TM 11-2025

WAR DEPARTMENT TECHNICAL MANUAL

CARRIER TERMINAL OA-13/FC, CARRIER REPEATER OA-10/FC, AND CARRIER FILTER F-36/FC

(TYPE H CARRIER TELEPHONE PACKAGED EQUIPMENT)

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TM 11-2025, Carrier Terminal OA-13/FC, Carrier Repeater OA-10/FC, and Carrier Filter F-36/FC (Type H Carrier Telephone Packaged Equipment), is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut—Use axes, handaxes, machetes.

3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. Explosives—Use firearms, grenades, TNT.

5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Panels, switches, controls, vacuum tubes, terminal strips.

2. Cut—Cables, cords, all wiring.

3. Burn—Resistors, capacitors, coils, technical manuals, equipment drawings.

4. Bend—Mounting plates.

5. Bury or scatter—All of the above pieces after destroying their usefulness.

DESTROY EVERYTHING

SAFETY NOTICE

Voltages used in this equipment are high enough to endanger life and may be fatal if contacted by operating personnel. Attendants must be careful not to contact high-voltage plate circuits and the a-c input connections. Do all testing with insulated test leads. Disconnect a-c powercord when making adjustments and when disassembling any part of the equipment.

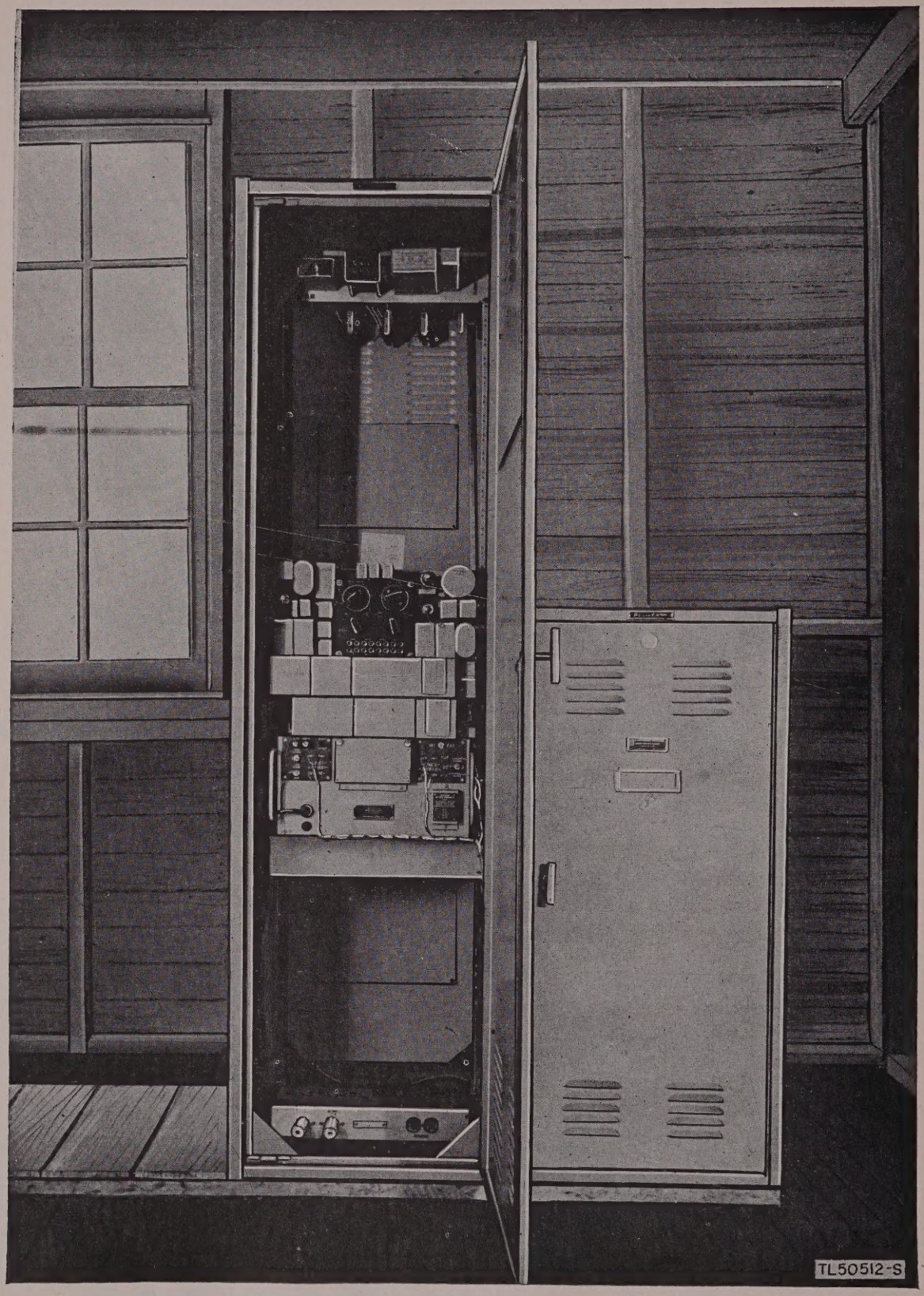


Figure 1. Typical installation of type H carrier telephone packaged equipment.

This manual supersedes TM 11-2025, Type H Carrier Telephone Packaged Equipment, 30 June 1944, and TM 11-2038, Installation Instructions for Type H Carrier Telephone Packaged Equipment, 30 June 1944.

PART ONE

INTRODUCTION

Section I. DESCRIPTION

1. General

a. Carrier Terminal OA-13/FC (Western Electric type H carrier terminal panel X-66217A), Carrier Repeater OA-10/FC (Western Electric type H carrier repeater panel X-66217B), and Carrier Filter F-36/FC (Western Electric type H carrier line panel X-66217C) are used to form a carrier system which is generally known as type H. Type H carrier telephone packaged equipment (fig. 1) provides means for superposing one additional telephone channel on an existing open-wire voice-frequency circuit, or two additional telephone channels on a radio circuit. The type H carrier channel may be used for a voice-frequency telegraph system within certain limitations. The equipment consists of three panels designated H CARR TERM, H CARR REP, and H CARR LINE. The equipment is mounted on panels, suitable for installation in apparatus cabinets or on standard 19-inch relay racks which must be provided separately. Equipment for protection against excessive line voltages must also be provided separately.

(1) A complete carrier terminal requires one carrier terminal panel and one carrier line panel. The carrier terminal panel may be used either as an East or a West[1] terminal, and may be terminated on the switchboard side either on a two-wire or a four-wire basis. Terminal panels may also be used at each end of a radio link to permit operation of one or two carrier telephone channels in addition to the regular radio talking channel. Voice-frequency ringing equipment must be provided separately for signaling over the H carrier system.

(2) A complete carrier repeater requires one carrier repeater panel and two carrier line panels.

