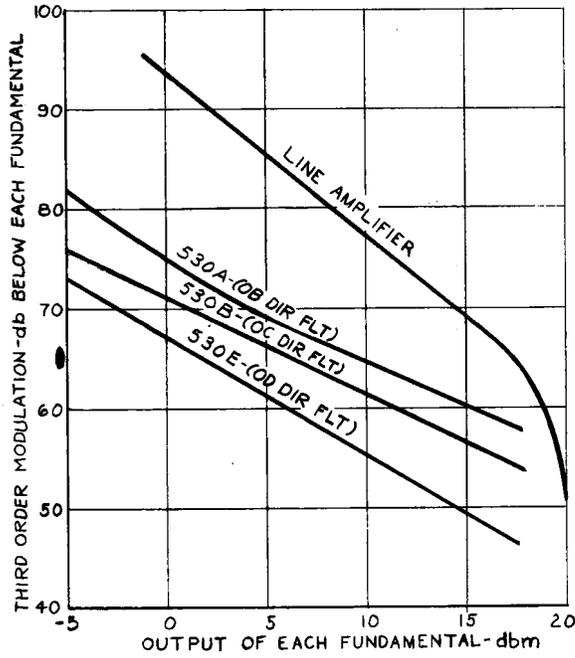


Fig. 102 - OBl, OC1, OD1 Line Amplifier and Directional Filter - Third Order Modulation Falling in Same Group

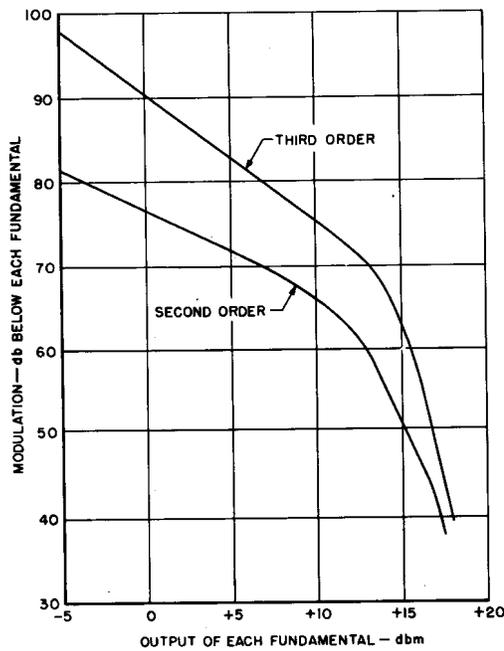


Fig. 103 - OAl Repeater Line Amplifier - Modulation Characteristics

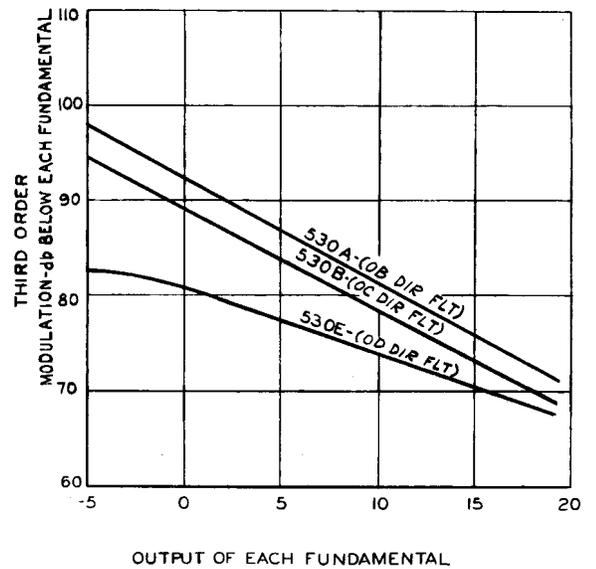


Fig. 104 - OBl, OC1, OD1 Directional Filters - Third Order Modulation Falling in Opposite Group

to the correct level. This adjustment is for the 4-channel group, and two carriers are involved. The value of +6 dbm given in Fig. 149 is for each carrier. The REG control in the twin-channel unit serves to adjust the twin-channel regulator to its proper operating point. The twin-channel regulator is activated only by the carrier associated with its two channels. The R control in the carrier frequency subassembly adjusts the expander input and output while the REC control at the expander output makes it possible for the VF output level to be adjusted from +10 db to -16 db referred to transmitting toll switchboard. The EXP potentiometer is normally set at maximum clockwise position but may be used in connection with the R potentiometer to obtain higher 3700-cycle levels when required.

4.05 The controls indicated SIG, BRK and REL CUR in the signal receiving circuit are used in line-up to adjust sensitivity, per cent break, and relay current, respectively.

B. Line Levels

4.06 The carriers are normally transmitted to the high frequency line at +6 dbm. At this point the signaling tones are 0 dbm and the message level is 0 db. Fig. 105 shows, for illustration, the high frequency portion of a one-repeater OB system such as might be found in nonsleet areas. Levels are shown for dry and wet weather conditions. Attention is drawn to the fact that lengths of line involving an even number of line sections tend to be self-equalizing. This is not true for an OA system where the frequencies are not frogged. It will also be noted that the small regulation error of the group receiving circuit is corrected by the twin-channel regulator. Under severe sleet conditions this correction becomes quite important, the regulation error of the group receiving circuit being in this case much more pronounced.

C. Regulation

4.07 The regulation characteristics of the repeaters and group receiving units of the type O systems are shown in Figs. 106, 107, 108, 109, and 110. The regulating action is such that the total power output, most of which is in the two carriers, is

nearly constant. Characteristics are shown for three typical settings of the OUT potentiometer. The regulation error that results because of sleet or rain depends upon the original operating point except for the OAl LG repeater amplifier and low-group receiving unit, in which the original operating point is adjusted to be the same regardless of the original line loss.

4.08 Since the power in the sidebands is continuously changing due to talkers and signaling tones the gain of the repeater or group receiving circuit tends to change slightly to keep output power constant. The maximum change of about 2 db occurs when all four signaling tones go on or off together. The change is relatively slow, however, and occurs to the greatest extent in the first repeater, since any change in the first repeater reduces the necessary correction in subsequent repeaters. Hence the change does not multiply as the number of repeaters is increased. Any residual is taken care of by the faster acting twin-channel regulator.

4.09 Long speech bursts will cause a slight gain change but ordinary conversation has practically no effect. Typical stabilization time of the output to within 0.2 db of its final value is shown in Fig. 111 for the OB1, OC1, OD1 repeater or group receiving unit for a particular operating point. For a large sudden increase in input, say 20 db, the repeater overloads and a longer stabilization time results.

4.10 One twin-channel carrier circuit of a terminal regulates by holding the 184-kc carrier output constant and the other by holding the 192-kc carrier output constant. Because of the carrier pick-off filter in the control circuit the gain is not affected by speech or signaling sidebands. Fig. 112 shows the regulation characteristic. Adjustment of the REG control changes the input to the circuit. The stabilization time of the twin-channel carrier circuit is about 100 times as fast as that of the group receiving circuit or repeater, so for a sudden change in line loss the twin-channel compensates first, returning to normal as the group receiving circuit adjusts.

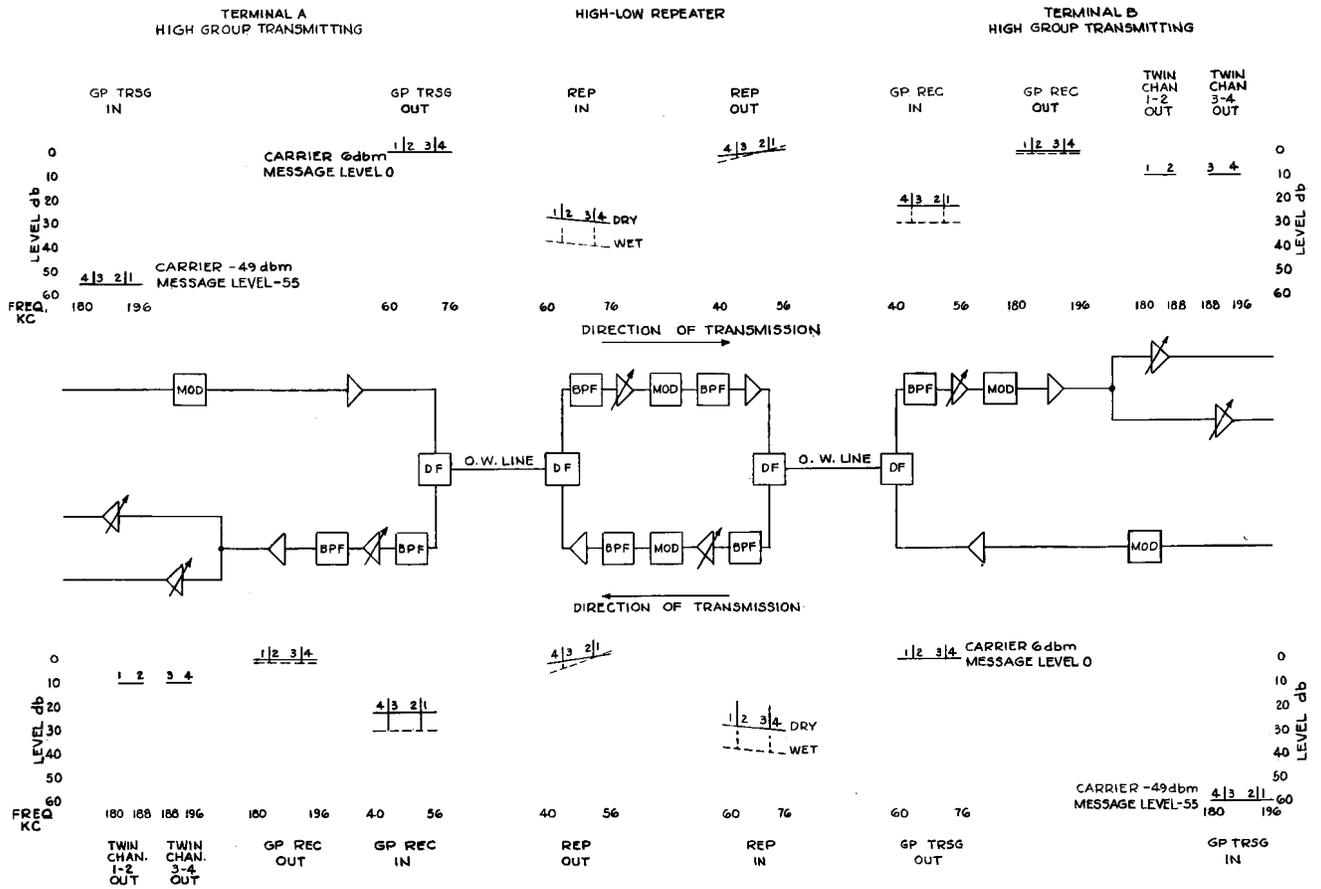
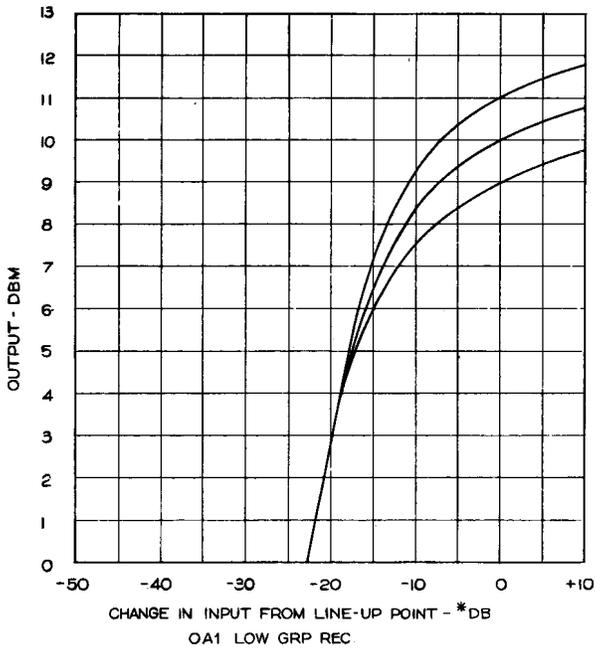


Fig. 105 - Illustrative Line Levels for OB System

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* LINE-UP POINT FOR LOW GROUP (0 DB ON HORIZONTAL AXIS) DEPENDS ON LINE LOSS, AND CAN BE AS LOW AS APPROX. -21 DBM WITH REG. POTENTIOMETER IN ITS EXTREME COUNTER-CLOCKWISE POSITION

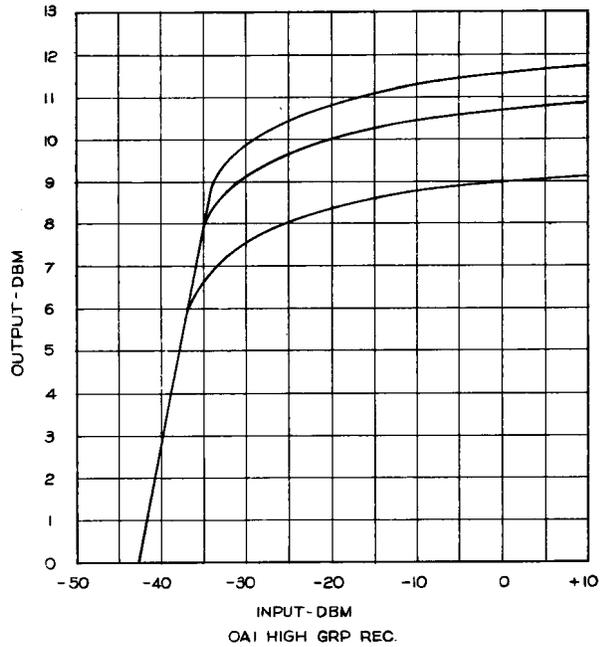
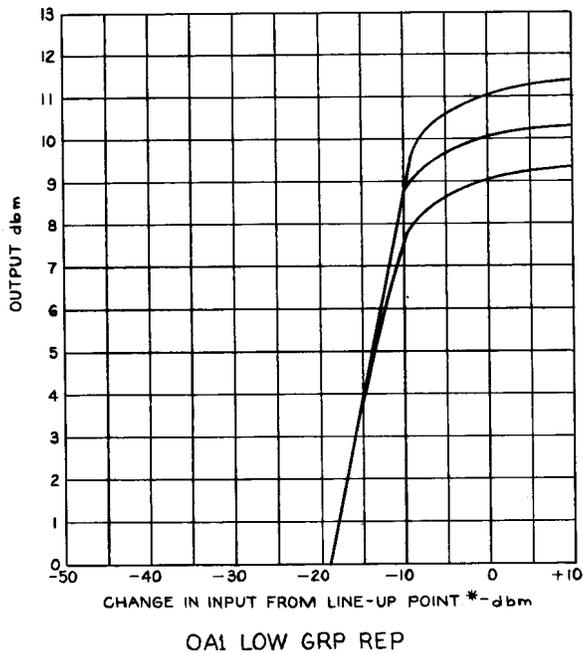


Fig. 106 - OA1 Group Receiving Unit - Regulation Characteristics



* LINE-UP POINT FOR LOW GROUP (0 db ON HORIZONTAL AXIS) DEPENDS ON LINE LOSS, AND CAN BE AS LOW AS APPROX. -8 dbm WITH REG. POTENTIOMETER IN ITS EXTREME COUNTER-CLOCKWISE POSITION

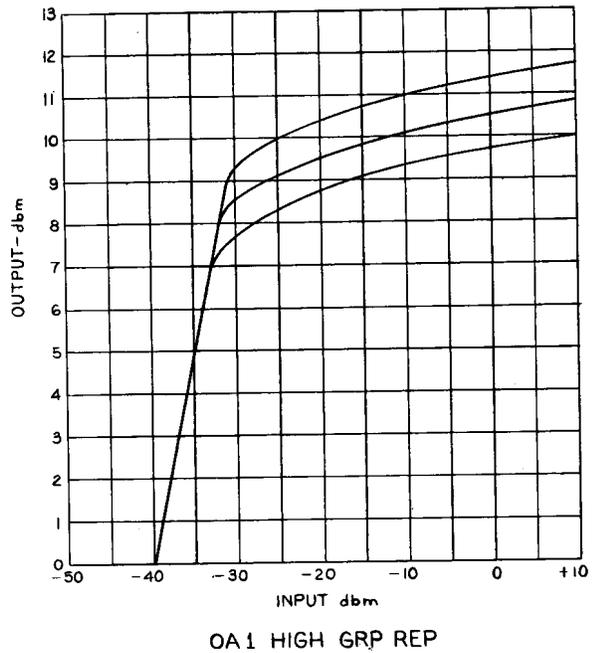


Fig. 107 - OA1 Repeater - Regulation Characteristic

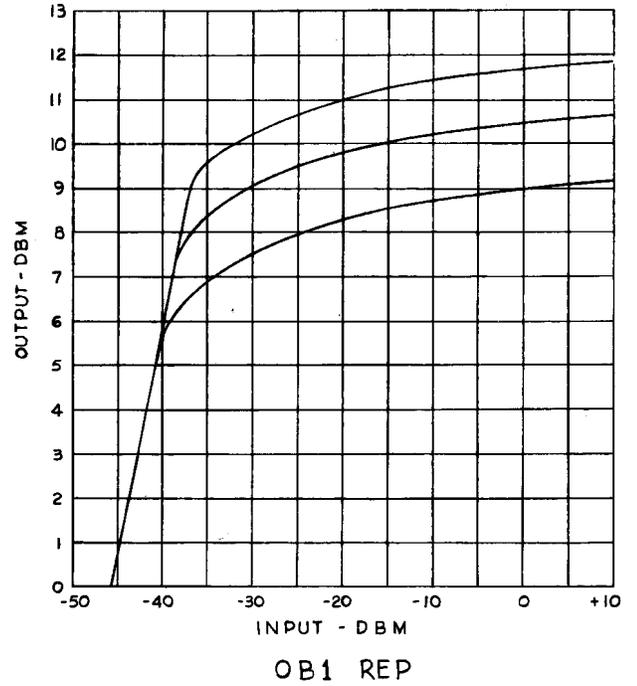
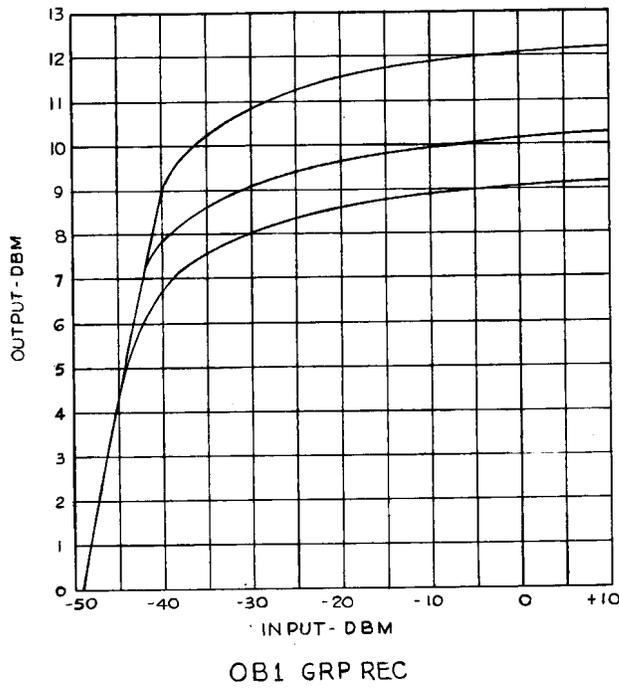