(3) Where it is desired to transfer the carrier circuit without being repeatered, two line panels are used in tandem.

b. The arrangement for superposing a type H carrier system on an open-wire pair is shown in figure 2, which also shows the application of terminal and line panels. As illustrated, two telephone channels are provided, one voice-frequency circuit and one carrier circuit.

c. No equalization or automatic regulation of the circuit net losses is provided to compensate for variations in line attenuation with weather. The over-all distance over which satisfactory operation is obtainable is limited by the type of open-wire line used and by the absence of automatic gain regulation. (See table III for specific distances.) With two repeaters these distances can be more than doubled but some narrowing of the transmission band results due to the transmission characteristics of the carrier repeater. For this reason and because no automatic regulation is provided with the system, it will generally be desirable to limit the number of repeaters in any one system to two.

d. A source of 105- to 125-volt, 50- to 60-cycle a-c power is required for the operation of the terminals and repeaters. No power is required for the line panels.

e. Type H carrier equipment is moisture-resistant and is designed to operate over wide ranges of temperature and humidity. It uses the same frequency bands as the commercial (Western Electric type H-1) carrier equipment, and may be interconnected with that equipment. However, this commercial equipment uses East and West terminals, which are not interchangeable, with built-in ringing equipment.

[1] The ends of wire circuits and the associated equipment are generally designated East and West, depending upon their geographical location or local agreement. For lines running North and South, the ends are usually designated East and West respectively.

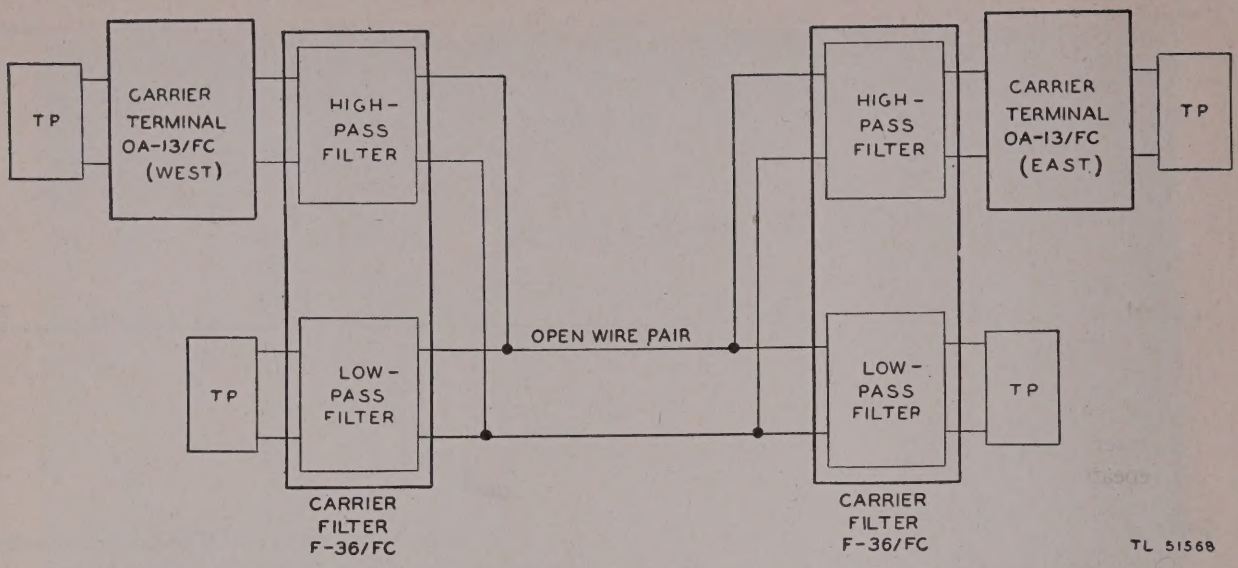


Figure 2. Type H carrier superposed on open-wire pair, block diagram.

2. Table of Major Components

The major components of type H carrier telephone packaged equipment are listed below. The weights and dimensions shown are for the equipment unpacked and ready for use. Installing materials and spare vacuum tubes furnished with the equipment are not shown. See the Signal Corps catalog for a complete list of small parts, or appendix I of this manual where the list is included for reference.

Component	Weight unpacked (lb.)	Dimensions (in.)	Mounting plate spaces required
Carrier Terminal OA-13/FC	50	12¼ x 19	7
Carrier Repeater OA-10/FC	35	8¾ x 19	5
Carrier Filter F-36/FC	15	3½ x 19	2

3. Physical Description of Panels

Each panel is made of sheet steel and is arranged to be mounted in an apparatus cabinet or on standard 19-inch relay rack. Controls for operation, jacks for testing and patching, and designation card holders are located on the front of the panels. The terminal strips for terminating connections to other equipments are located on the rear of the panel, together with the power cord terminations. Shipped with each panel are schematic and wiring diagrams, copies of this manual, and four designation cards.

a. Carrier Terminal OA-13/FC (fig. 3). This panel contains equipment for changing voice-frequency signals to carrier-frequency signals in the transmitting direction, for reconverting carrier-frequency signals to voice-frequency signals in the receiving direction, and for amplification of the signals to the desired strength in both directions of transmission. The EQPT switch is used for arranging the terminal for the type of termination desired, two-wire or four-wire. The LINE switch is used to arrange the terminal for the type of line connection desired, to an East line, a West line, radio transmission, or radio reception. The REC GAIN and TR GAIN controls are used to vary the losses of the transmitting and receiving gain pads, and thus control the signal strength. These pads provide losses up to 50 decibels (db) in 2-db steps. One vacuum tube is used in each of the amplifier circuits, transmitting and receiving, and in the oscillator circuit. Six spare vacuum tubes are shipped with the equipment.

b. Carrier Repeater OA-10/FC (fig. 4). This panel contains equipment for amplifying the signals in both directions of transmission. The strength of signals is controlled by the W-E GAIN and E-W GAIN switches, which in turn control the amplifier gain pads and provide up to 50-db loss in 2-db steps. One vacuum tube is used in each amplifier circuit, and six spare tubes are shipped with the equipment.

c. Carrier Filter F-36/FC (fig. 5). This panel contains high-pass and low-pass filters for separating the voice and carrier frequencies, and balancing filters for use with the balancing networks of voice-frequency repeaters. Enough balancing filters are provided for balancing purposes when the carrier equipment is used on a physical two-wire line or on a phantom group. This panel is connected between

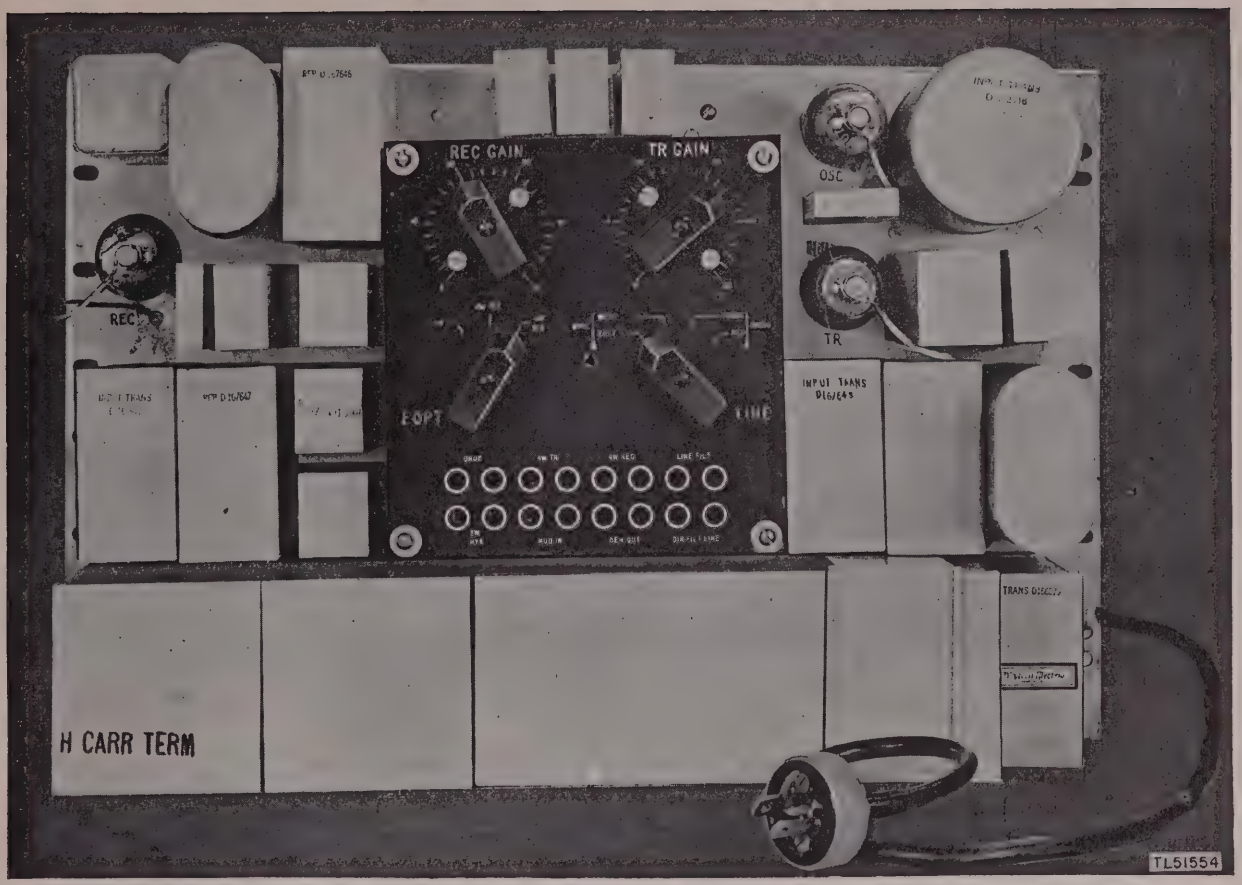


Figure 3. Carrier Terminal OA-13/FC, front view.

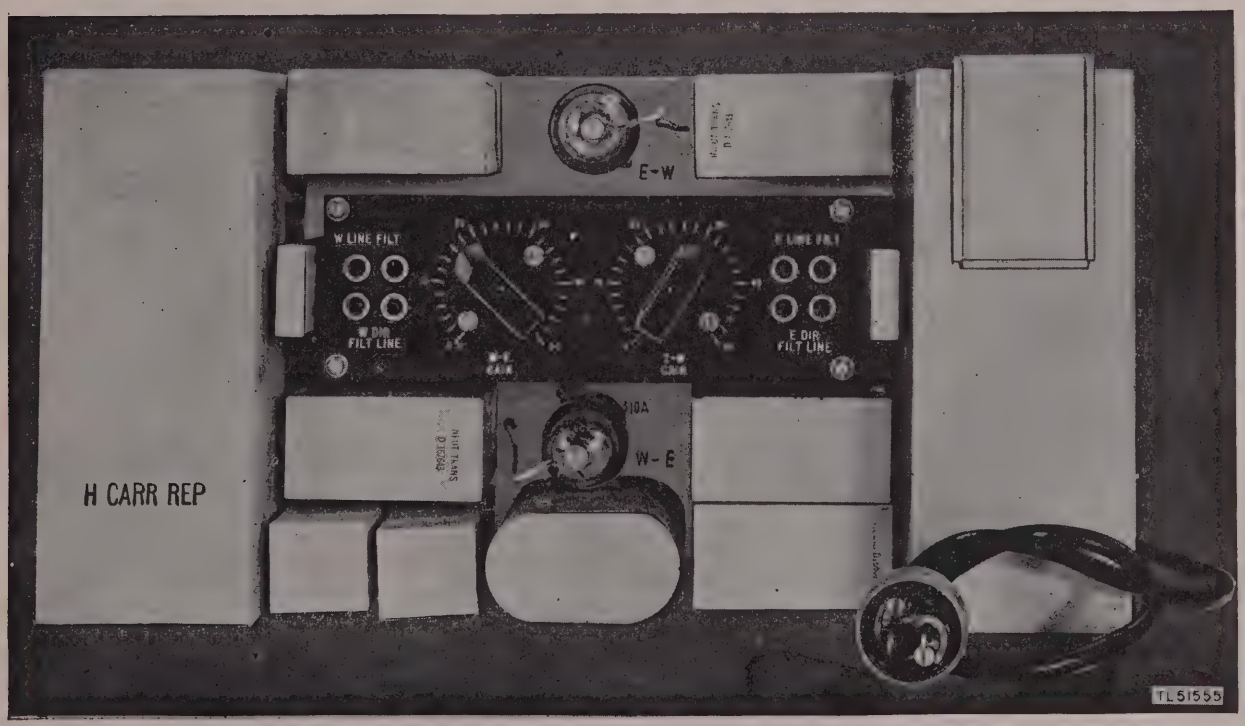


Figure 4. Carrier Repeater OA-10/FC, front view.

the line and a terminal or a repeater. Two of these panels are connected back-to-back when it is necessary to terminate the voice circuit at an intermediate point in the system, to by-pass the carrier system around a voice-frequency repeater, or to transfer the carrier circuit from one open-wire line to another open-wire line. Connecting wire (205 feet) is shipped with the panel.