Fig. 108 - OB1 Group Receiving and Repeater Regulation Characteristic

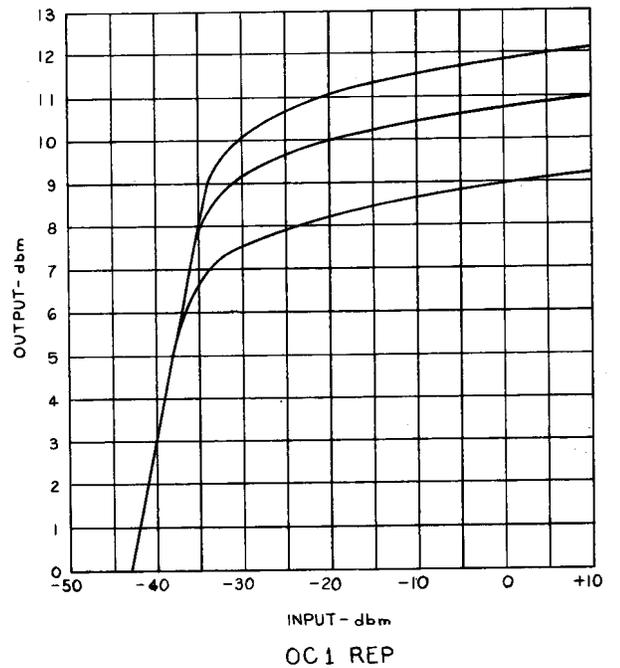
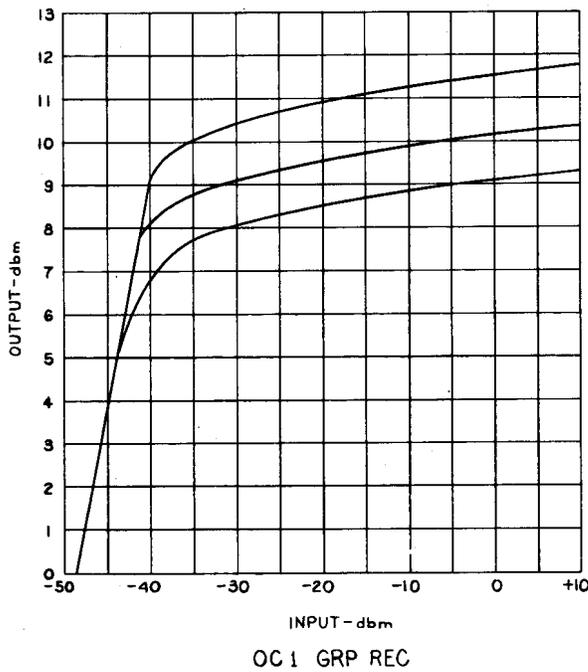


Fig. 109 - OC1 Group Receiving and Repeater Regulation Characteristics

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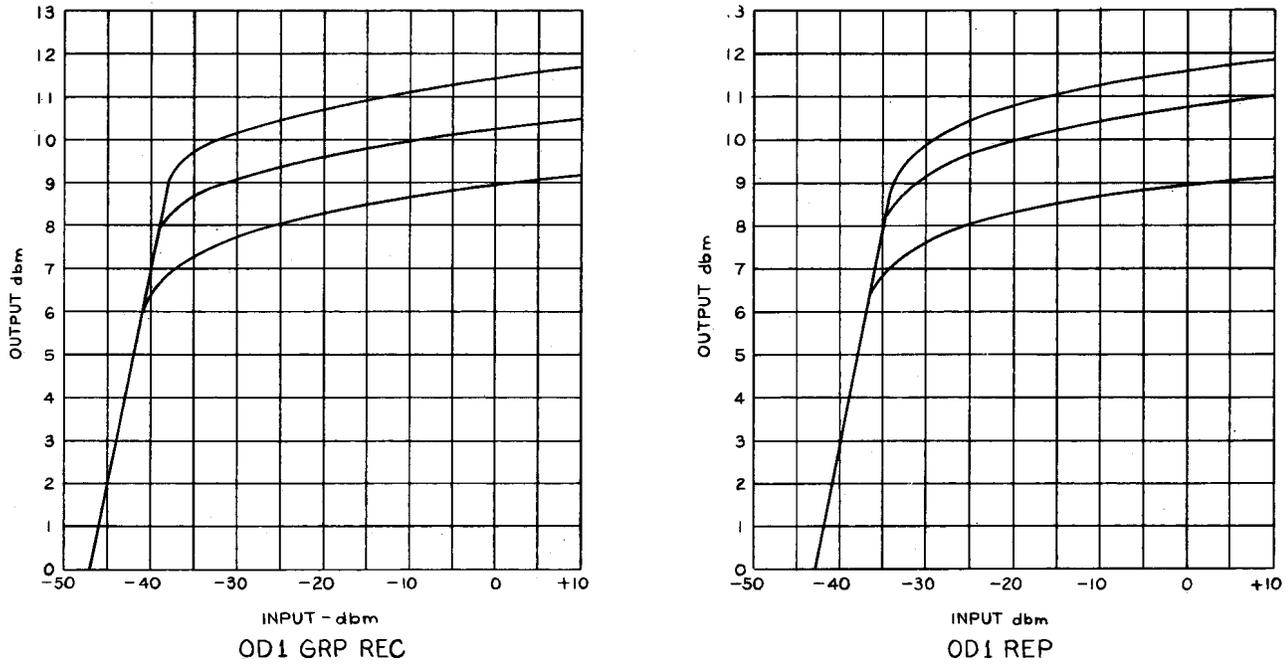


Fig. 110 - OD1 Group Receiving and Repeater Regulation Characteristics

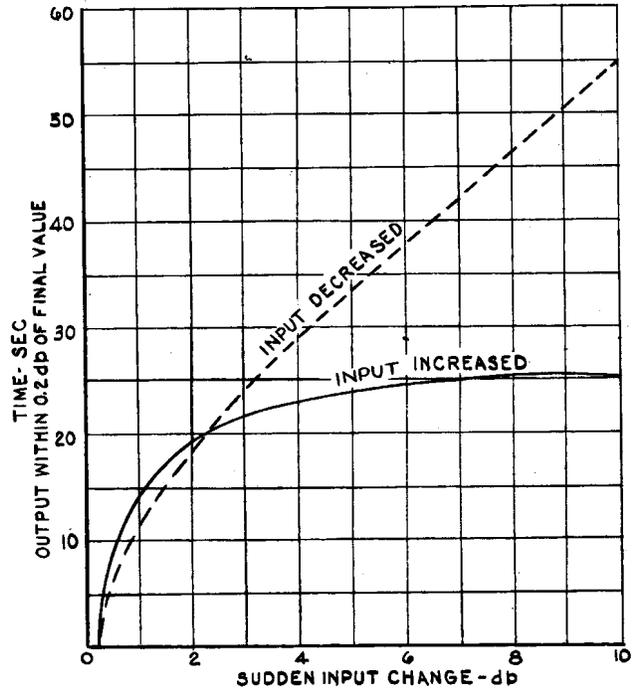


Fig. 111 - OBI, OC1, OD1 Repeater and Group Receiving Circuit - Regulator Stabilization Time

4.11 The over-all net loss variations obtained for large changes in line loss are shown in Fig. 113 for all of the type O systems. These curves represent typical channels of non-repeated systems. All of the curves show change in channel output with total line loss except for the OA system transmitting from an LGT terminal to an HGT terminal. For this case the curve shows change in channel net loss with change in attenuation from the original line-up point.

D. Transmission Performance

4.12 A typical average channel transmission characteristic for the type O systems is shown in Fig. 114. This curve is based on non-repeated systems with flat line loss having channel band filters manufactured after October, 1953, and having 60-ohm terminations on the filters. Earlier filters used with 75-ohm terminations would give greater variations. Due to the fact that the expander doubles any variation in its input, any transmission variations between the compressor and expander appear twice as large at the channel output when measurements are made with single frequencies. Therefore, the effective change in transmission over the band with speech input to the channel is approximately one-half of the change measured with a single frequency (as in Fig. 114).

4.13 A typical over-all channel load characteristic is given in Fig. 115. The data give performance from compressor input to expander output and illustrate the departures from linearity caused by the compander action.

4.14 The noise in a channel due to terminal equipment alone is less than 10 dba at zero level. The repeater equipment noise contribution will depend upon the gain used and will be in the order of 12 dba at zero level for maximum gain.

4.15 The maximum interference arising in the terminal equipment as a result of intersystem far-end crosstalk will be about 25 dba at zero level for a 0 VU talker. The average is about 12 dba. Far-end crosstalk between type O systems on the same pair is negligible. For a receiving gain of 40 db the intersystem near-end crosstalk due to modulation within the terminal equipment for the OBl, OC1, and OD1 terminals is a maximum of about 27 dba at 0 level for a 0 VU talker with some combinations of the OBl, OC1, and OD1 terminals multiplied to the pair. With only one system on a pair, the corresponding near-end crosstalk will be a maximum of about 15 dba. Intersystem near-end crosstalk for an OAl LGT terminal due to the terminal modulation is about 19 dba at zero level for a 0 VU talker with a receiving gain of 40 db. For an OAl HGT terminal and a receiving gain of 30 db the corresponding crosstalk is about 3 db higher.

For a receiving gain of 40 db the intersystem near-end crosstalk due to equipment modulation between OBl, OC1, and OD1 terminals on the same pair may give a maximum of about 27 dba at 0 level for a 0 VU talker with some terminal combinations. The crosstalk between an OAl terminal and an OBl, OC1, or OD1 terminal is negligible. The performance of repeaters with respect to near-end crosstalk is essentially the same as that of the terminals. It should be noted that only 0.3 per cent of talkers reach zero VU level.

4.16 The signaling circuit functions through controlled interruptions of a 3700-cycle tone in each channel. For supervisory or ringdown signals the on and off periods of the tone are relatively long while in the case of dialing the information is transmitted in the form of short spurts. The signals are transmitted over the system with a minimum of distortion in order to assure reliable performance.

Stability

4.17 Since the carrier is transmitted in the type O systems, there can be no shift in frequency from voice at one end to voice at the other end. Frequency stability in the carrier portion of the system is important because the carriers must fall in the bands of the pick-off filters of the twin-channel carrier circuits at the receiving terminal. For ambient (surrounding) temperatures of 40 to 110 degrees F the oscillators and filters are expected to be within the following limits of their nominal frequencies.

Unit	System			
	OA Cycles	OB Cycles	OC Cycles	OD Cycles
Twin Chan. Osc.	±6	±6	±6	±6
Group Osc.	±6	±7	±9	±10
Repeater Osc.	-	±4	±6	±8
Pick-off Filter	±40 cycles, minimum bandwidth ±100 cycles when used with ON systems)			

Pole-mounted repeaters are subjected to lower temperatures. The oscillators have a positive temperature coefficient of about 1/4 (for OBl) to 1/2 (for OD1) cycle per degree F below the range quoted above. Because of frequency frogging, if two successive repeaters are subjected to the same temperature, the frequency deviations cancel out.

4.18 Variations in amplitude of the transmitted carrier, supplied by the twin-channel carrier circuit, are reflected directly as variations in sideband trans-

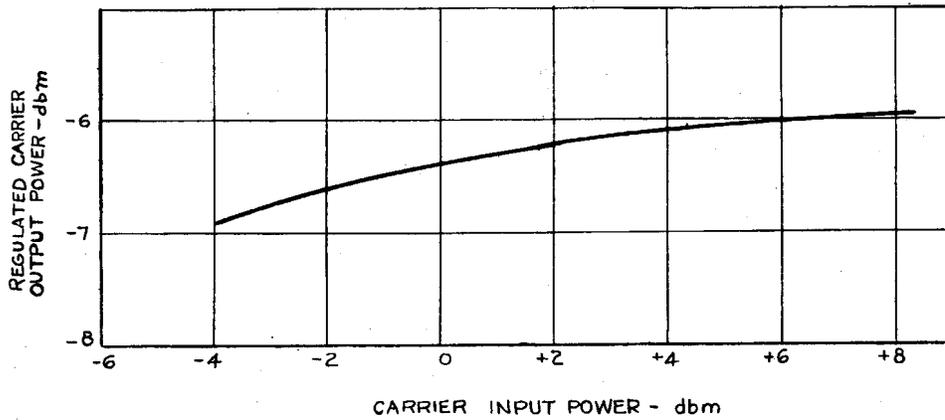


Fig. 112 - Twin-Channel Circuit - Regulating Characteristic

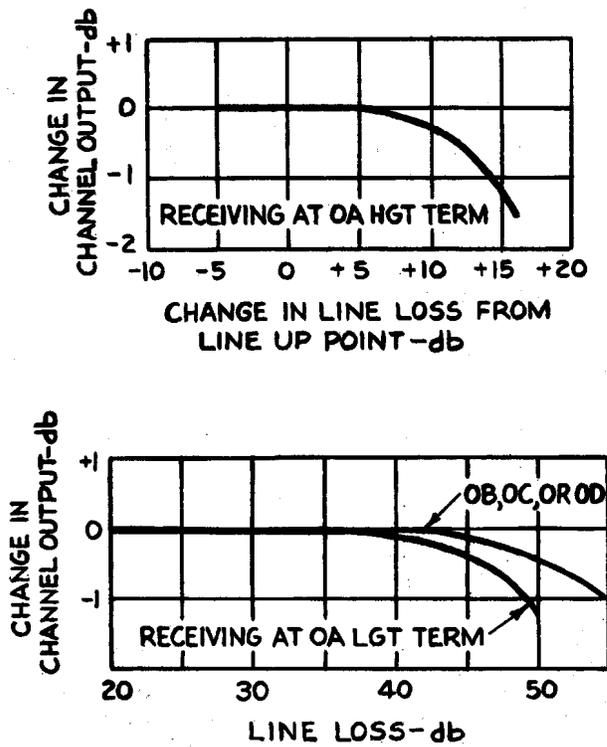


Fig. 113 - Typical Channel Regulation Characteristics - (Nonrepeated System)

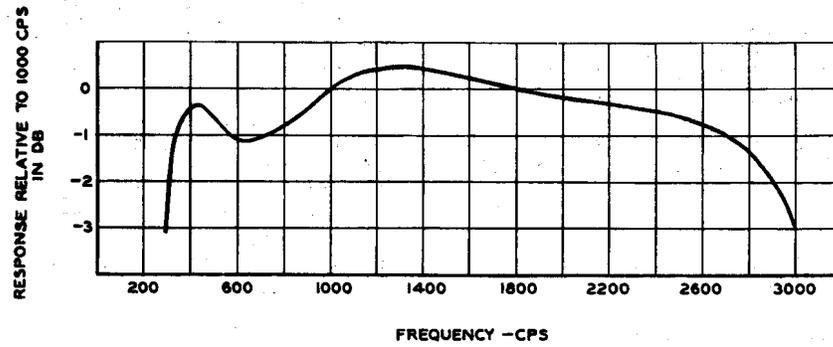


Fig. 114 - Typical Average Over-all Channel Frequency Characteristic

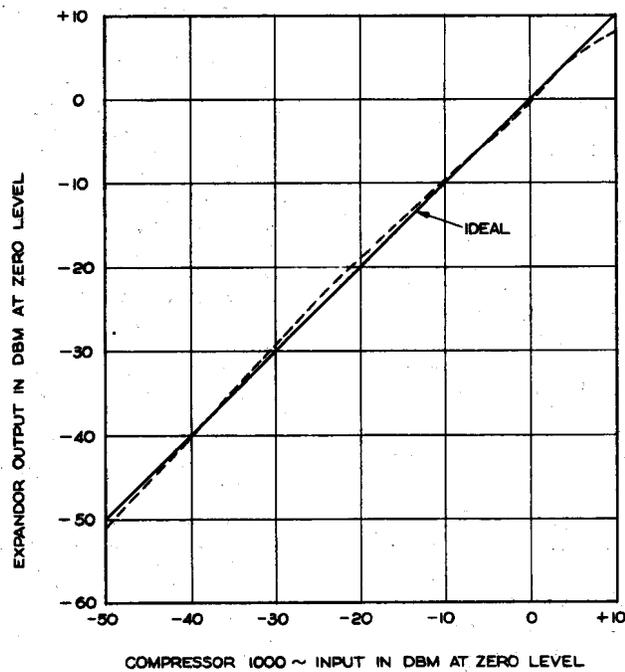


Fig. 115 - Typical Over-all Channel Load Characteristic

mission equivalent which are doubled by the expander in their effect on the over-all circuit equivalent. With new tubes the variation in amplitude of the carrier is about $\pm 1/4$ db. An oscillator tube at end of life may add another $\pm 1/4$ db.

4.19 Variation in over-all channel equivalent caused by normal battery variations and ordinary office temperature variations are not expected to exceed +1 or -2 db. The additional variation caused by weather conditions on the line depends on the line length and is discussed in part 4C.

E. Line Filters

4.20 Four classes of line filters have been designed to separate:

- (a) OB and higher frequencies from lower frequency systems, with a cut-apart region of 30 to 40 or 36 to 40 kc;
- (b) OC and OD systems from OB and lower frequency systems, with a cut-apart in the region of 76 to 80 kc;
- (c) OD systems from OC and lower frequency systems, with a cut-apart in the region of 116 to 120 kc; and
- (d) Frequencies below about 1.8 kc from an OA system.

4.21 Line filters designed to separate OB and higher frequency systems from lower frequency facilities operated on the same pair may be either office-mounted or pole-mounted. Those designed for office mounting are the 537A, 537C, and 219S. Pole-mounted versions of these filters are the 538A, 538C, and 538D filters, respectively. The 537A and C and 538A and C filters (see Fig. 116) were designed with a cut-apart region from approximately 30 to 40 kc and were to be used to separate type C systems from OB, OC, and OD systems. The 537A and 538A filters differ from the 537C and 538C filters only in the transformer located in the high-pass branch of the filter. The transformer in the 537A and 538A filters was found to introduce undesirable modulation under certain conditions. It was replaced with an improved transformer and the new filters coded 537C and 538C. The 219S filter and the pole-mounted version, the 538D filter, are suitable for separating the OA system or other types of carrier not in excess of 36 kc from the OB, OC, and OD systems (see Fig. 117). These filters use ferrite coils to provide a cut-apart region between 36 and 40 kc. Since these filters are satisfactory for separating types C and H, as well as OA, carrier systems from the OB, OC, and OD systems, manufacture of the 537A and C and 538A and C filters has been discontinued.

4.22 The loss of the 537A or C or 538A or C line filters is less than 0.13 db up to 3.5 kc, and that of the 219S or 538D filter is less than 0.1 db. The line side and the drop side of the low-pass branch of the filters have been designed to present 600-ohm impedances. The drop side of the high-pass branch of the filters presents an impedance of 135 ohms. Although any of the above line filters may be in a voice circuit in some applications, it is not necessary to make provision in the network circuit of 2-wire voice frequency repeaters for balancing it. The presence of a line filter will have a negligible effect upon the repeater balance because the cut-off frequencies of the filters are high compared to the highest frequency involved in the repeater balance.

4.23 The 220F line filter with a cut-apart region from 76 to 80 kc is designed to separate OB and lower frequency systems from OC and higher frequency systems. Similarly the 220G with a cut-apart region from 116 to 120 kc is designed to separate OC and lower frequency systems from OD. Both are 600-ohm filters but the drop side of the high pass may be made to present an impedance of 135 ohms to match a cable or 135-ohm equipment by connecting a 600- to 135-ohm transformer in the circuit. The transformer is located in the filter case and is connected to terminals on the filter terminal block. It is not intended for use at the drop side of the low-pass branch as the dc path would be opened and thus preclude dc testing of the line. Nor would the transformer be generally satisfactory from the standpoint of transmission as the loss is approximately 1 db at 2 kc. Both filters will be made available in a case similar to the one used for 538-type filters for mounting on a crossarm. Schematics of the filters and loss characteristics are shown in Figs. 118 and 119. Balancing arrangements are not required in the network circuits of voice repeaters when these filters are used in voice circuits.