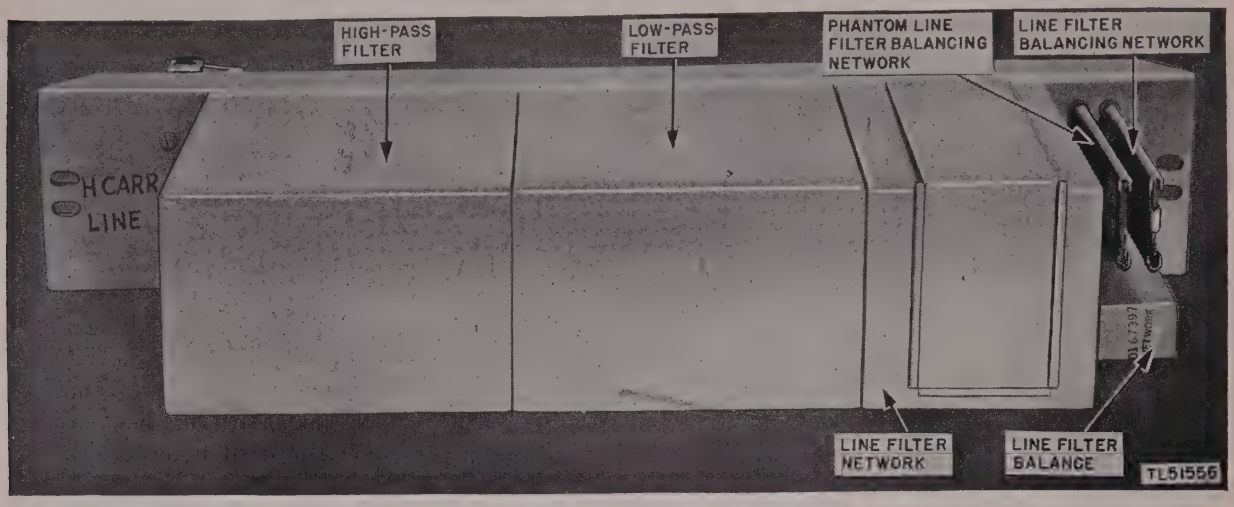


Figure 5. Carrier Filter F-36/FC, front view.

4. General Functioning of Terminal Panel

a. Two-wire Telephone Transmitting Circuit. A terminal arranged for telephone operation and terminated on a two-wire basis on the switchboard side is shown in figure 6. With switch EQPT at 2W, and switch LINE at EAST or WEST, as required, the carrier terminal operation is as follows:

(1) Voice-frequency signals pass through the hybrid coil HYB and enter the transmitting portion of the low-pass filter LP. The balancing network (BAL NET) connected to the hybrid coil is used to balance the two-wire side of the hybrid coil.

(2) The output of the low-pass filter connects to balanced varistor modulator MOD. The modulator, which raises the voice-frequency signals to carrier frequencies, is supplied with a source of 7,150 cycle current by vacuum tube oscillator OSC.

(3) The modulator output is connected to band-pass filter BF arranged to pass the upper side band (approximately 7,400 to 10,150 cycles) if it is an East terminal, or the lower side band (approximately 4,150 to 6,900 cycles) if it is a West terminal.

(4) The selected side band passes through the transmitting gain potentiometer TR GAIN, which is adjusted by control TR GAIN on the front panel, to the input of transmitting amplifier TR.

(5) From the transmitting amplifier the side band passes through directional filter DF which provides additional suppression for the unwanted frequencies. The transmitting portion of the directional filter is arranged to pass the same side band as passed by transmitting band-pass filter BF.

(6) From the directional filter the carrier side band passes to the open-wire line through the carrier line panel high-pass filter and through protector equipment.

b. Two-wire Telephone Receiving Circuit. The incoming side-band path is as follows:

(1) After passing through the protector equipment and carrier line panel, the receiving unit of directional filter DF selects the lower side band if it is an East terminal (the upper side band if it is a West terminal) and passes the side-band frequencies through gain control potentiometer REC GAIN, which is adjusted by the REC GAIN control on the front panel. The side-band frequencies then pass through band-pass filter BF, arranged to pass the lower side band if it is an East terminal, or the upper side band if it is a West terminal, and thence to demodulator DEM.

(2) The demodulator is a balanced varistor bridge and is supplied with a source of 7,150 cycle current from the same vacuum-tube oscillator OSC that supplies the modulator. The demodulator lowers the carrier frequencies to voice frequencies.

(3) The voice-frequency output from the demodulator is connected to the receiving portion of low-pass filter LP and thence to receiving amplifier REC.

(4) From the receiving amplifier the voice-frequencies pass through a 7.6-db fixed loss pad R2 to hybrid coil HYB and then to the two-wire extension.

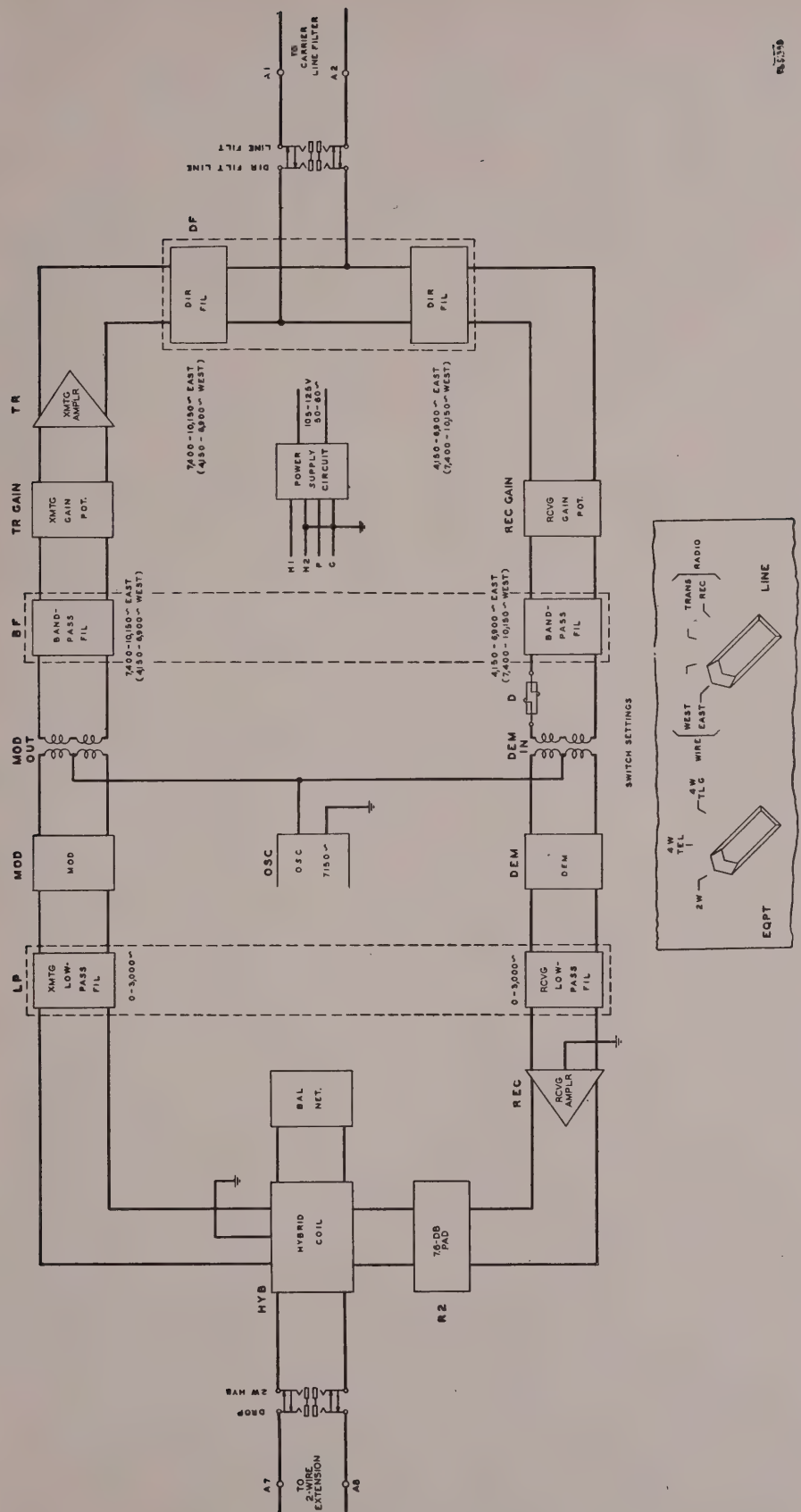


Figure 6. Type H terminal terminated on a two-wire basis, block diagram.

c. Four-wire Circuit (fig. 7). With the EQPT switch at 4W TEL and the LINE switch at EAST or WEST, as required, the terminal circuit is similar to that described in *a* and *b* above except that the function of hybrid coil HYB is changed to that of a repeating coil, an 8-db pad R1 is inserted at the input to transmitting low-pass filter LP, and the 7.6-db fixed pad R2 is eliminated from the receiving path. The terminal is terminated on a four-wire basis when the type H carrier system is extended to another adjacent carrier terminal, an adjacent voice-frequency telephone repeater, or a voice-frequency carrier telegraph terminal. The 4W TLG position of switch EQPT is provided for cases where it is desired to remove the 8-db pad R1 from the transmitting path.

d. Radio Link Circuit. When a type H carrier system is operated over a four-wire radio link, two terminal panels are required at each end of the link. The arrangement at each end of the link is shown in figures 8 and 9. For explanatory purposes, the terminals used at the West end of the radio link have been arbitrarily designated 1A and 2A, and those at the East end 1B and 2B. Transmission and reception are described only for the West-to-East path; East-to-West transmission follows a similar path. The arrangement consists essentially of connecting the receiving circuits of the carrier terminals to the radio receivers, and the transmitting circuits to the radio transmitters.

(1) *West End of Radio Link* (fig. 8). Voice frequencies (250 to 3,000 cycles) from type H telephone channel 1 enter terminal 1A, are raised by modulation to carrier frequencies (7,400 to 10,150 cycles), and passed by directional filter DF through the carrier line panel to the radio transmitter. Voice frequencies (250 to 3,000 cycles) from type H telephone channel 2 enter terminal 2A, are raised by modulation to carrier frequencies (4,150 to 6,900 cycles), and also passed by directional filter DF of terminal 1A through the carrier line panel to the radio transmitter. Note that terminal 1A is called the transmitting terminal and that terminal 2A the receiving terminal. The LINE switches of the respective terminals are so positioned.

(2) *East End of Radio Link* (fig. 9). Carrier frequencies from the radio receiver, after passing through the carrier line panel, are separated by directional filter DF of terminal 2B. The higher frequencies (7,400 to 10,150 cycles) are passed to terminal 1B, lowered by demodulation to voice frequencies, and transmitted to type H telephone channel 1. The lower frequencies (4,150 to 6,900 cycles) are passed to terminal 2B, lowered by demodulation to voice frequencies, and transmitted to type H telephone channel 2. Note that terminal 2B is called the receiving terminal and that terminal 1B is called the transmitting terminal. The LINE switches of the respective terminals are so positioned.

e. Talking Arrangements from the Terminal Panel. If it is desired to talk over the type H carrier system, it is recommended that the terminating switchboards be used since no facilities are provided for talking from the carrier terminal. However, if it is necessary to talk between two terminal panels, a magneto telephone and a patching cord with spade terminals at one end must be available at each terminal. Connect the spade terminals to the magneto telephone. Remove the system from service, insert the plug of the patching cord into jacks 2W HYB on the terminal, and set switch EQPT on the 2W position. (The hand generator of the magneto telephone cannot be used to signal over the system from the carrier terminal.) After the conversation is completed, restore switch EQPT to its original position and remove the patching cord. Echo or hollowness may be noticed when talking over the system in this manner, but such echo does not indicate trouble unless echo is noted also when talking between the terminating switchboards.

f. Power Supply. The carrier terminal requires an external source of 105- to 125-volt, 50 to 60-cycle, a-c power. Equipment is provided in the panel to convert this power to 10.5 volts alternating current (ac) to operate the heaters of the vacuum tubes and approximately 150 volts direct current (dc) for the screen and plate circuits. The carrier terminal panel provides no fuse or alarm circuits.

5. General Functioning of Repeater Panel (fig. 10)

a. Transmission Circuit. For the West-to-East direction, side-band frequencies enter directional filter W DF which selects the correct frequency band (4,150 to 6,900 cycles) and passes it to gain potentiometer W-E. This potentiometer is adjusted by the W-E GAIN control on the front of the panel and controls the strength of the signal passed to amplifier W-E, which amplifies the side band to the desired level. The amplified side band then passes to the open-wire line through directional filter E DF, the line panel, and protector equipment. For the East-to-West direction, the operation is similar to that described above.

b. Talking Arrangements. It is impractical to talk over the carrier channel from a repeater. When talking from repeater offices, a voice-frequency circuit must be used.