4.24 The 207F line filter was designed to make available the frequency space below the OA carrier line frequencies for purposes such as voice-frequency telegraph or short haul order-wire use. It has a cut-apart region from approximately 1800 to 2300 cycles. Standard circuit arrangements for use on the line side of this filter have been provided for use with dc telegraph and phantom circuits. A schematic and an attenuation characteristic of the 207F filter are shown in Fig. 120.

4.25 Typical reflection coefficients against a resistance of 600 ohms measured at the line side of the 219S or 538D line filter are shown in Figs. 121, 122, 123, and 124 for OA, OB, OC, and OD ter-

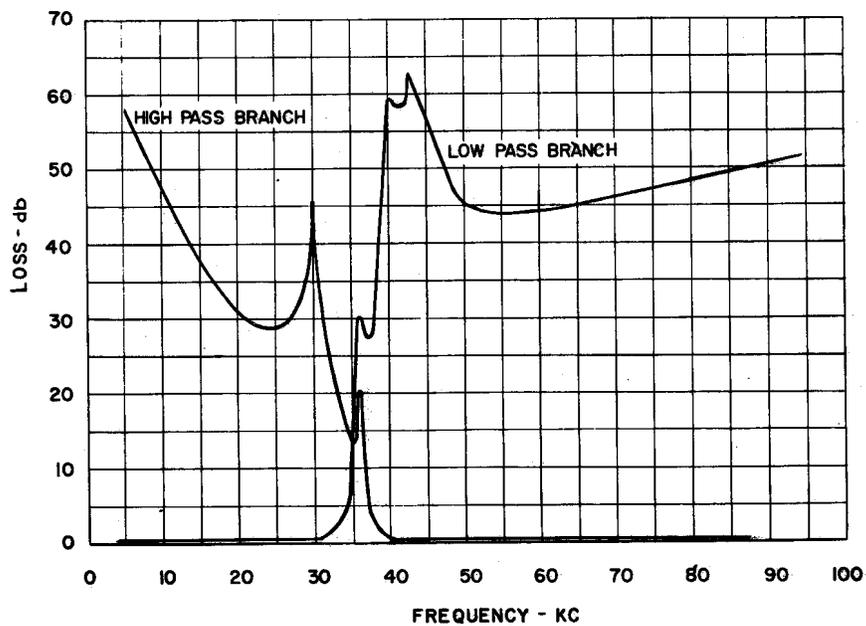
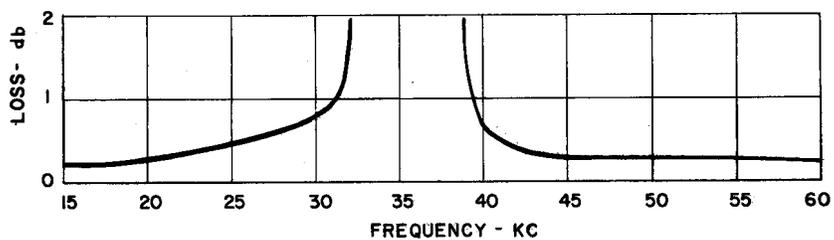
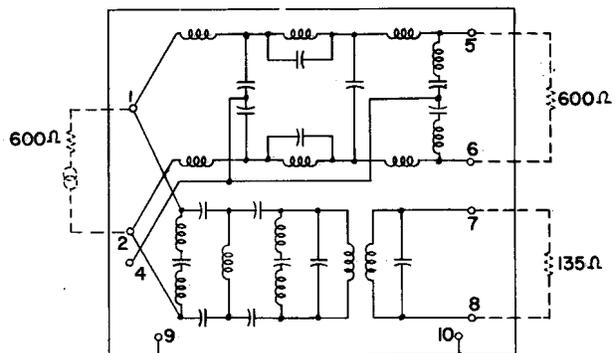


Fig. 116 - Schematic and Loss-Frequency Characteristic of 537A, 537C, 538A, or 538C Line Filter

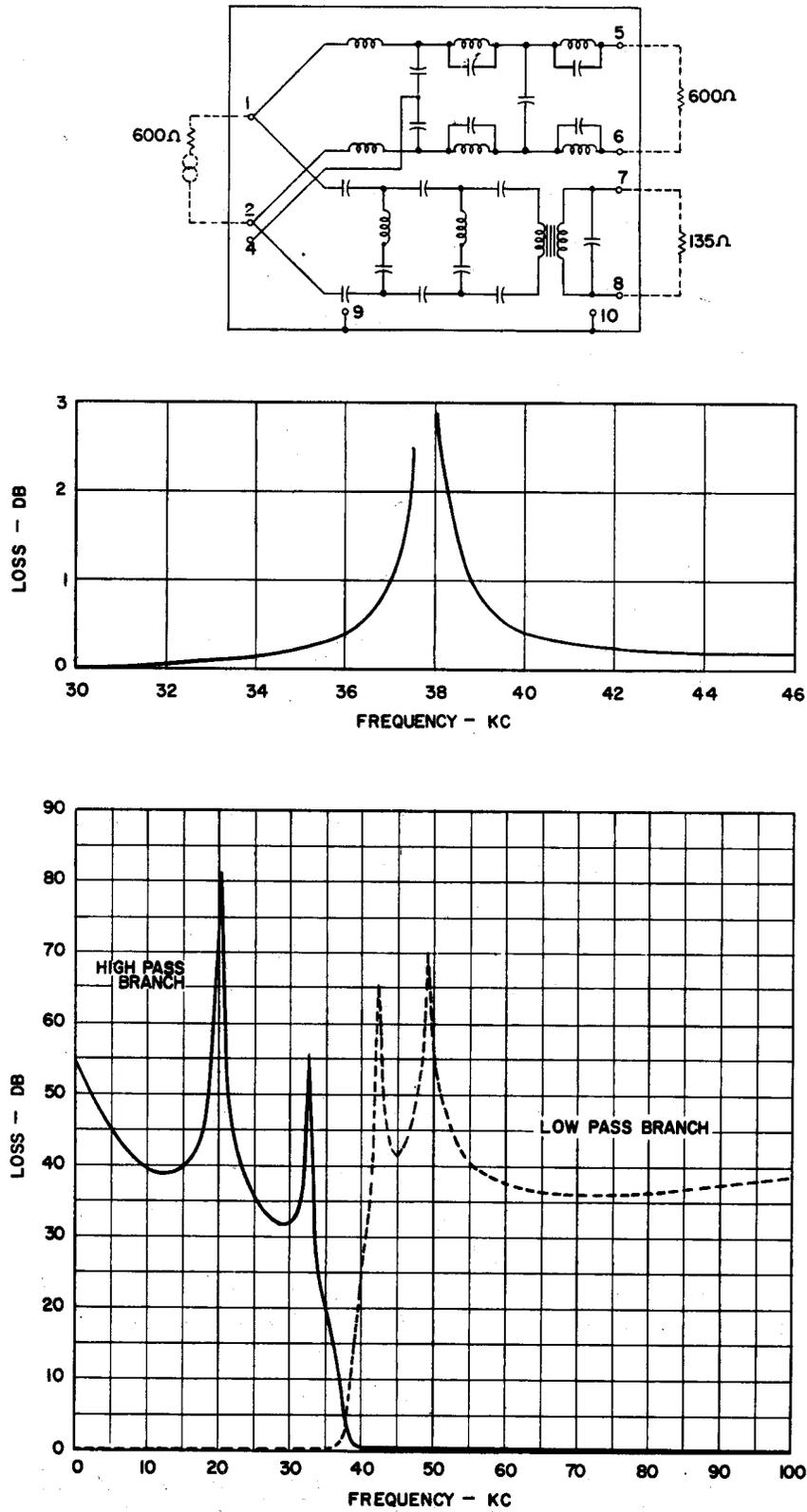


Fig. 117 - Schematic and Loss-Frequency Characteristic of 219S or 538D Line Filter

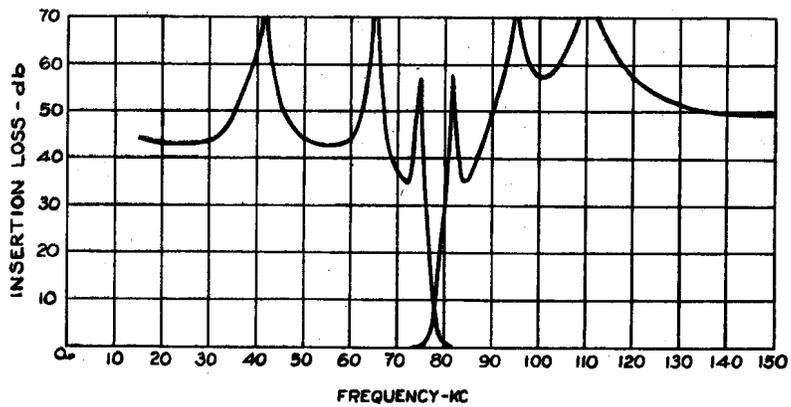
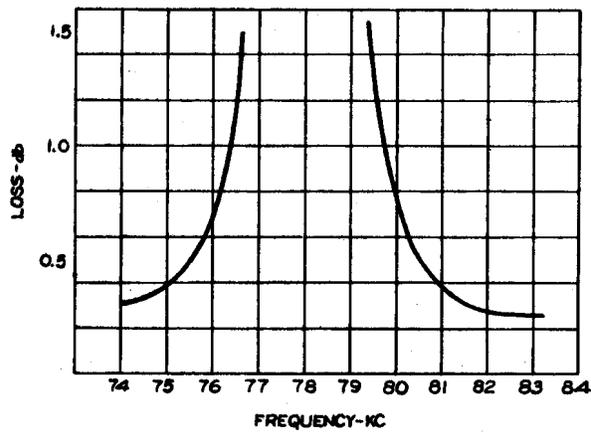
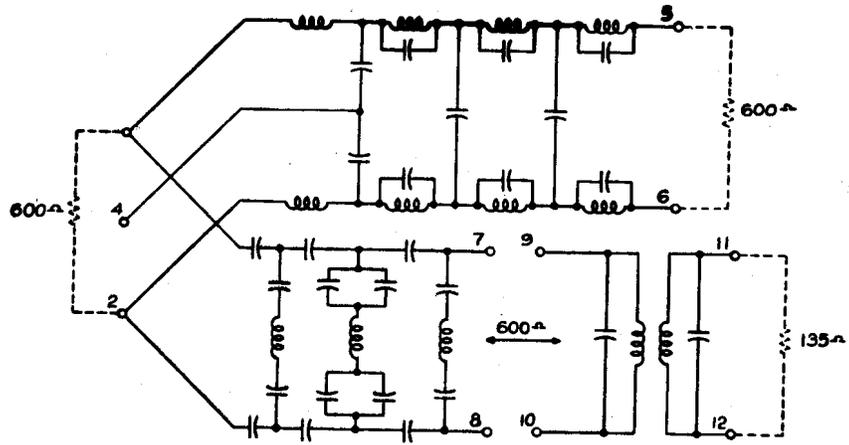


Fig. 118 - Schematic and Loss-Frequency Characteristic of 220F Line Filter

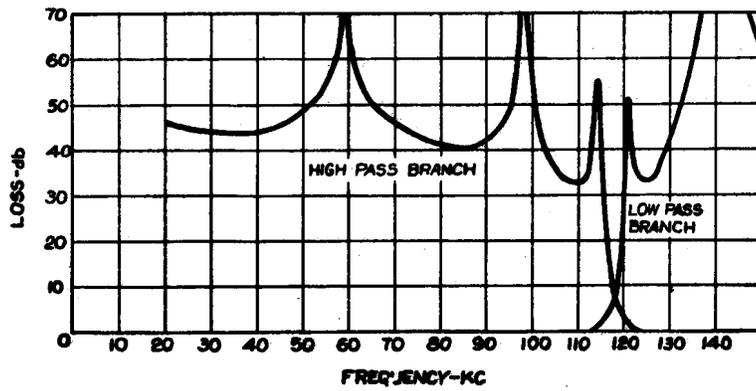
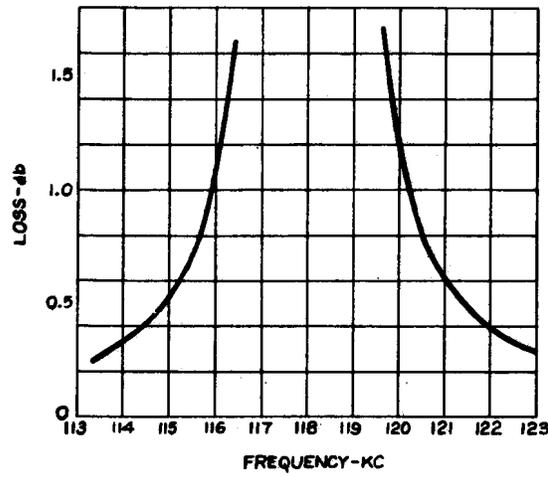
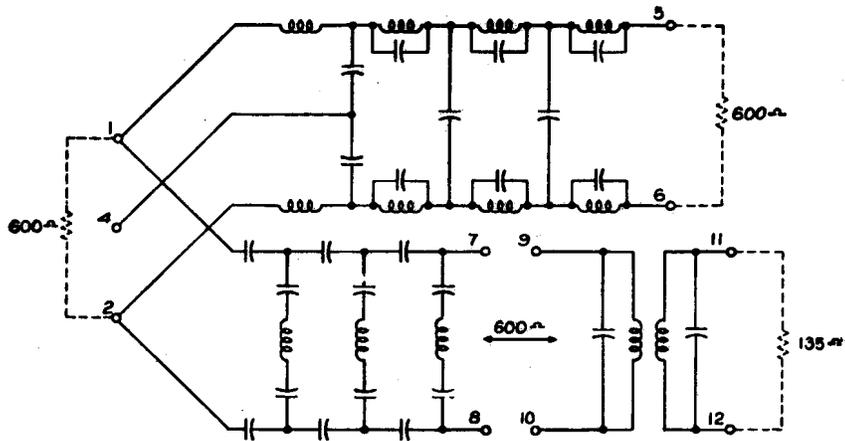


Fig. 119 - Schematic and Loss-Frequency Characteristic of 220G Line Filter

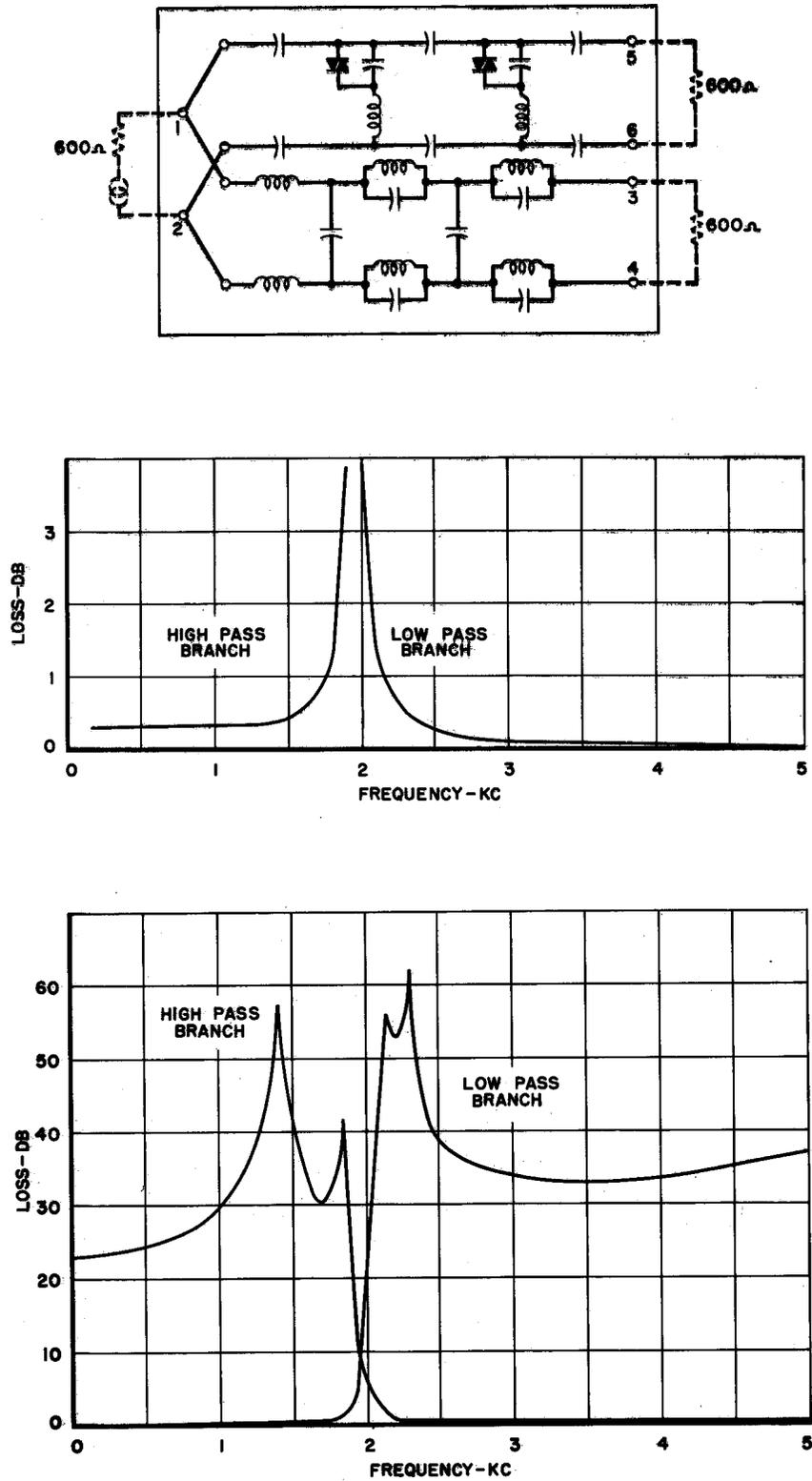


Fig. 120 - Schematic and Loss-Frequency Characteristic of 207F Line Filter

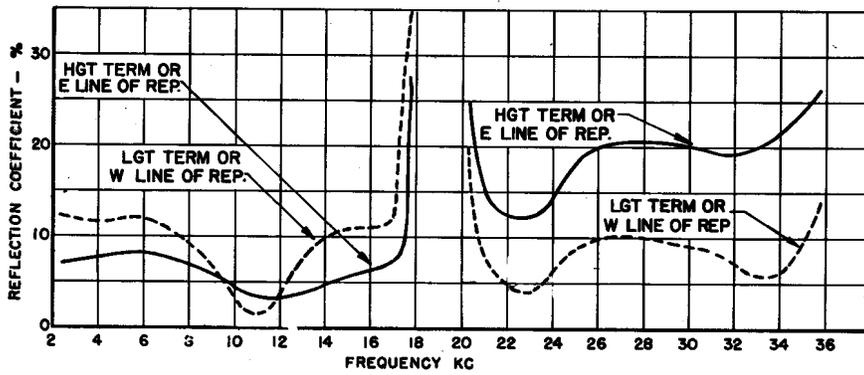


Fig. 121 - OAI Terminal or Repeater Reflection Coefficient

Note: Terminal with Zero Slope Setting

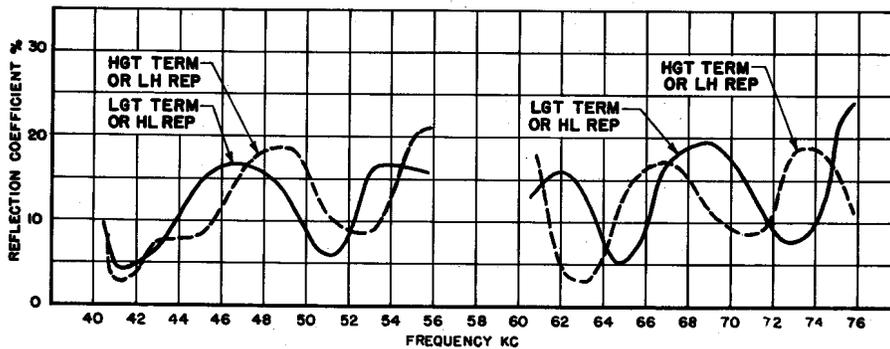
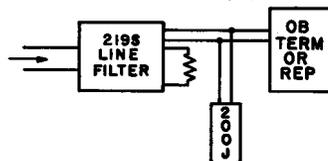


Fig. 122 - OBI Terminal or Repeater Reflection Coefficient

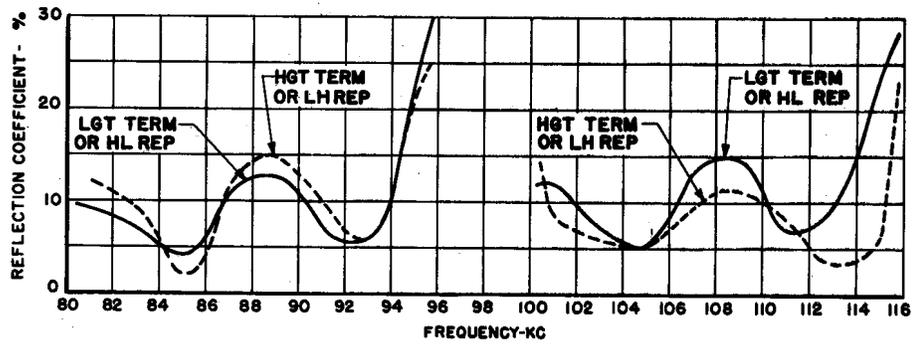
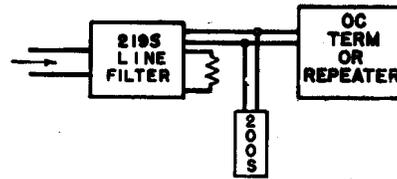


Fig. 123 - OC1 Terminal or Repeater Reflection Coefficient

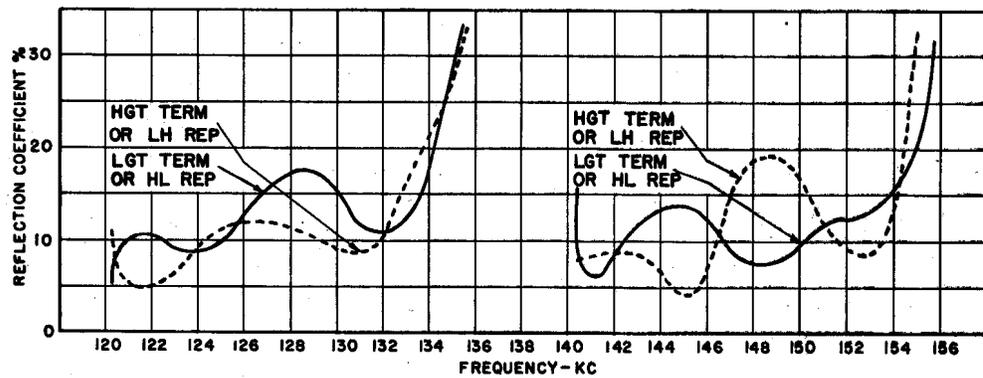
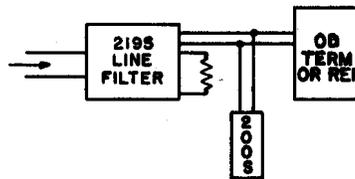


Fig. 124 - OD1 Terminal or Repeater Reflection Coefficient

minals or repeaters. These curves were taken with no entrance cable between the line filter and the terminals or repeaters. Improved characteristics should be obtained with increasing amounts of entrance cable, depending upon the characteristics of the cable. Typical reflection coefficients against a resistance of 600 ohms are shown in Figs. 125 and 126 for the 220F and 220G filters. Phase and delay characteristics for the various line filters are shown in Figs. 127, 128, 129, 130, and 131. The equivalent capacitance of the line filters to dc telegraph and the dc resistance per line is as follows:

Type	Capacitance	Resistance
537A or 538A	0.0325 mf	11.4 ohms
537C or 538C	0.0325	11.4
219S or 538D	0.024	2.4
207F	0.475	8.1
220F	0.013	1.8
220G	0.0077	1.2

4.26 The 537A, 537C, or 219S line filter is a metal case mounted on a 5-1/4-inch by 19-inch panel. The 537A or 537C filter is located in the type C line equipment bay or in other available space, as specified. The 219S filter is located in the type C line equipment bay when used with type C carrier, or in other available space, as specified. The above filters may be associated with an auto-transformer circuit used to bring the carrier and wire frequencies into the office over a single nonloaded cable pair. This equipment is mounted on the same panel as the line filter. Another panel mounts the equipment necessary to balance the auto-transformer and cable for voice repeaters. The 207F filter is in a metal case mounted on a 3-1/2-inch by 19-inch panel. It is located where space is available.

4.27 The line filters designed for pole-mounting are the 538A, 538C, and 538D filters. They consist of a 537A, 537C, or 219S filter, respectively, with protectors enclosed in a weatherproof sheet metal container. The 538A and C filters have protectors connected to the line side of the filter and to the drop side of the high-pass portion. The 538D filter has, in addition, protectors at the drop side of the low-pass portion. Brackets are provided so that the filter can be bolted to the crossarm. Figs. 132 and 133 are photographs of the 219S and 538D filters.

4.28 If a type C carrier system operates on a line which has several 537A or C or 538A or C line filters in it, consideration must be given to the transmission distortion introduced in the C system by the filters. It may be reduced by using a 42A equalizer

at a type C terminal or repeater point. The equalizer was designed for use with type J carrier line equipment but provides satisfactory equalization for a varying number of 537A or C or 538A or C line filters. Fig. 134 shows the transmission through six line filters without equalizers. The transmission through one 42A equalizer and 6, 8, 10, and 12 line filters is also shown. Additional information on the 42A equalizer may be obtained from Section E44.505. The equalizer is not required when 219S, 538D, 220F or 220G line filters are used because of the higher cut-off frequency of the low-pass branch.

4.29 When one of the side circuits of a phantom group is equipped with line filters it is necessary to preserve the longitudinal balance of the phantom circuit by inserting a similar impedance in the other side circuit. That requirement is fulfilled when the same type of filter is placed in each side circuit. In order to use phantom circuits with these filters it was necessary to design the low-pass branches so that the two line filters on the two side circuits appear as a low-pass filter to the phantom circuit. It is shown in Figs. 116, 117, 118, and 119 that the midpoint of the low-pass branches have been brought out to terminal 4. To form a phantom circuit these terminals on the two line filters of the two side circuits are connected together and become the midpoint of the equivalent phantom low-pass filter. Then the phantom low-pass filter may be visualized by imagining straps between terminals 1 and 2 and between terminals 5 and 6 to form the input and output terminals of one side of the phantom low-pass circuit. The other side is formed similarly by the filter in the other side circuit.

Bypass and Branching Circuits

4.30 In some applications of the type OB, OC, and OD systems it may be desirable to bypass one or two of the systems around repeaters or terminals of one of the other of OB, OC, or OD systems on the same pair. In other cases it may be desirable to branch a system from one pair to another. In order to accomplish such things as these provision has been made to connect directional filters of the OB, OC, or OD systems back-to-back to form bypassing circuits. Although not originally intended to be used in this manner, the directional filters are expected to be satisfactory for most applications. The circuits may be mounted either in an office or in a pole-mounted cabinet. Loss characteristics of the circuits, measured from the drop sides of the line filters, are shown in Figs. 135, 136, and 137. Typical reflection coefficients against a resistance of 600 ohms measured at the line side of a 219S or 538D line filter connected directly to OBl, OC1, and OD1 bypass circuits are shown in Fig. 138. Improved reflection characteristics should be obtained with increasing amounts of entrance cable, depending upon the characteristics of the cable.

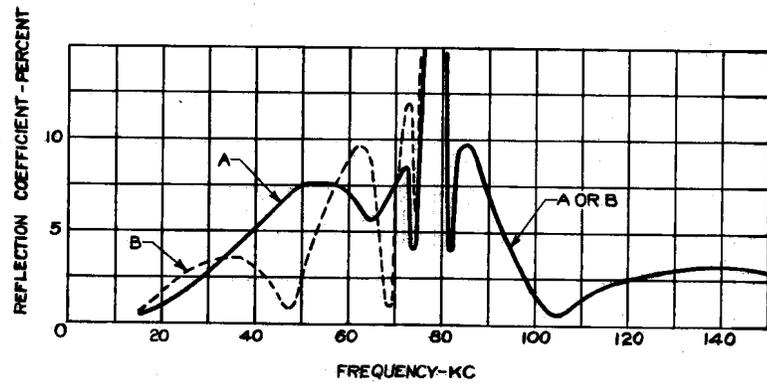
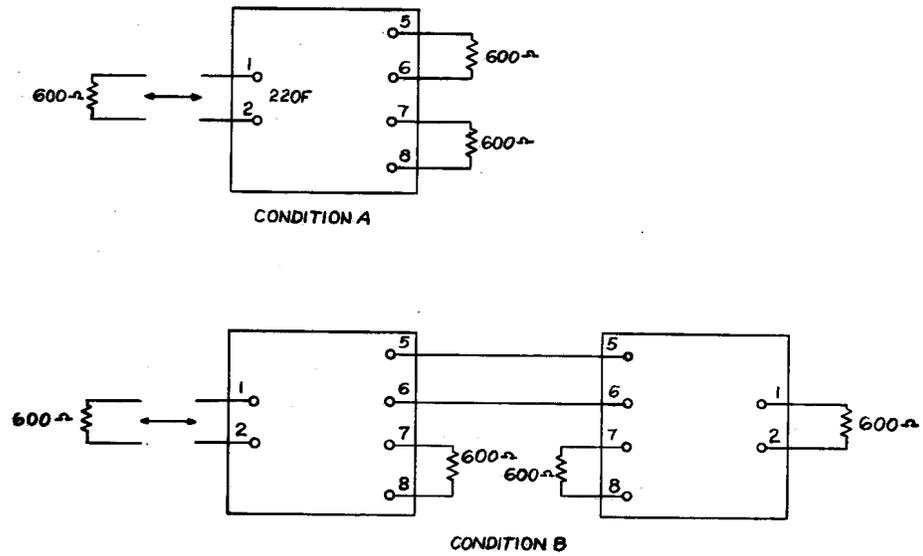


Fig. 125 - Reflection Coefficient of 220F Filter

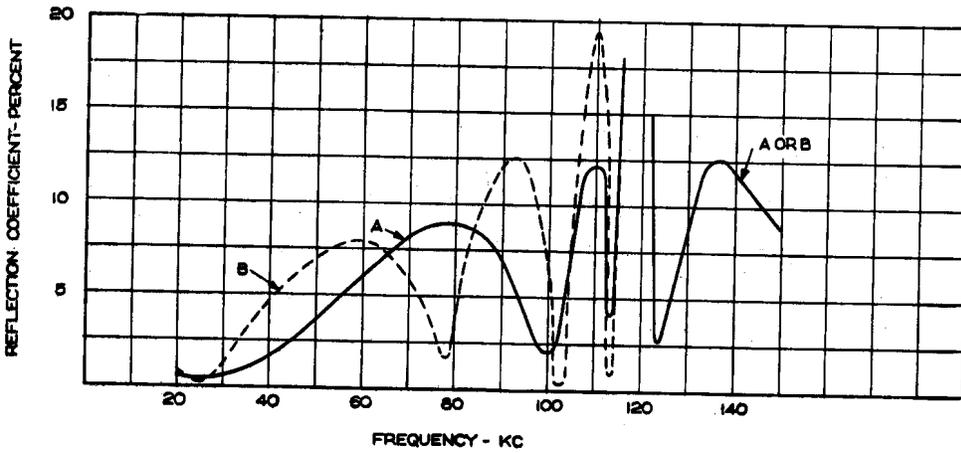
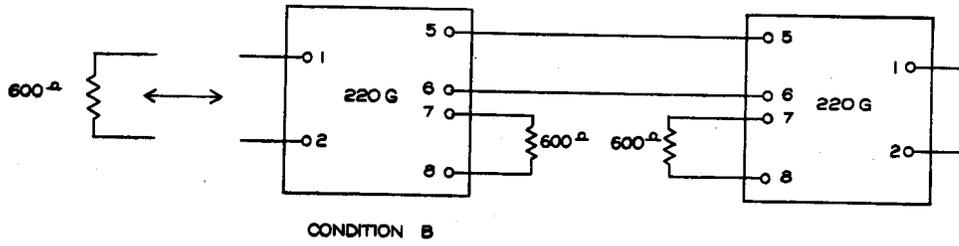
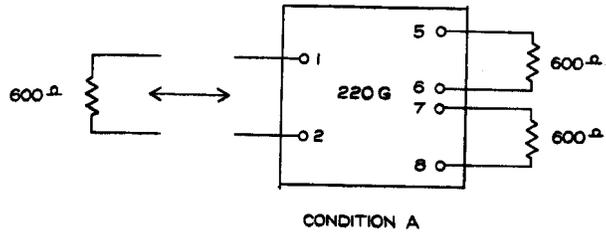


Fig. 126 - Reflection Coefficient of 220G Filter

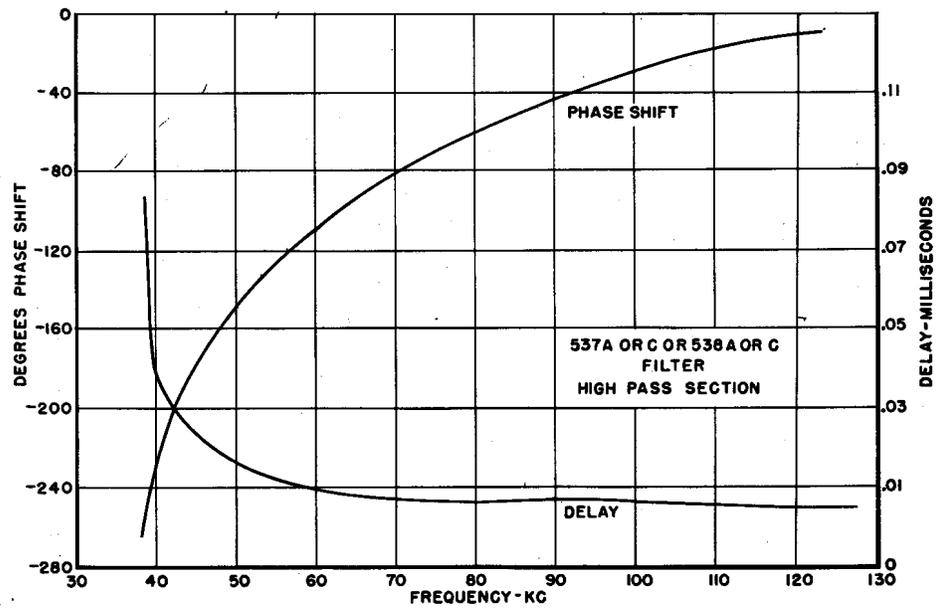
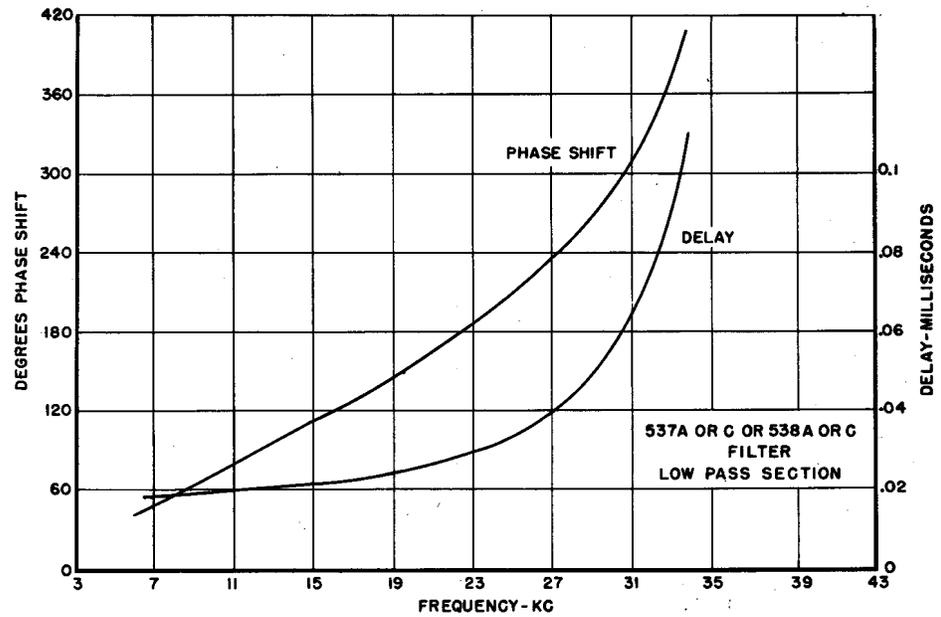


Fig. 127 - Phase Shift and Delay Characteristic of 537A or C or 538A or C Filter

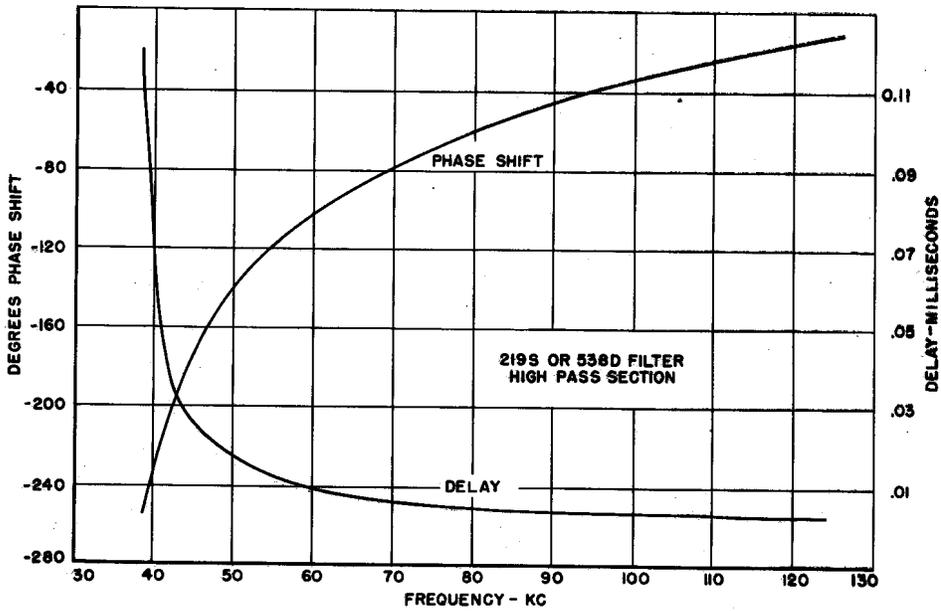
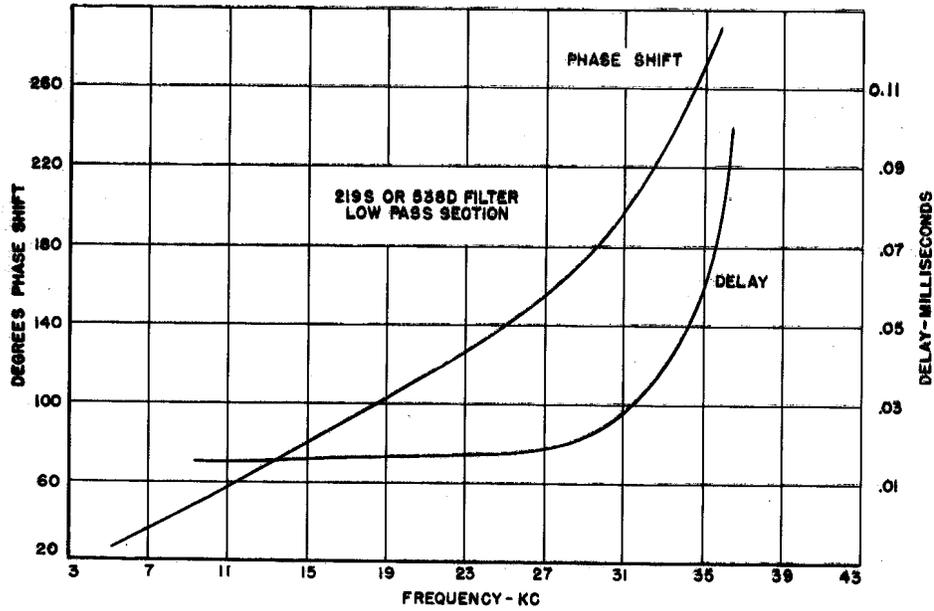