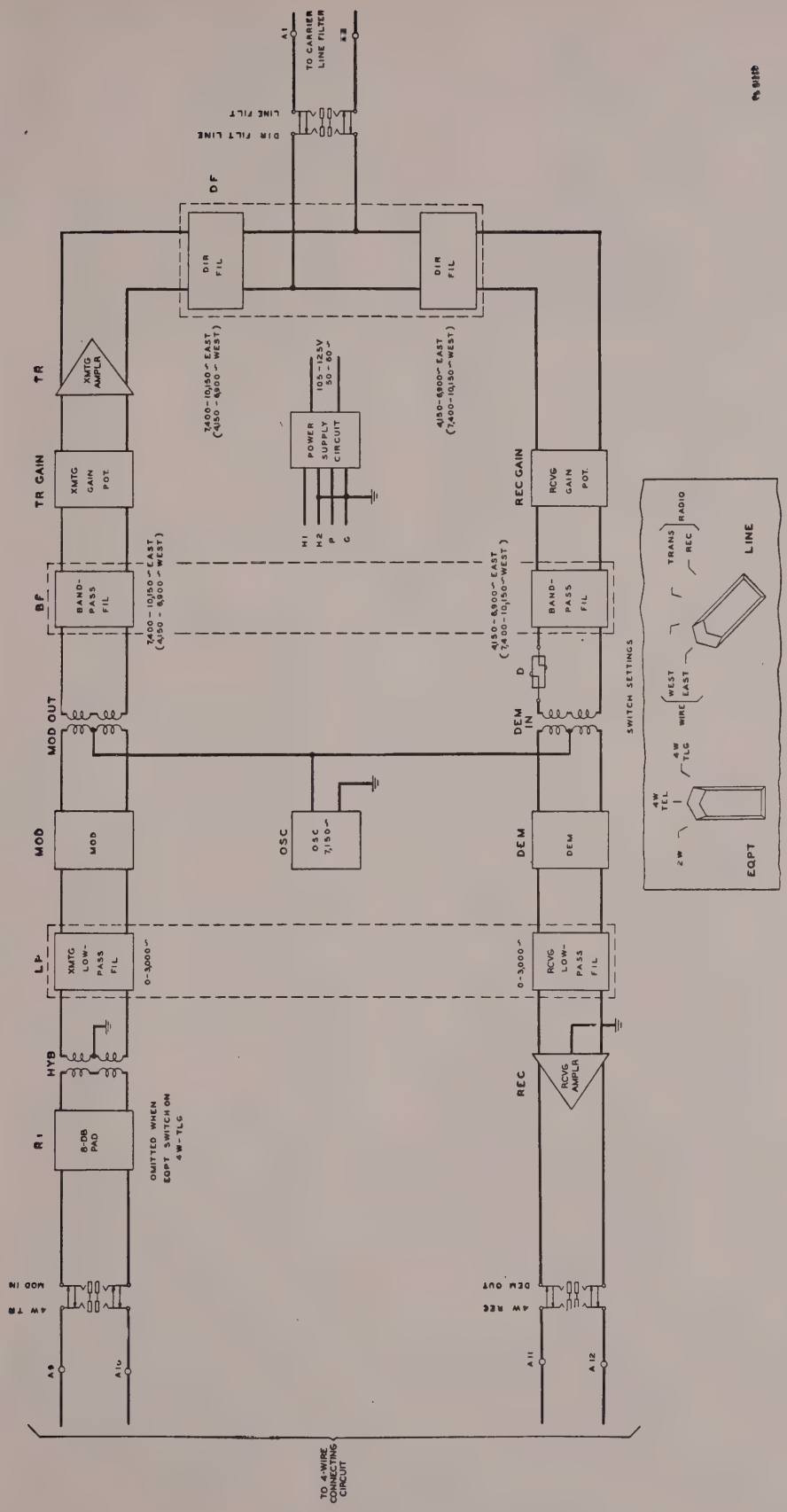


Figure 7. Type H terminal terminated on a four-wire basis, block diagram.

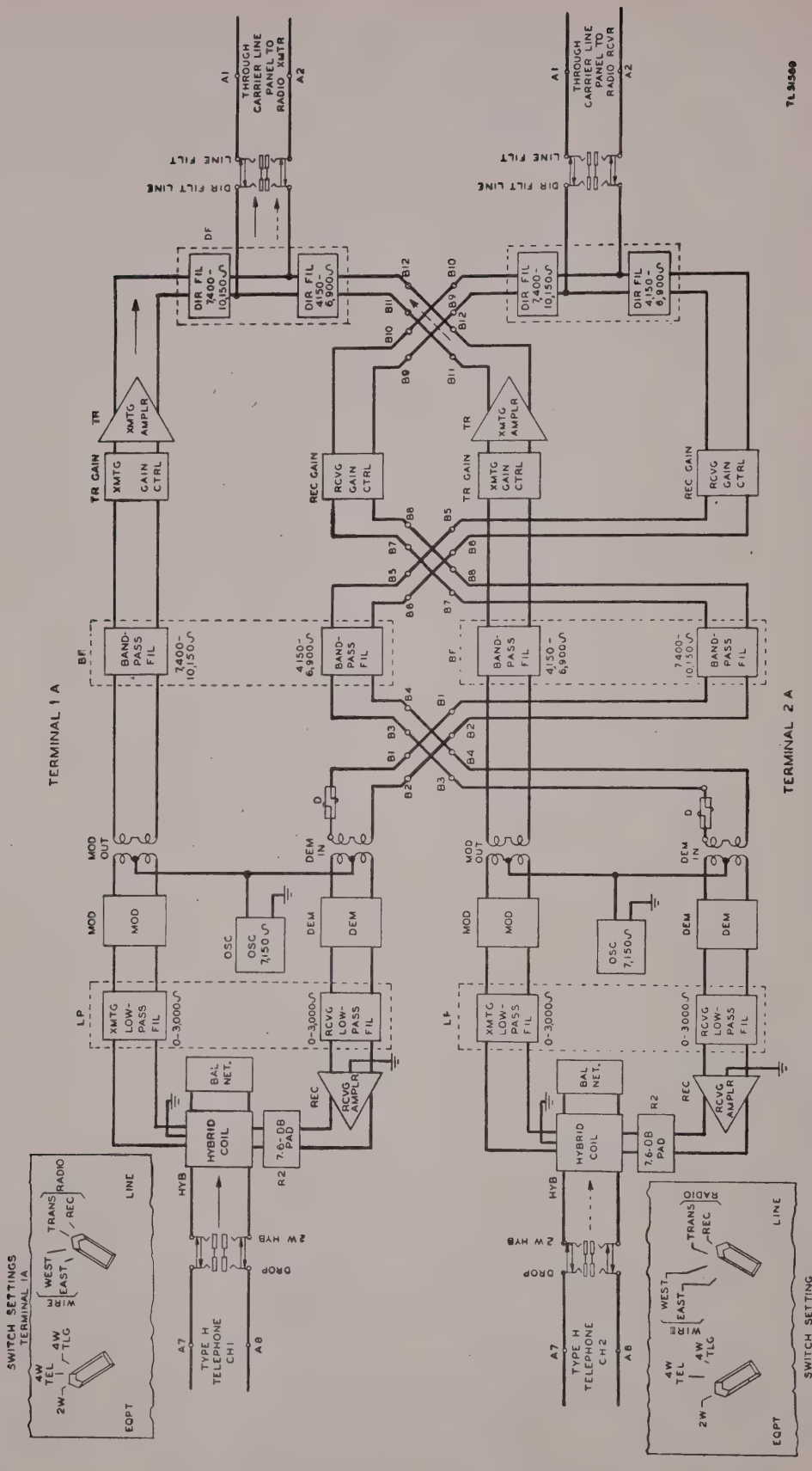


Figure 8. West end of radio link, block diagram.