Fig. 128 - Phase Shift and Delay Characteristic of 219S or 538D Filter

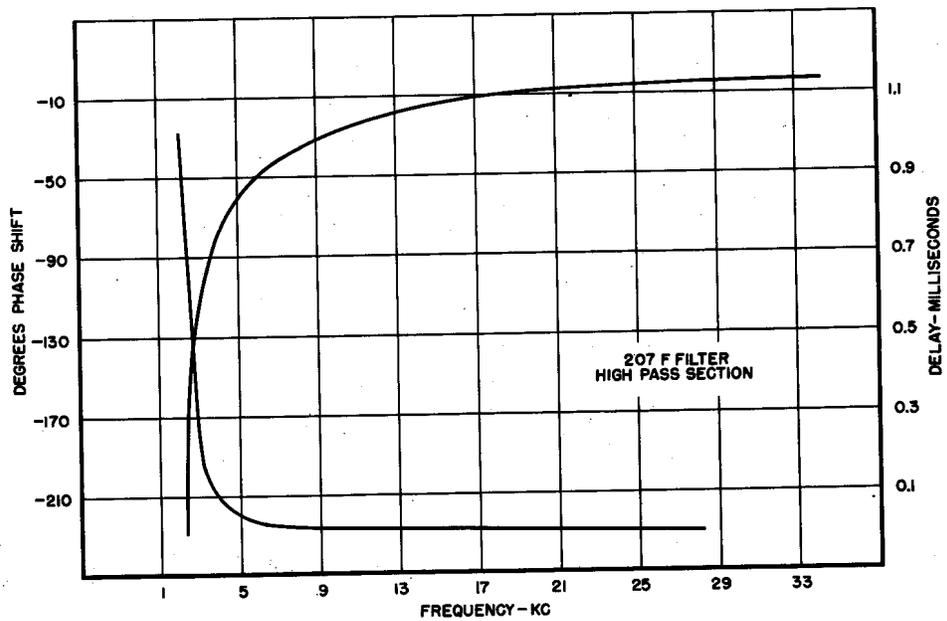
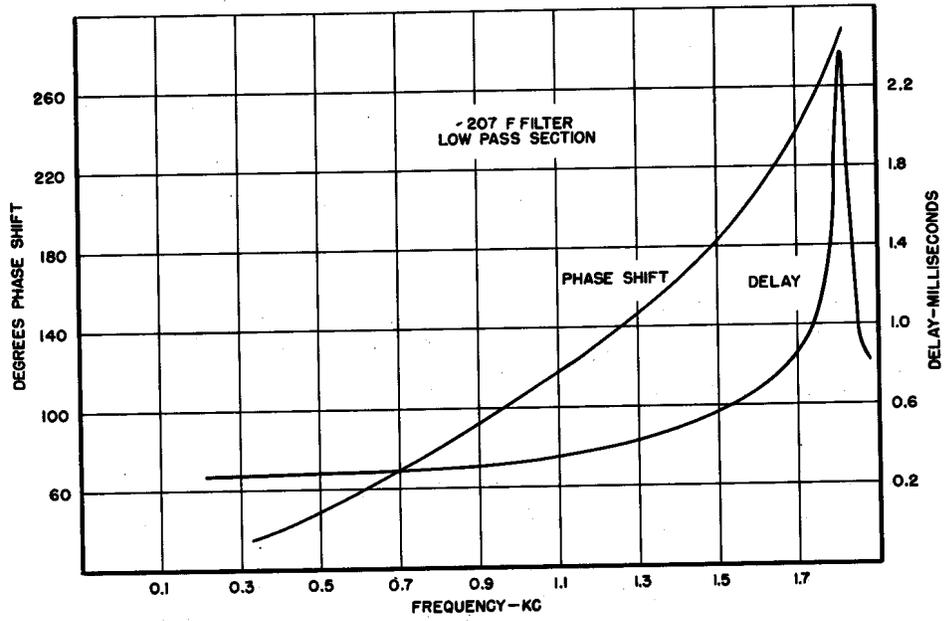


Fig. 129 - Phase Shift and Delay Characteristic of 207F Filter

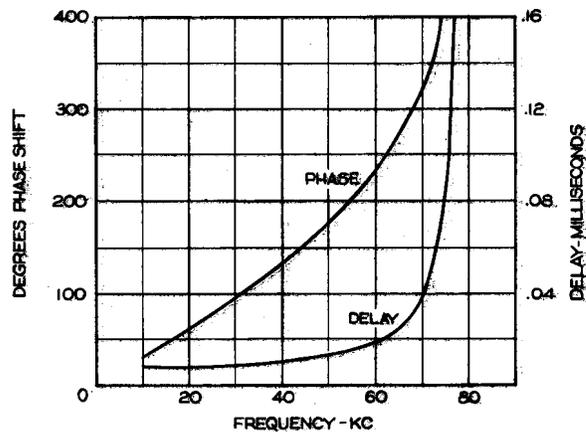
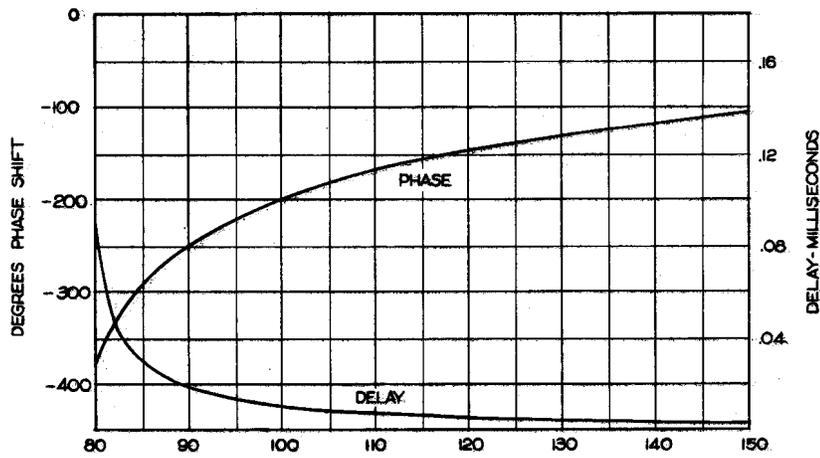


Fig. 130 - Phase Shift and Delay Characteristic of 220F Filter

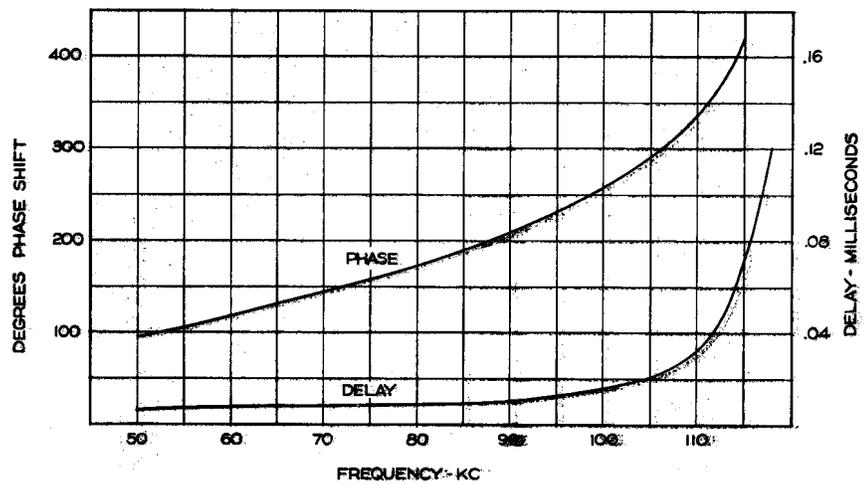
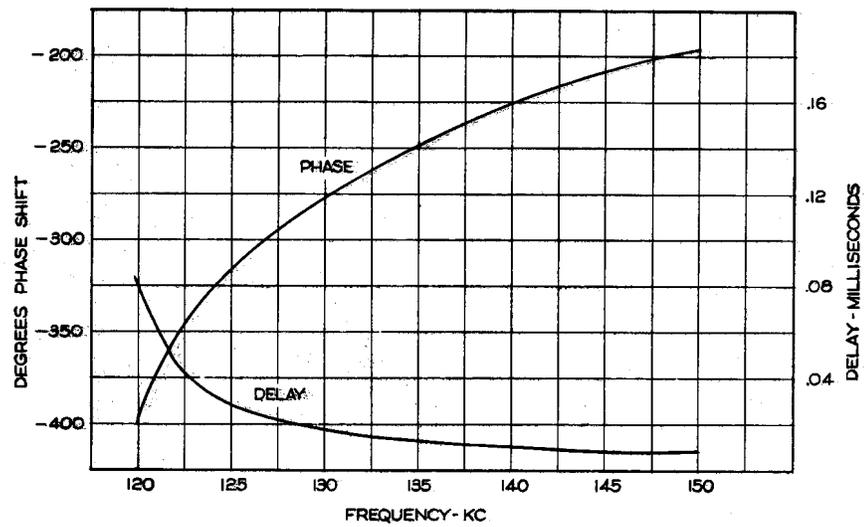


Fig. 131 - Phase Shift and Delay Characteristics of 220G Filter

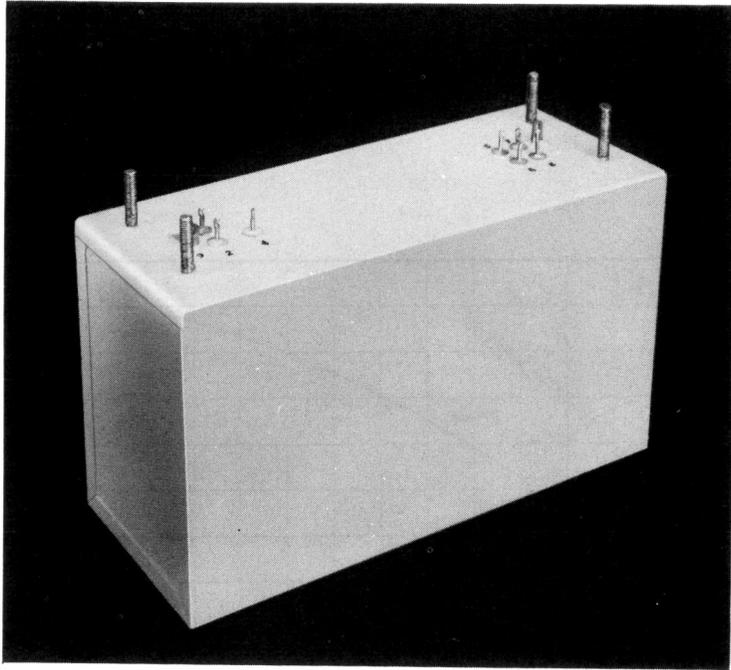


Fig. 132 - 219S Filter

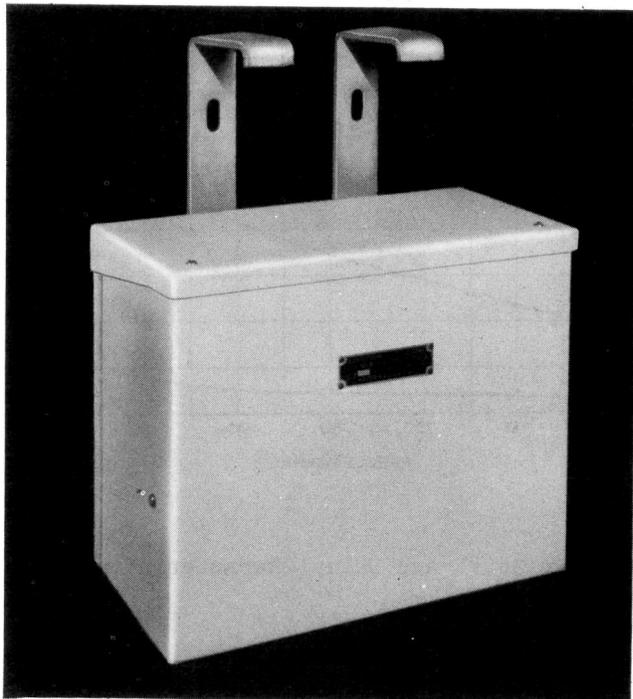


Fig. 133 - 538D Filter

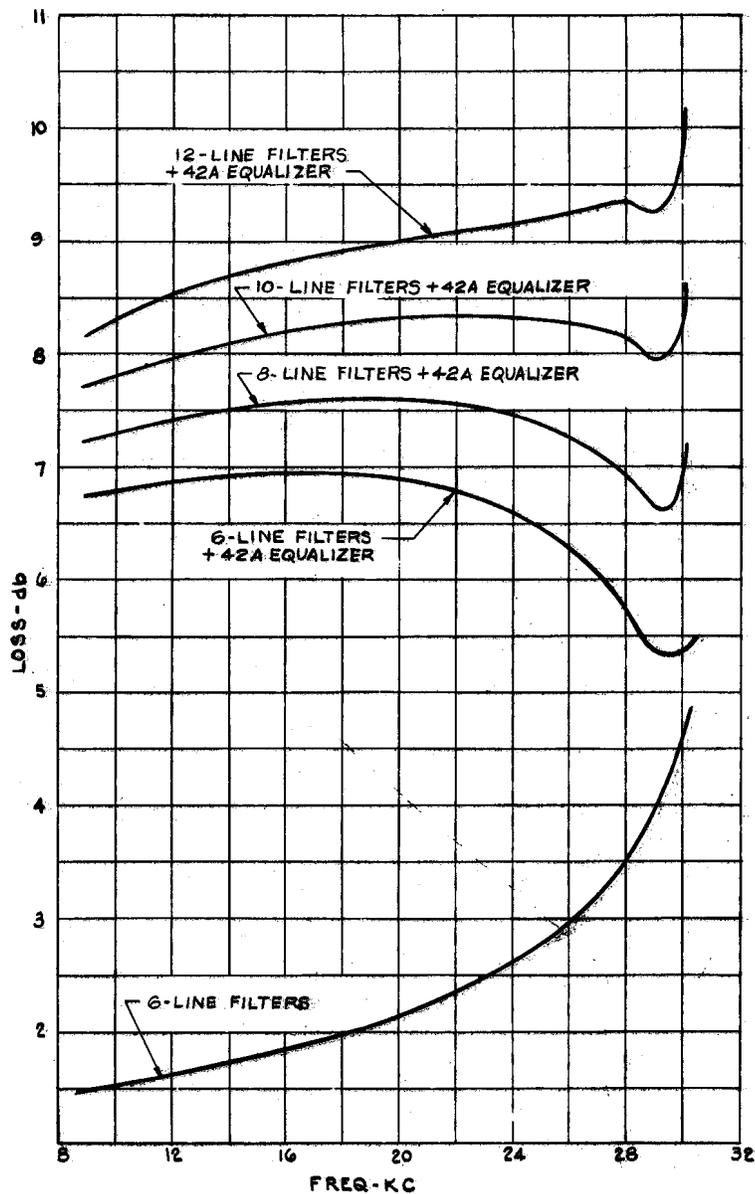


Fig. 134 - Equalization of 537A or C or 538A or C Line Filters with 42A Equalizer

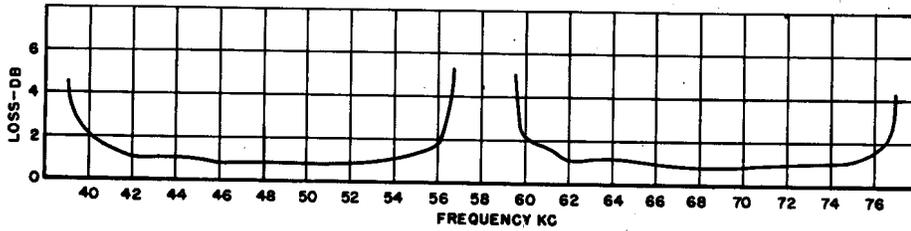
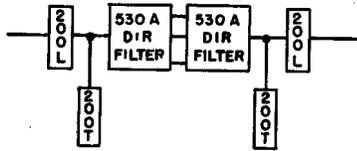


Fig. 135 - OB Bypass and Branching Circuit Loss Characteristic

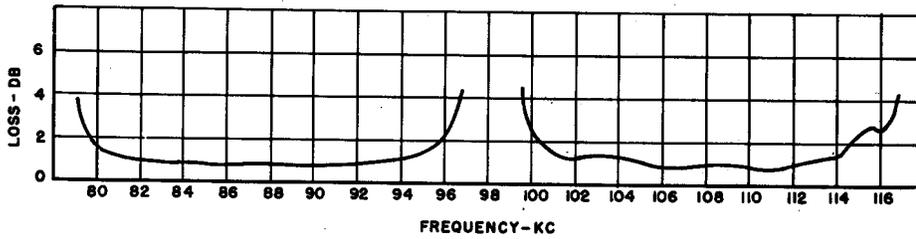
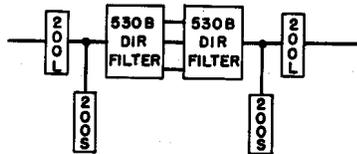


Fig. 136 - OC Bypass and Branching Circuit Loss Characteristic

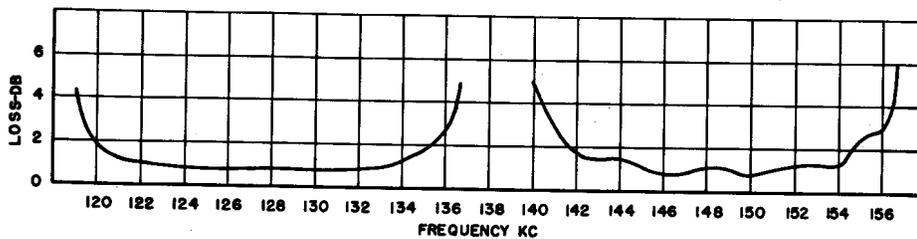
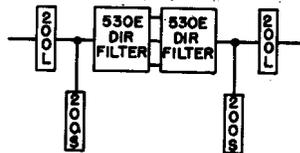
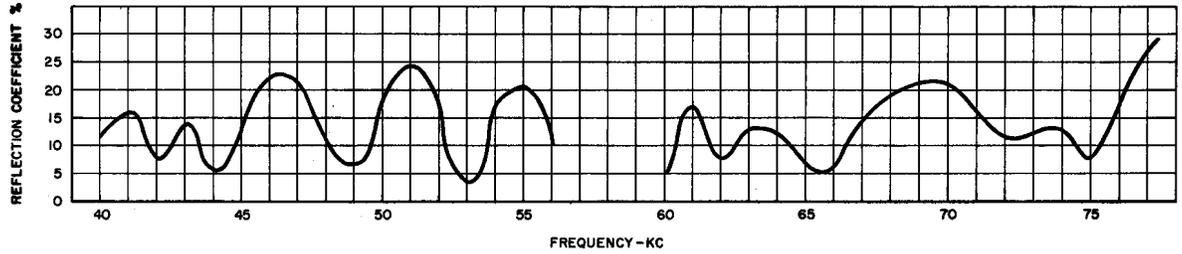
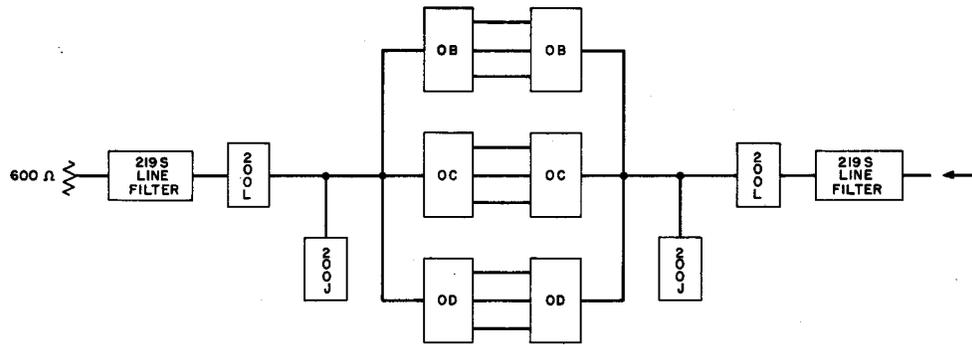
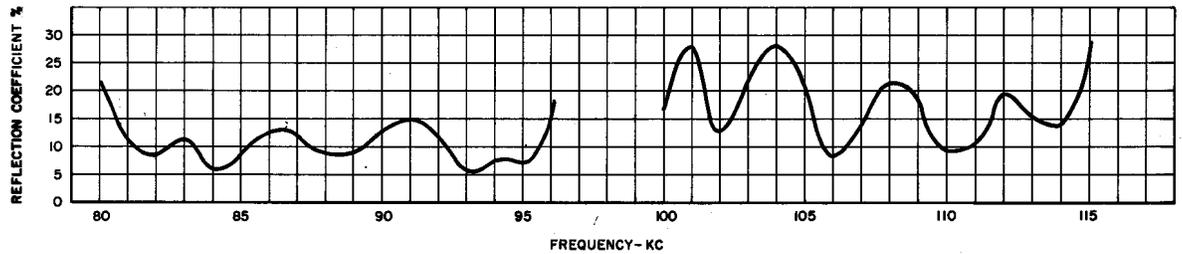


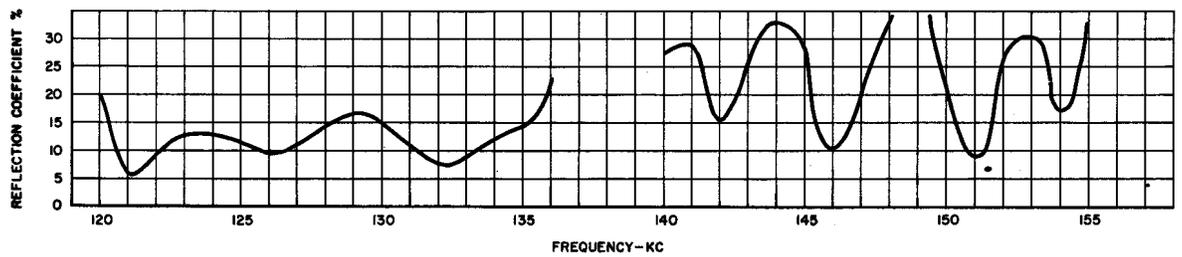
Fig. 137 - OD Bypass and Branching Circuit Loss Characteristic



OB RANGE REFLECTION COEFFICIENT



OC RANGE REFLECTION COEFFICIENT



OD RANGE REFLECTION COEFFICIENT

Fig. 138 - Bypass Arrangement - Reflection Coefficient

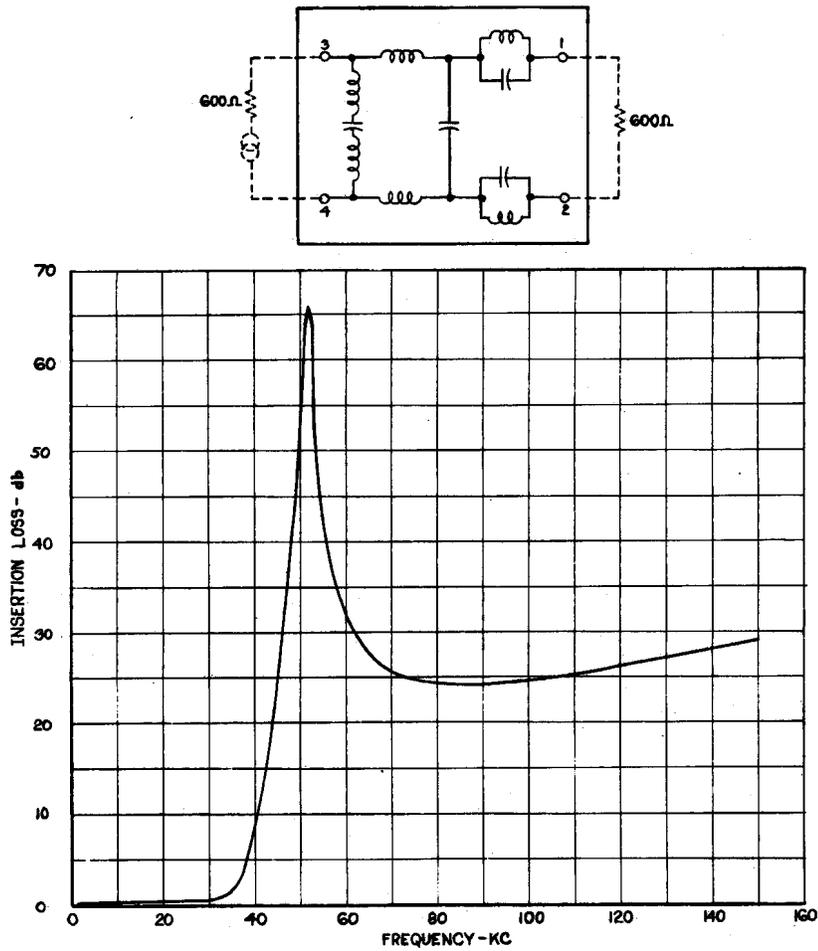


Fig. 139 - Schematic and Loss-Frequency Characteristic of 202C Roof Filter

4.31 In order to bypass higher frequencies around an OA1 repeater or terminal or other facilities below OB frequencies, the high-pass sides of the 36-kc line filters are connected together. Similarly, in order to bypass an OA system or other low-frequency facility around OB, OC, or OD facilities, the low-pass sides of the line filters are connected together. It should be noted that when these connections are made without intervening equipment, it may be impossible to employ full repeater gains. The drop sides of the low-pass branches of two 220F line filters may be connected together to bypass all frequencies below 76 kc around a point where OC or OD branches or connects to repeaters or terminals. Similarly two 220G filters may be used to bypass all frequencies below 116 kc at a point where OD branches or connects to a repeater or terminal. By connecting the drop sides of the high-pass branches together, the frequencies above the cut-apart region may be bypassed around a point where the lower frequency systems branch or connect to terminals or repeaters. Telegraph or order-wire facilities are bypassed around OA facilities by connecting together the low-pass sides of the 207F line filters.

Modification of Type C Carrier Equipment

4.32 When J68756B feedback amplifiers are used on type C systems operating on an open-wire lead with type O, consideration must be given to the possibility of interference from type C into type O. As there is very little feedback above the type C frequency band, the modulation products falling in the type O band are not reduced greatly and may result in excessive interference. This type of interference will be found only at the output of a west terminal or at the output of a west-to-east repeater using J68756B amplifiers. At east terminals and at the output of east-to-west repeaters the modulation products are reduced to satisfactory levels by the type C low-pass output directional filter. Modulation products formed in type C push-pull amplifiers will not result in objectionable interference.

4.33 The unwanted products may introduce objectionable noise in the frequency bands of an OB or OC system provided there is sufficient level difference between the two systems. Interference may get from a type C system to an O system in two different ways. One is by way of the line filter when the C and O systems operate on the same open-wire line. The other involves a C system and an O system on separate pairs, and the interference may be due to near-end crosstalk on the open-wire line. In this case the interference falling above the C band will reach the open-wire line without benefit of any suppression except in the case of type C loaded cable and may cross-talk into the input of an O system operating on another pair.

4.34 The remedial measure consists in suppressing the unwanted products at the source by inserting a low-pass filter known as a "roof filter" at the output of each type C amplifier which is a potential source of interference. This filter has been coded the 202C. A typical transmission characteristic is shown in Fig. 139 along with the filter schematic. The roof filter is in a rectangular metal case approximately 6-7/8 inches by 1-1/2 inches by 5 inches deep, and arranged for stud mounting.

F. Power Supply

4.35 The terminals require dc power at -48 and +130 volts. Repeaters can be operated on +130 volts dc only, or on -48 and +130-volt dc power where 48-volt battery is available. Suitable rectifier power plants, for use either with or without battery reserve, are available for small installations such as a single terminal or one to four repeaters.

4.36 Each terminal and repeater is equipped with alarm-type fuses for heater and plate circuits. One set of discharge leads for -48 and +130-volt and ground supplies is required for odd numbered terminal or repeater bays and a second set for even numbered bays.

4.37 The nominal power requirements for terminals and repeaters are as follows:

	<u>-48V</u>	<u>+130V</u>
Current per terminal (4 channels equipped)	2 amp.	0.5 amp.
Current per repeater (-48 and +130V)	0.3 amp.	0.1 amp.
Current per repeater (+130V only)	-	0.25 amp.

Terminal Power Supply

4.38 Power supply for the entire terminal is obtained through a power plug and receptacle from the +130V and -48V office batteries or power supplies as shown in Fig. 140. Plate battery for the terminal passes through a single fuse to the terminal mounting jack and plug assembly, through the L31 retard coil and thence to channel circuits 1 and 2 and twin-channel circuit 1-2 by one lead, to channel circuits 3 and 4 and twin-channel circuit 3-4 by a second lead, and to the three group circuits by a third lead. Retard coil L31 and capacitors C34 and C35 provide plate battery filtering. If the +130V fuse blows, the resulting loss of carrier and 3700-cycle signaling supply will bring in the office alarms as described later.

4.39 48-volt power is distributed from the plug and receptacle assembly in the

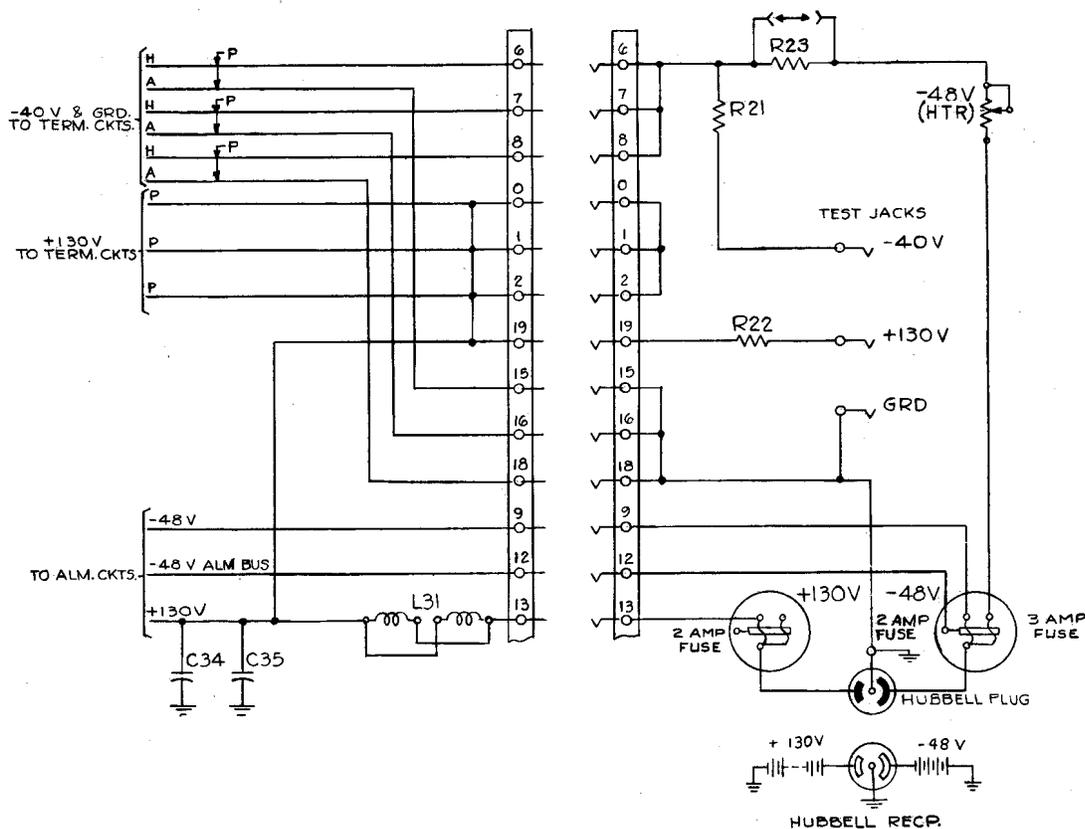


Fig. 140 - Terminal Power Supply

same manner as the plate supply. One fuse furnishes power to the transmission circuits and another furnishes power for the alarm circuit. A 48V fuse alarm is provided. When a -48V fuse blows, the -48V lamp in the terminal lights and the ALM relay operates to turn on the aisle lamp and audible alarm.

4.40 The heater supply circuit in the terminal is adjusted, with all terminal units in position, so that the voltage at the -40V test jack is -38.5 volts when the 48-volt supply is at its nominal value. Where the resistance of the voltage dropping rheostat (R24) is inadequate, the 7-ohm resistor (R23) is added by removing the strap around it.

Repeater Power Supply

4.41 Power is supplied to the repeater through fuses which have an associated alarm relay and lamps. If a +130V power supply only is used, optional wiring is made on the repeater fuse panel as shown in Fig. 141 so that the power for the tube heaters is obtained from the same source as is the

plate power. The inductor and capacitor serve to filter noise from the power source so that it will not be introduced into the repeater amplifiers. The FIL CUR potentiometer is adjusted to obtain a total heater current of 0.147 amperes as determined by measuring the voltage drop across the FIL CUR jacks. The positive jack of the FIL CUR jacks is also used for testing the plate voltage. If +130V and -48V power supplies are available, plate power is obtained as above, but optional wiring is made on the fuse panel as shown in Fig. 142 so that the heater power is supplied by the -48V battery. The 48V FIL potentiometer is adjusted to obtain a voltage across the parallel strings of two heaters, each of 38.5 volts as measured between the -40V jack and ground. It is preferable to use a -48 volt supply for the heaters rather than the +130 volt arrangement, as longer tube life is expected under the former condition.

4.42 If the repeater is pole-mounted, it is wired so that the heaters are supplied by the +130 volt supply. In the pole-mounted cabinet there is provided a +130V rectifier for each two repeaters. The +130

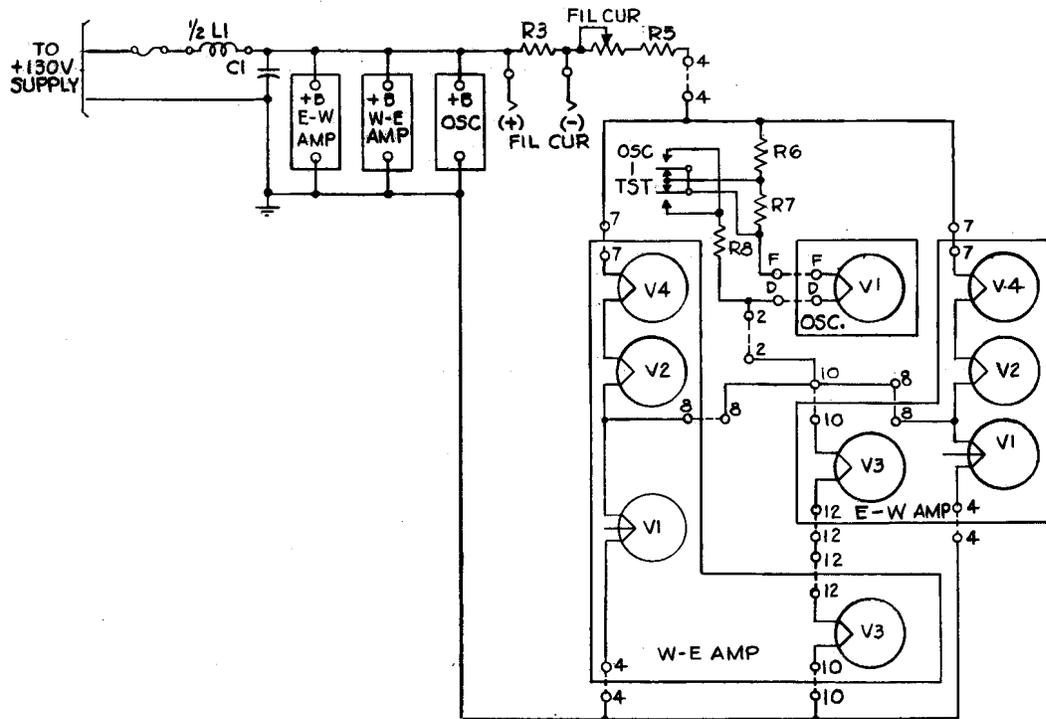


Fig. 141 - Repeater Power Supply Circuit with Heaters Supplied from +130V Source

volt supply is stabilized by a constant voltage transformer between the ac supply and the rectifier. Also included in the power supply is a transfer circuit used with the reserve power supply described below.

4.43 A reserve power supply, for two or four repeaters, contained in one or two additional cabinets, is available for use at pole-mounted repeaters. The equipment contained in the first cabinet consists of a 24V storage battery, a 24V-130V DC dynamotor, a rectifier for charging the battery, and the necessary control and alarm circuits. The second cabinet contains another battery, dynamotor, and rectifier.

G. Testing

4.44 Testing and maintenance of the system components is partly on an "in-service" and partly on an "out-of-service" basis. In general, more facilities are provided for in-service tests in units common to several channels than in the individual channel units. The in-service tests are made on a bridging basis by the use of pin jacks. Patching jacks are not provided as a part

of the O carrier equipment except for the carrier line and equipment jacks at terminals and office-mounted repeaters.

Terminals

4.45 The single-channel components, the channel units, permit some checks to be made on an in-service basis, but a major portion of the maintenance testing and circuit adjustment must be performed on an out-of-service basis. Test points provide a means whereby a vacuum tube voltmeter may be used to isolate a trouble in the transmission path of a particular channel without removal of units from the terminal mounting. The channel unit may be operated out of the terminal mounting by using the channel unit test stand and associated cord. This test stand contains jacks which permit testing both toward the switchboard and toward the line. Tests and adjustments may be performed on the unit, as its component parts are readily accessible when it is removed from the terminal mounting. In the case of a defect the whole channel unit or a defective subassembly may be replaced.