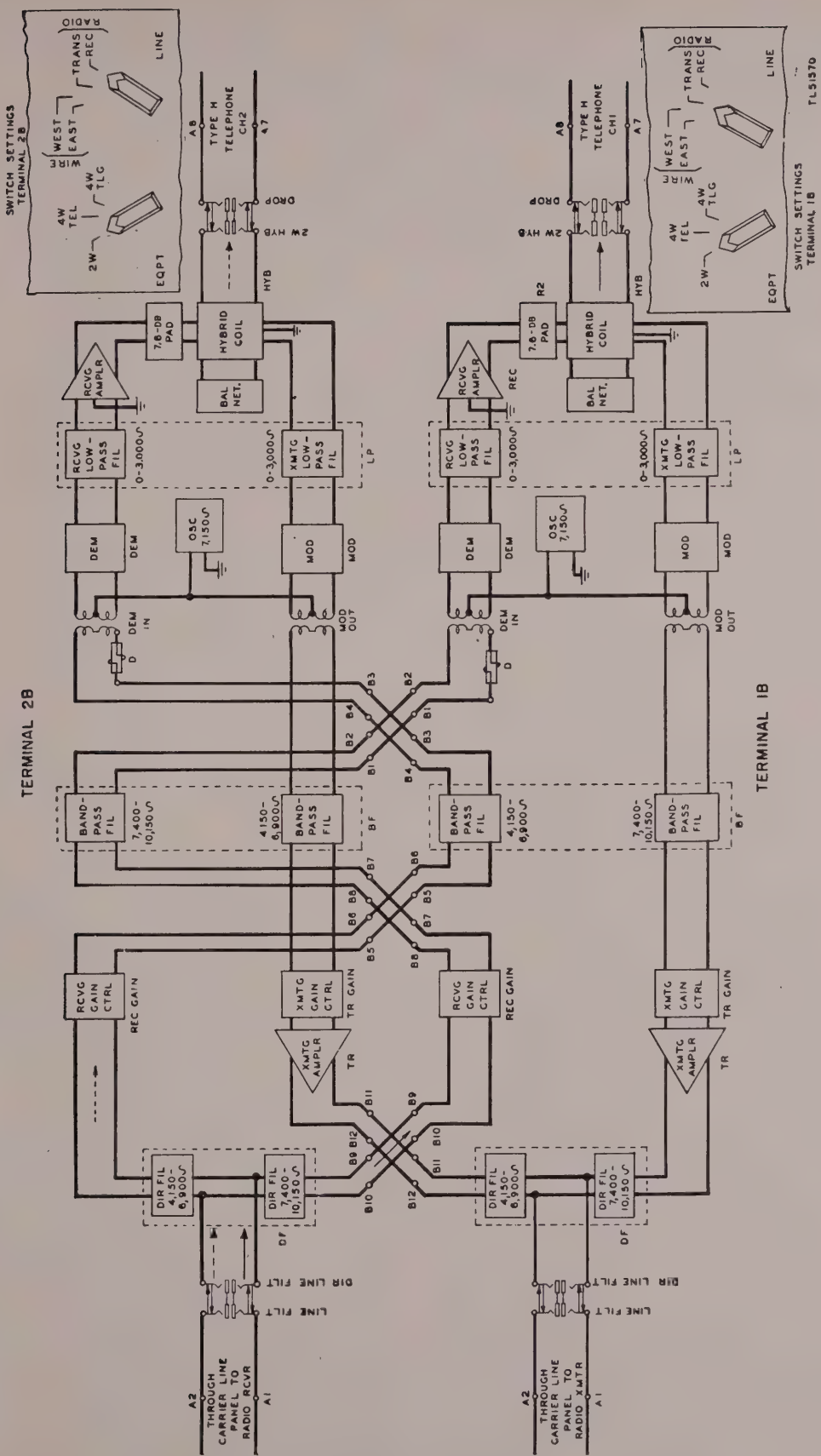


Figure 9. East end of radio link, block diagram.

c. Power Supply. The repeater power equipment is similar to that used in the terminal. An external source of 105- to 125-volt, 50- to 60-cycle, a-c power is required. The repeater power supply provides 10.5 volts ac for the heaters of the vacuum tubes and approximately 150 volts dc for the screen and plate voltages. The repeater panel provides no fuse or alarm circuits.

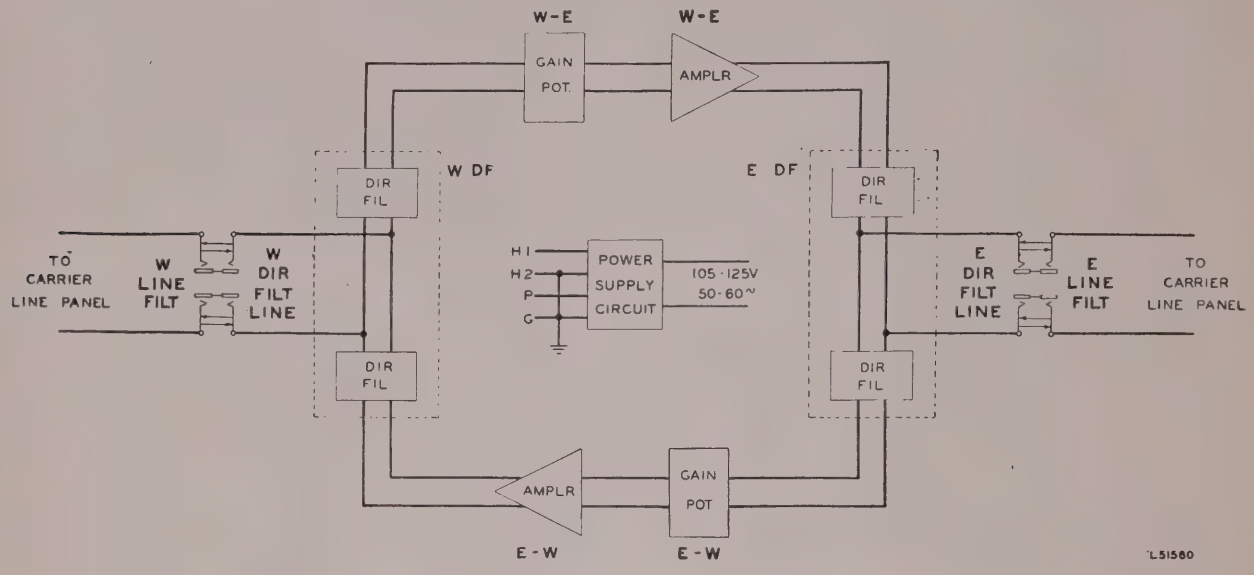


Figure 10. Type H repeater, block diagram.

6. General Functioning of Line Panel (fig. 5)

The line panel provides the line filters and balancing equipments required for use with terminal and repeater panels and at transfer points. Five separate units, which may be connected as desired, are included.

a. Line filter LF consists of two sections, a low-pass and a high-pass filter, for separating the voice and carrier frequencies.

b. For phantom-group operation, it is necessary that both side circuits of the phantom group be kept electrically identical. Line filter balance LFB is provided for this purpose and is connected in series with the line wires of the other side circuit, when this circuit is not equipped for H carrier operation, to balance the line filter on the carrier side circuit.

c. Line filter network LFN is connected into the balancing network of a voice-frequency repeater to balance line filter LF.

d. Line filter balancing network LF BN is connected into the balancing network of a voice-frequency repeater to belance line filter balance LFB.

e. Phantom line filter balancing network PH LF BN is connected into the balancing network of a phantom voice-frequency repeater to balance line filter LF and line filter balance LFB in the side circuits.