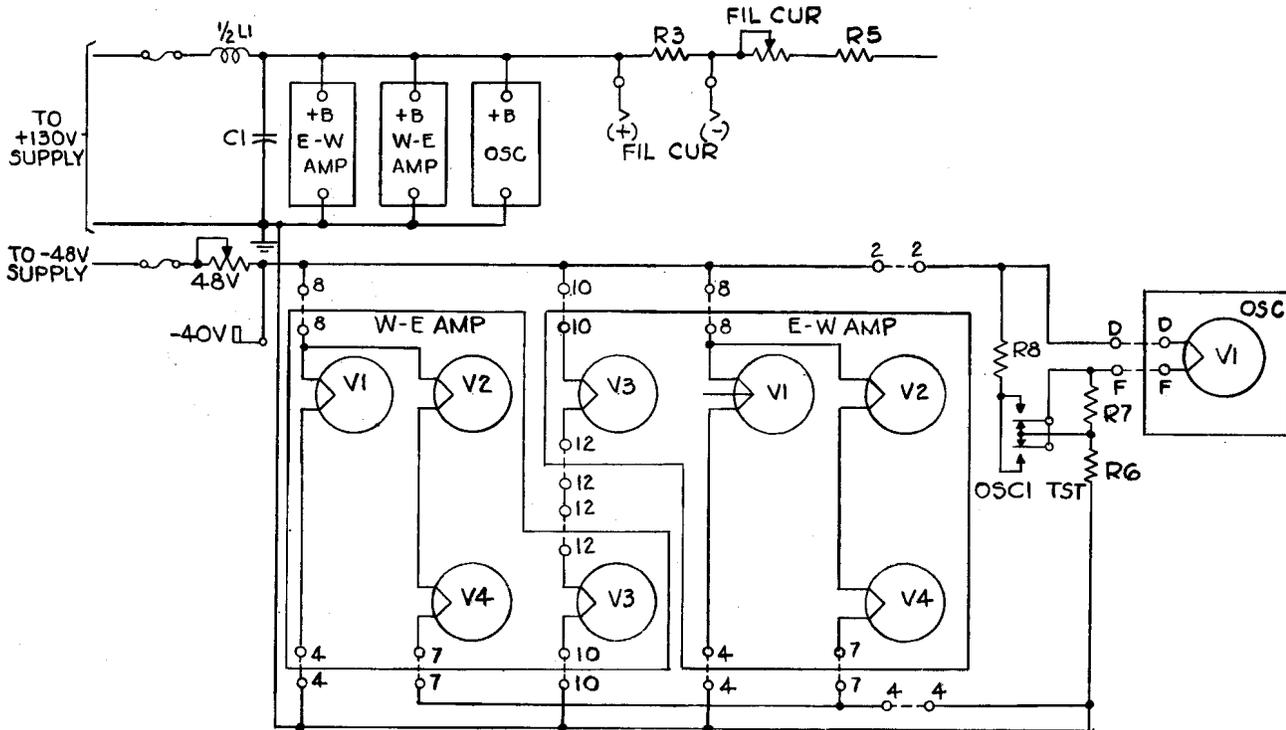


Fig. 142 - Repeater Power Supply Circuit with Heaters Supplied from -48V Source

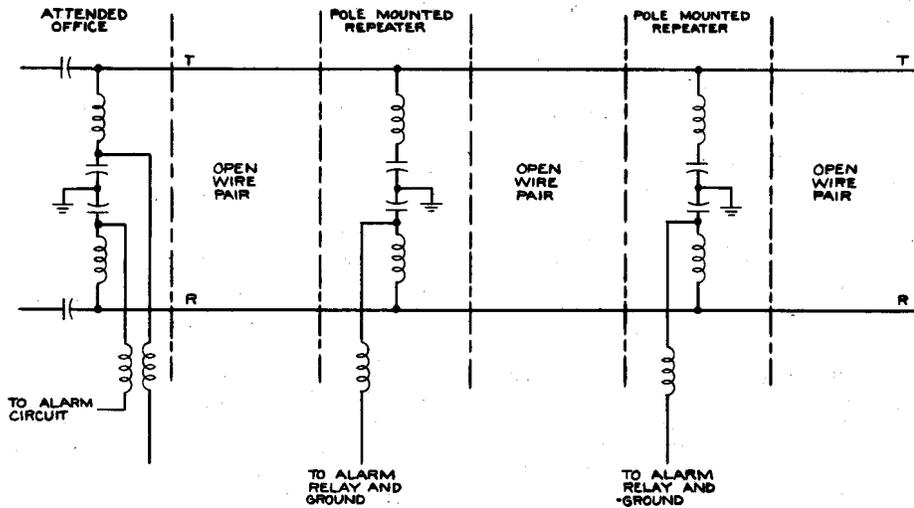


Fig. 143 - Simplified Schematic of Repeater Alarm

- 4.46 The multichannel units which include the twin-channel, group transmitting, group receiving, and group oscillator circuits also have pin jacks for in-service testing on a bridging basis. The twin-channel unit may also be mounted on the channel unit test stand for tests and adjustments out of the mounting, where controls and components are accessible. The group units may be operated out of the mounting by using the cord associated with the test stand.
- 4.47 Some amplifier tubes of the terminal group circuits and of the repeaters are tested on a space-current history basis. After a certain drop of the total space current in the tube, the tube is considered to be at end of its useful life and is replaced. This test is made by measuring the voltage drop across a cathode resistor. Jacks are provided on the front panels for this purpose. Other amplifier tubes are not tested unless suspected of being the source of trouble.
- 4.48 Tubes in the channel and twin-channel circuits are not tested in the circuit. If operating adjustment limits are not met and trouble is suspected in a tube, tube activity is checked in a standard tube test set and the tube replaced if subnormal.
- Repeaters
- 4.49 The testing facilities for the type O1 repeaters are arranged so that certain tests may be made on an in-service basis. The tests include: (1) testing of some electron tubes, (2) measurements and adjustments for each individual repeater of the current in the heater strings or of the voltage across the heater strings, (3) measurements of input and output carrier voltages to check on proper repeater operation, (4) measurement of plate voltage. Out-of-service routine testing is not necessary.
- 4.50 The repeater line amplifier tubes are tested on a space-current history basis. The oscillator tube of OBl, OC1, and OD1 repeaters is tested by measuring the output voltage when the heater voltage is reduced twenty per cent. A nonlocking key is provided on the front of the fuse panel, which reduces the heater voltage, and the output voltage is read on jacks. The regulating amplifier tube and control amplifier tube are tested in a standard tube test set if they are suspected of being a source of trouble.
- 4.51 The measurement of the total heater current when only a +130 volt supply is used is made by measuring the voltage drop across a resistor. This measurement is made with a specially calibrated volt-ohm-milliammeter between jacks on the fuse panel. A potentiometer on the panel is

used to adjust the current to the desired value of 0.147 ampere. When the heaters are supplied from -48V battery, the heater voltage is adjusted to -38.5 volts with a potentiometer mounted on the fuse panel, as measured between a jack on this panel and a ground jack on one of the repeater amplifier units.

- 4.52 The measurement of input and output carrier voltage can be made by connecting a selective detector to jacks provided on the face of the repeater amplifier unit. The voltmeter is then tuned to the carriers that should be present and their levels checked.
- 4.53 The plate voltage is measured by connecting a voltmeter between the (+) jack of the FIL CUR jacks and ground.

H. Order-Wire and Alarm Facilities

- 4.54 Type O systems normally use existing order-wire and alarm facilities provided in the plant for testing and maintenance. An exception is the case of new repeater locations which are established for type O systems.
- 4.55 Where type O1 terminals are located in partially or wholly attended offices, the existing order-wire facilities are employed and connection is made to the office alarm circuits. In nonattended offices, such as CDO locations, communication between offices is carried on over an idle circuit between the offices. Type O alarms are connected into the office alarm checking center as a major or minor alarm as desired, and the normal functions of the alarm checking center are employed. An assigned subscriber line circuit is employed at an unattended office to reset the carrier-off alarm circuit of the O1 terminal.
- 4.56 Fuse alarms of repeaters located in existing toll terminal or repeater offices connect to the normal audible and visual alarms associated with the office. Existing order-wire facilities will be used.
- 4.57 Where new repeater locations are established for type O (pole-mounted cabinets, for example), provision is made for an alarm circuit into an attended point. The general features of this alarm arrangement are shown in Fig. 143. The alarm circuit may be bridged across a noncarrier pair, a carrier pair not having frequencies higher than OA frequencies or the low-pass branch of a 219S or similar filter. At pole-mounted repeaters without reserve power an alarm is provided which will operate in the event of a fuse failure, ac power failure, or 130-volt rectifier failure. At pole-mounted repeaters with reserve power an alarm indicates the transfer from regular to reserve power, ac power

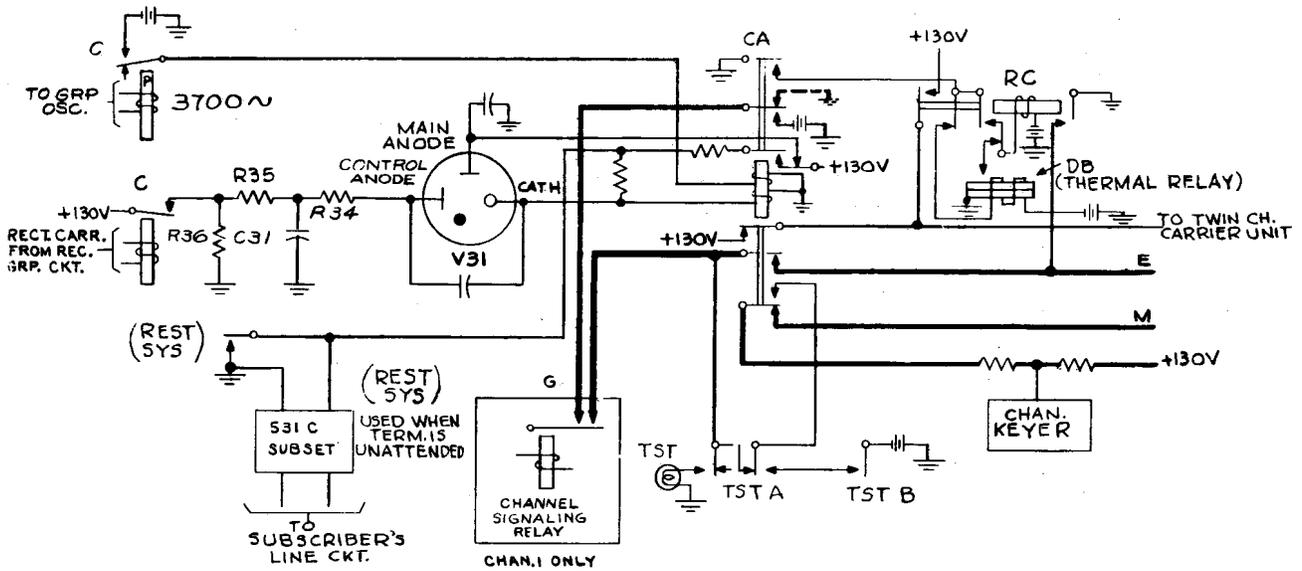


Fig. 144 - Terminal Alarm and Busy Test Circuit

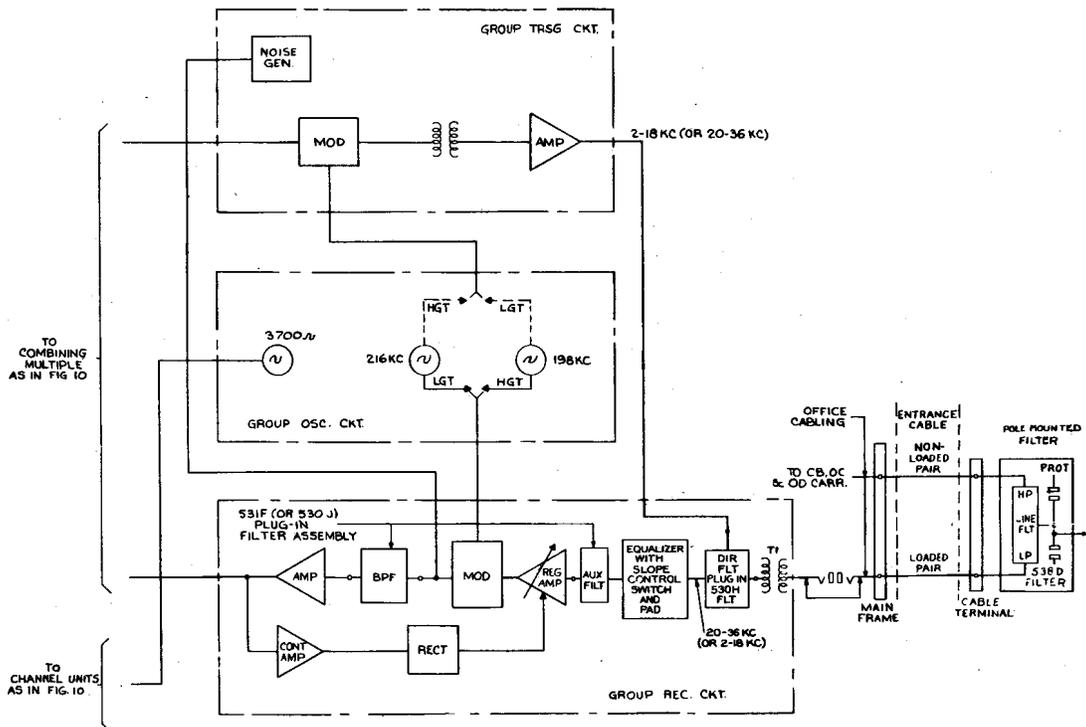


Fig. 145 - Block Schematic of OAL Terminal Group Equipment

failure, fuse failure, high- or low-battery voltage, or failure of the charging rectifier. When two or more repeaters make use of the same alarm circuit, identification of the alarm source is made by means of a resistance measurement from the attended office. The alarm composite set will permit the use of dc telegraph on the other wire of the pair. Balancing arrangements are required in the other side of the phantom; balances at two wire repeaters are not affected. Provision is also made for the appearance of a voice circuit in the pole-mounted cabinet so that a lineman's talking set can be bridged for order-wire use.

4.58 The alarm and busy test circuits associated with the terminals are located physically in the terminal mounting. A simplified schematic is shown in Fig. 144. Channel 1 includes continuity testing not necessary on more than one channel. For simplicity the description will be concerned with channel 1, only.

4.59 Let it be assumed that a trouble condition has appeared which caused the loss of received carrier at the terminal. The absence of received carrier will cause the release of relay (C). After a period of perhaps 5 seconds, relay (C) may re-operate due to noise or crosstalk which has increased in magnitude because of the increase in gain of some of the repeaters or of the group receiving circuit. During the period between the release of relay (C) and its reoperation, the C31 capacitor has charged up sufficiently (in about 2 seconds) to cause the firing of the gas tube (V31) via the control anode and cathode, and the operation of relay (CA). Once relay (CA) operates it locks up on current through the make-before-break contacts and from that point on the alarm circuit is independent of the line noise and crosstalk. Through the operation of relay (CA) five results are obtained as follows:

- (a) Plate battery is removed from a portion of the twin-channel circuit so that transmission of carrier from the terminal is stopped.
- (b) The E lead to the office supervisory or dial equipment is opened so that interfering signaling pulses due to crosstalk or noise will not reach the office equipment. In the case of channels 2, 3, or 4 this is accomplished by removing the ground on the G lead to the channel circuits.
- (c) Ground is connected to the winding of thermal relay (DB) which will operate after about 10 seconds and cause the operation of the (RC) relay which locks under the control of relay (CA).

(d) Ground is removed from the G lead to channel 1 and replaced by -48V battery. In the released condition, the signaling relay in channel 1 will supply battery through the TST A key to the keyer circuit in channel 1. The presence of battery on the keyer will cause the 3700-cycle signaling current to be removed.

(e) Plate battery is removed from the main anode of the gas tube so that the gas tube will be extinguished. It remains extinguished even though the (C) relay is operated again by noise or the reappearance of carrier.

With the operation of relay (RC), the +130V supply is restored to the twin-channel carrier circuit and carrier is again transmitted from the terminal. Ground is also supplied on the E lead to the office terminal equipment. This will make the channel appear busy when used with dial signaling.

4.60 By the sequence of events described above, the following has been accomplished in case of failure of either the received carrier or the 3700-cycle oscillator.

- (a) Office audible and visual alarms have been turned on.
- (b) Alarms have been operated at the distant terminal to identify the system in trouble and permit loop testing from either terminal (see 4.61).
- (c) The circuit has been prepared for loop testing.
- (d) A "wink" (or disconnect) interval has been provided which in the case of dial signaling permits subscribers to be disconnected from the channel prior to making it appear busy. When the 3700-cycle signaling system is used for ringdown operation, a line signal is given during this 10-second interval.

4.61 Loop testing is accomplished after an alarm has been received by holding the TST A key operated while the TST B key is intermittently operated. 3700-cycle signaling tone will be intermittently transmitted over channel 1 to the distant terminal and back. If the TST lamp follows the manipulation of the TST B key the circuit has returned to normal and it is safe to operate the REST SYS key. This will restore the alarm circuit and the system to normal.

4.62 In locations where one terminal is unattended it will be desirable to provide the subscriber set REST SYS (see Fig. 144). This will permit the alarm cir-

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cuits and system to be returned to normal from the attended terminal or any other point by calling or dialing the assigned subscriber line circuit number.

5. CIRCUIT DESCRIPTIONS REFERRED TO HEREIN (Not Attached)

CD-95191-01 - Through Channel Unit

6. DRAWINGS (Not Attached)

A. SD-Drawings

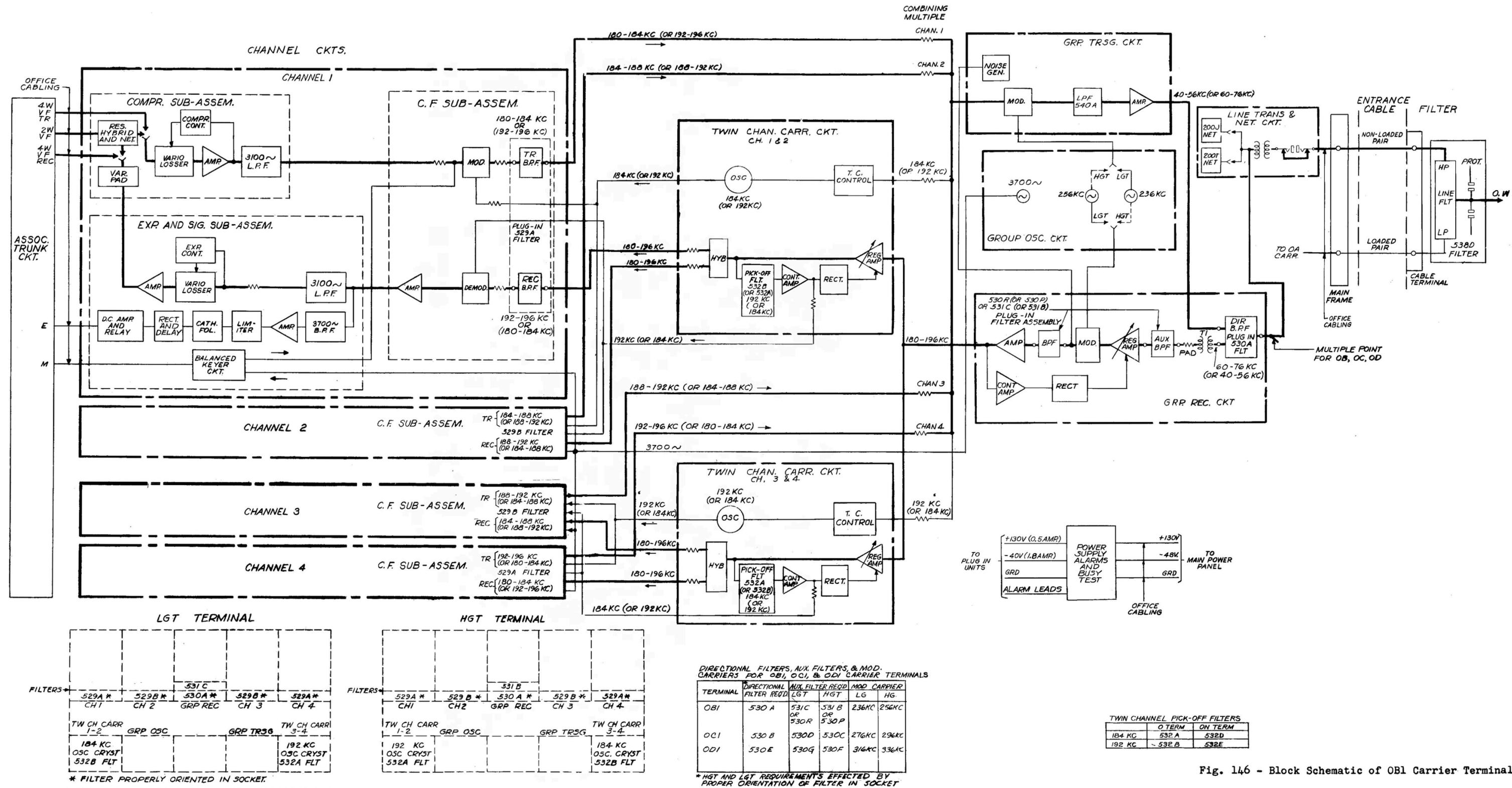
SD-95118-01 - N1 and O1 Channel Circuit
SD-95150-01 - Application Schematic O1 and ON1 Carrier Terminal
SD-95151-01 - O1 Twin-Channel Carrier Circuit
SD-95152-01 - OBl, OC1, OD1 Group Receiving or Repeater Amplifier and ON1 Group Receiving Circuit
SD-95153-01 - OBl, OC1, OD1 and ON1 Group Transmitting Circuit
SD-95154-01 - O1 Terminal Group Oscillator and ON1 Group Oscillator Circuits
SD-95155-01 - Application Schematic O1 Carrier Repeaters
SD-95158-01 - O1 Repeater Oscillator and Miscellaneous Oscillator and ON1 Miscellaneous Oscillator Circuits
SD-95163-01 - Channel Test Stand Circuit
SD-95165-01 - Application Schematic - Power Supply and Alarm Filter Circuit
SD-95171-01 - OBl, OC1, OD1 Carrier Bypass and Branching Circuit
SD-95172-01 - OAl Group Transmitting Circuit
SD-95174-01 - OAl Group Receiving Circuit
SD-95176-01 - OAl Repeater Amplifier Circuit
SD-95180-01 - Attended Office Alarm Circuit for Use with Pole-Mounted Repeaters
SD-95181-01 - Application Schematic - Line Filter and Auto-Transformer Circuit.
SD-95184-01 - Loop Test Circuit
SD-95191-01 - N1 and O1 Thru Channel Circuit

B. ED-Drawings

ED-62545-01 - Grounding Methods on Duct-Type Bay Frameworks
ED-92317-01 - N1 and O1 Channel Unit Compressor Subassembly Equipment
ED-92318-01 - N1 and O1 Channel Unit Expander and Signaling Subassembly Equipment
ED-92484-01 - Miscellaneous Equipment
ED-92600-01 - O1 and ON1 Terminal Mounting
ED-92601-01 - O1 and ON1 Carrier Terminal Mounting Fuse Panel
ED-92602-01 - O1 Repeater Mounting

ED-92603-01 - O1 Carrier Repeater Mounting and ON1 Carrier Junction Mounting Fuse Panel
ED-92604-01 - O1 Channel Unit Carrier Subassembly Equipment
ED-92605-01 - O1 Channel Unit Equipment
ED-92606-01 - O1 Twin-Channel Carrier Unit Equipment
ED-92607-01 - OBl, OC1, OD1 Group Receiving or Repeater Amplifier and ON1 Group Receiving Units
ED-92608-01 - OBl, OC1, OD1 and ON1 Group Transmitting Unit
ED-92609-01 - O1 and ON1 Terminal Group Oscillator Circuits
ED-92610-01 - O1 Repeater Oscillator and Miscellaneous Oscillator and ON1 Miscellaneous Oscillator Circuits
ED-92611-01 - OBl, OC1, OD1 Terminal Bay Arrangements 11-foot,6-inch, 10-foot,6-inch, and 9-foot, 0-inch Type Bays
ED-92612-01 - OBl, OC1, OD1 Terminal Bay Arrangement for 6-foot,0-inch, and 7-foot,0-inch Floor Supported Bays
ED-92613-01 - Loop-Test Unit Equipment
ED-92614-01 - OBl, OC1, OD1 Repeater Bay Arrangement 11-foot,6-inch and 10-foot,6-inch Duct-Type or Channel-Type Bays
ED-92615-01 - OBl, OC1 and OD1 Repeater Bay Arrangement for 6-foot,0-inch and 7-foot,0-inch Floor Supported Bays
ED-92617-01 - OAl, OBl, OC1, and OD1 Pole-Mounted Repeaters - Cabinet Equipment
ED-92618-01 - OAl, OBl, OC1, and OD1 Line Network Panels for Pole-Mounted Locations
ED-92619-01 - O1 and ON1 Terminal Bay Cabling
ED-92620-01 - OBl, OC1, and OD1 Repeater Bay Cabling
ED-92668-01 - Line Transformer and Network Panel for OBl, OC1, and OD1 Carrier Terminal and ON1 Junction
ED-92669-01 - Channel Unit Test Stand
ED-92679-01 - Line Network Panels for Office-Mounted OBl, OC1, OD1 Repeaters
ED-92689-01 - Modification of KS-14296-01, 11 Cabinet for Pole-Mounted Repeaters and Power Plants
ED-92693-01 - Alarm Filter Panel for Pole-Mounted Repeaters
ED-92695-01 - Signaling Link Panel
ED-92698-01 - Cord Assemblies for Pole-Mounted Repeater Cabinet
ED-92717-01 - Miscellaneous Details
ED-92730-01 - Attended Office Alarm Panel for Terminating Alarm Circuit from Pole-Mounted Repeater Location
ED-92742-01 - O1 Carrier Repeater Mounting and ON1 Carrier Junction Mounting Fuse Panel

ED-92743-01	- O1 Repeater Oscillator and Miscellaneous Oscillator and ON1 Miscellaneous Oscil- lator	ED-92755-01	- OB1, OC1, and OD1 Bypass and Branching Panel for Office Locations
ED-92747-01	- O1 and ON1 Terminal Mounting Fuse Panel	ED-92756-01	- Line Jack Panel for OAl Carrier Terminal and ON1 Junction
ED-92752-01	- OAl and ON1 Group Trans- mitting Unit	ED-92802-01	- Through Voice Frequency Channel Subassembly
ED-92753-01	- OAl and ON1 Group Receiving Unit	ED-92805-01	- Line and Balancing Equipment
ED-92754-01	- OAl Repeater Amplifier Unit	ED-92808-01	- OB1, OC1, and OD1 Carrier Bypass and Branching Panel for Pole-Mounted Locations



LGT TERMINAL

FILTERS	529A *	529B *	530A *	529B *	529A *
	CH 1	CH 2	GRP REC	CH 3	CH 4
	TW CH CARR 1-2		GRP TRSG	TW CH CARR 3-4	
	184 KC			192 KC	
	OSC CRYST			OSC CRYST	
	532B FLT			532A FLT	

HGT TERMINAL

FILTERS	529A *	529B *	530A *	529B *	529A *
	CH 1	CH 2	GRP REC	CH 3	CH 4
	TW CH CARR 1-2		GRP TRSG	TW CH CARR 3-4	
	192 KC			184 KC	
	OSC CRYST			OSC CRYST	
	532A FLT			532B FLT	

DIRECTIONAL FILTERS, AUX. FILTERS, & MOD. CARRIERS FOR OBI, OCI, & ODI CARRIER TERMINALS

TERMINAL	DIRECTIONAL FILTER REQ'D	AUX. FILTER REQ'D		MOD. CARRIER	
		LGT	HGT	LG	HG
OBI	530 A	531C	531B	236KC	256KC
OCI	530 B	530D	530C	276KC	296KC
ODI	530 E	530G	530F	316KC	336KC

TWIN CHANNEL PICK-OFF FILTERS

	O TERM	ON TERM
184 KC	532A	532D
192 KC	532B	532E

* FILTER PROPERLY ORIENTED IN SOCKET.
NOTE: THE FREQUENCIES ARE INDICATED FOR LGT AND HGT TERMINALS (THE LATTER IN BRACKETS).

* HGT AND LGT REQUIREMENTS EFFECTED BY PROPER ORIENTATION OF FILTER IN SOCKET

Fig. 146 - Block Schematic of OBI Carrier Terminal

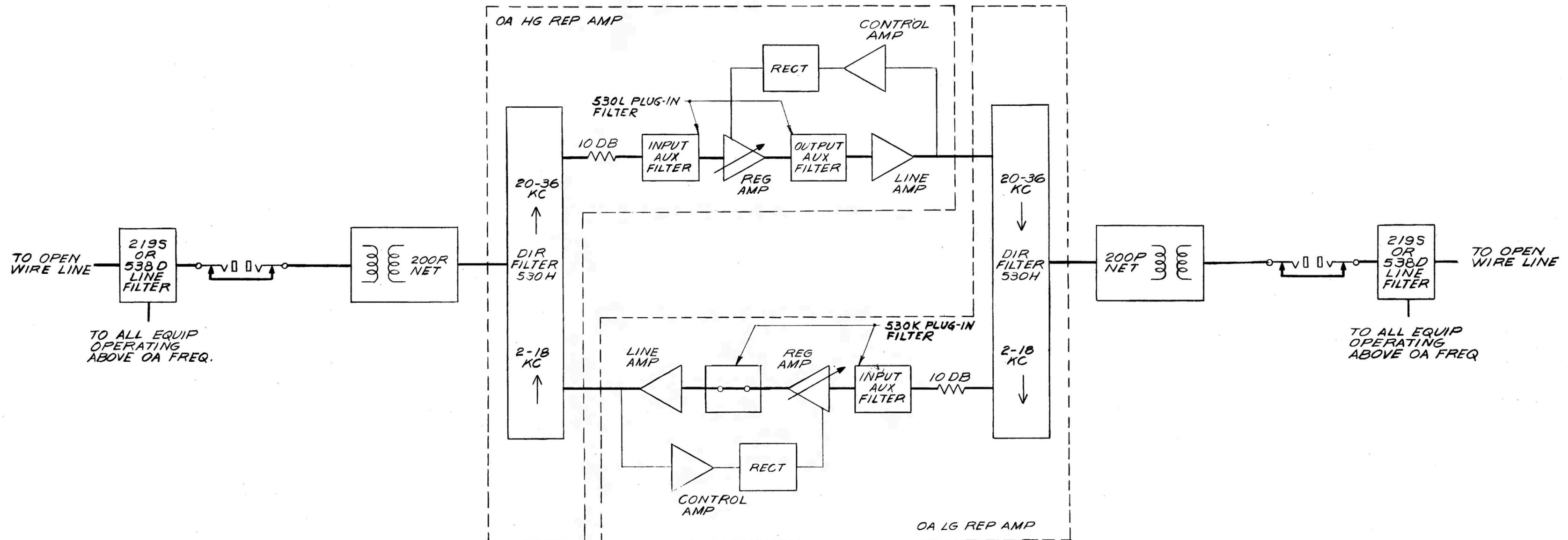
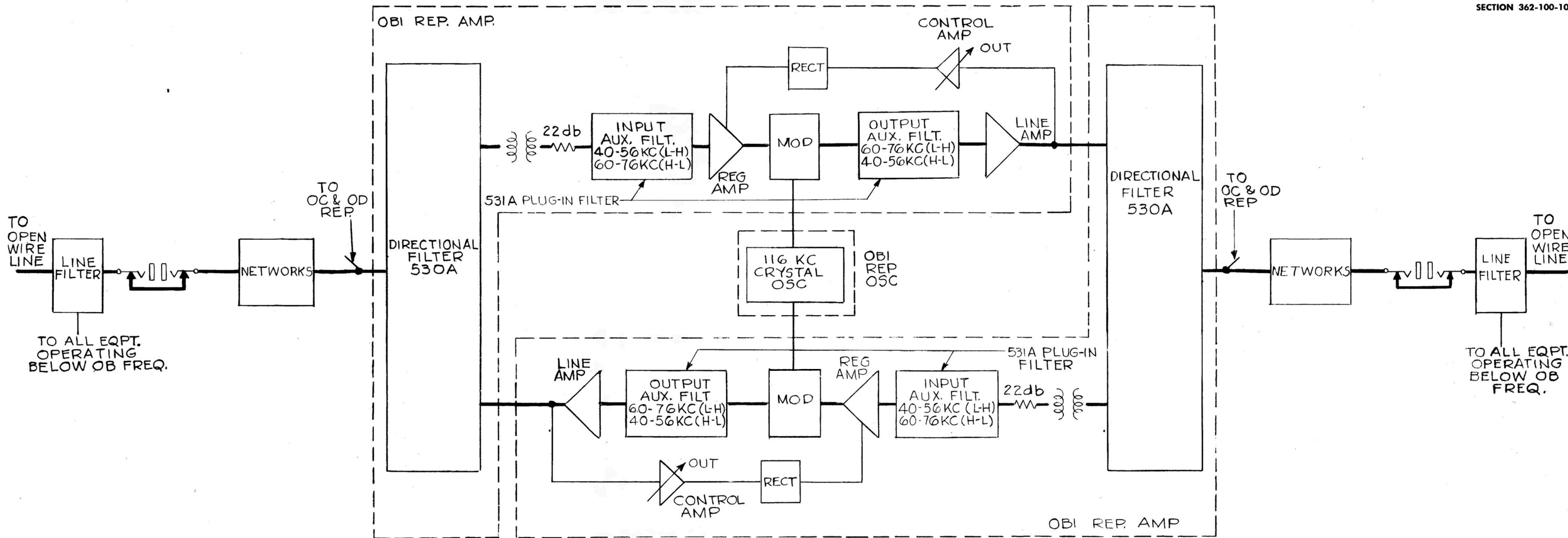


Fig. 147 - Block Schematic of Type OA Repeater



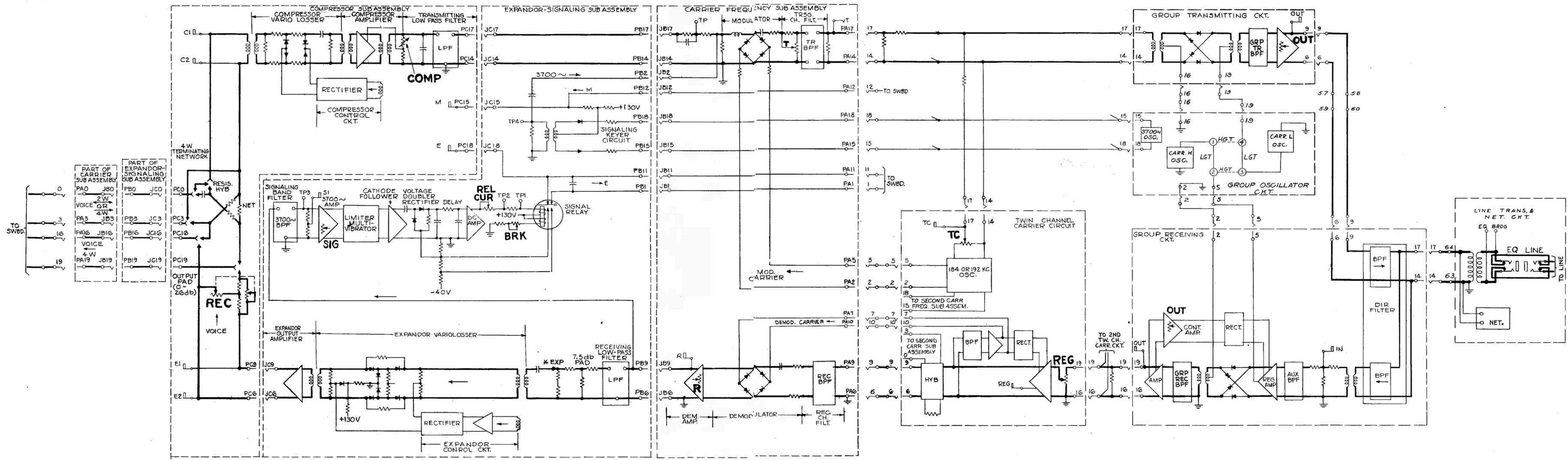
DIRECTIONAL FILTERS, AUXILIARY FILTERS, AND REP. MOD. CARRIERS FOR OBI, OCI, AND ODI REPEATERS

REPEATER	DIRECTIONAL FILTER REQ'D	AUXILIARY FILTER REQ'D	REP. MOD. CARRIER
OBI	530A	531A	116 KC
OCI	530B	531D	196 KC
ODI	530E	531E	276 KC

Fig. 148 - OBI Repeater Block Schematic

APPARATUS NOT ENCLOSED BY DASHED LINES IS LOCATED IN TERMINAL MOUNTING.

MESSAGE LEVELS -db (SEE NOTE 1) 0 (2W)	-16	0	-1	-37	-55	-61.5 -62.0 0.0	-0.5
MESSAGE POWER FOR 0 dbm AT 0 LEVEL -dbm	-16	+2.5	+1.5	-34.5	-52.5	-59 -59.5 +2.5	+2
MESSAGE VTVM READINGS FOR 0 dbm AT 0 LEVEL -db	-16	+11	+9	-41	-59	-51.5 -52 -4.0	
SIGNALING POWER -dbm				-37	-55	-61.5 -62.0 0.0	-0.5
CARRIER POWER -dbm					-49	-55.5 -56.0 +6.0	+3.0
IMPEDANCE - OHMS	← 600 →	← 600 →	4500 →	3500 →	140 →	← 135 →	← 135 →



MESSAGE LEVELS -db	+8 (MAX 2W)	+10	-13	-5.5	-4	-12	0	-54	-50	-44	-43	-22	-20.5	-20 **
MESSAGE POWER FOR 0 dbm AT 0 LEVEL -dbm +8 (MAX 2W)	+10		-10.5	-3	-1.5	-9.5	+2.5	-51.5	-47.5	-41.5	-40.5	-19.5	-18	-17.5
MESSAGE VTVM READINGS FOR 0 dbm AT 0 LEVEL -db	+10		+1.5	+0	+10.5									
SIGNALING -dbm						-12	0	-54	-50	-44	-43	-22	-20.5	-20
CARRIER -dbm					0	-6	+6	-48	-44	-38	-37	-16	-14.5	-14
IMPEDANCE - OHMS	← 600 →	← 600 →	← 10,000 →	← 10,000 →	10,000 →	75 →	← 135 →	← 135 →	← 135 →	135 →	← 135 →	← 100 →	← 135 →	← 135 →

* EXP POT. SET AT MAX.

** ASSUMED LEVELS

Notes:

1. WITHIN THE COMPRESSED PORTION OF THE CIRCUIT A ZERO LEVEL POINT IS DEFINED AS THE POINT WHERE THERE IS ZERO GAIN OR LOSS TO THE TRANSMITTING TOLL SWITCHBOARD WHEN THE INPUT POWER AT THE SWITCHBOARD IS +5 dbm.

Fig. 149 - OBI, OC1, OD1 Terminal Levels and Controls