7. Electrical Characteristics

a. Frequency. (1) The frequency range of the type H carrier system is from approximately 4 to 10 kilocycles.

(2) Frequency bands are obtained by modulating a common carrier frequency of 7,150 cycles with the frequencies produced by the voice. Single side-band transmission is utilized, the carrier frequencies and unwanted side bands being suppressed. For transmission in the East-to-West direction the system uses the upper side band (approximately 7,400 to 10,150 cycles) and in the West-to-East direction it uses the lower side band (approximately 4,150 to 6,900 cycles).

b. Transmission-frequency Characteristics. Since equalization is not provided in type H carrier Terminal equipment, the transmission-frequency characteristics of the system depend largely on the terminal equipment and on the attenuation characteristics of the line over which the system is operated.

(1) *Without repeaters.* In a system operating without repeaters, generally it should be possible to obtain transmission bands having losses at 300 and 3,000 cycles not more than 10 db above the loss at 1,000 cycles. A representative over-all frequency

characteristic for a type H carrier system operating over a 145-mile line of 104 copper-steel (40 percent) open wire without intermediate repeaters is shown in figure 11.

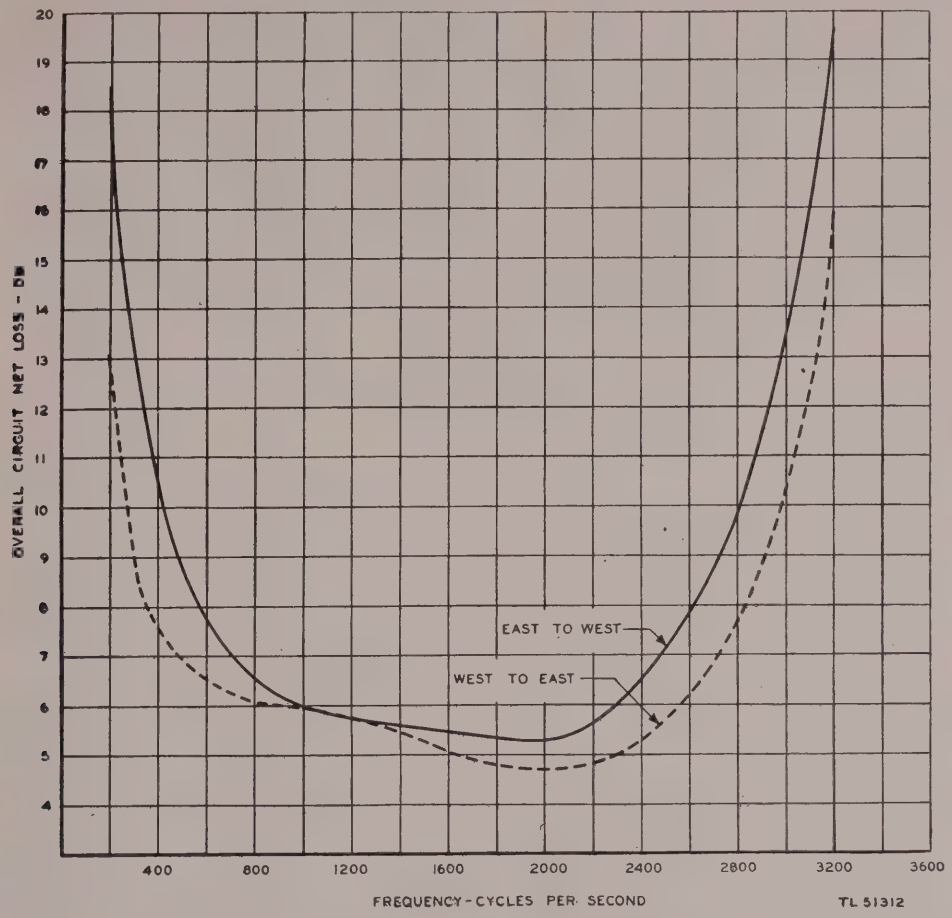


Figure 11. System transmission-frequency characteristics.

(2) *With repeaters.* When one or more repeaters are used in the system, some narrowing of the over-all transmission band results due to the attenuation characteristic of the additional line and the directional filters in the repeaters.

(a) Additional losses at upper and lower frequencies due to one repeater in the system are given in table I. This table shows losses referred to the loss at 1,000 cycles and is based on the gain-frequency characteristics for a representative repeater but does not include the attenuation effects of additional line.

Table I. Additional losses at edges of bands due to one repeater

Frequency (cps)	East-to-West loss (db)	West-to-East loss (db)
250	4.5	3.0
500	1.5	1.1
2,500	0.2	0.2
2,750	0.8	0.6
3,000	1.5	2.8

(b) Where more than one repeater is involved, the losses given in table I should be increased accordingly. Since no equalization is provided with the repeater, the attenuation-frequency characteristic of the additional line reduces the rounding-off effect at the lower edge of the East-to-West bands and the upper edge of the West-to-East bands. Correspondingly, it increases this effect for the lower frequencies in the West-to-East band, and the upper frequencies in the East-to-West band.

c. System Load Capacity. The system is designed to transmit an output power of about +16 dbm to the line. With the system properly adjusted, speech or telegraph currents should not cause appreciable overloading. When the terminal is arranged for two-wire operation on the switchboard side, powers up to +2 dbm can be delivered to the switchboard without appreciable distortion, and powers up to +5 dbm can be used if some distortion is permitted. When the terminal is arranged for four-wire

operation on the switchboard side, the system is arranged for an input and output of +4 dbm on the switchboard side.

d. Signaling. The type H carrier system requires voice-frequency ringing equipment at each terminal. Ringing equipment is not part of the type H system and must be provided separately.

e. Power. (1) The 105- to 125-volt, 50- to 60-cycle, a-c power source required by a type H carrier terminal and repeater is used to supply power to the vacuum tubes. The terminal uses approximately 20 watts of power and the repeater uses approximately 15 watts.

(2) A testing power, equivalent to one milliwatt at the two-wire input, (for circuits having extensions with a loss of 0.5 db or less), normally is used in setting up and maintaining a type H carrier system. All input and output powers in this manual are referred to this testing power. Power is expressed in dbm, which denotes power in decibels above or below 1 milliwatt (Odbm), terminated at 600 ohms. A plus sign is used to denote powers above 1 milliwatt and a minus sign for powers below 1 milliwatt.

Section II. APPLICATION

8. System Application

By utilizing a band of frequencies higher than the voice-frequency band, an additional telephone channel may be added to the channel already existing on a pair of telephone wires. Type H carrier equipment is designed to provide such a band of carrier frequencies for operation over an open-wire-line circuit. Operation of the type H system above the physical voice circuit has little effect on the physical circuit because the filters of the type H line panel prevent interference between the voice and carrier frequencies. The carrier system may be superposed on an open-wire pair terminated in voice-frequency repeaters, or on a nonrepeatered circuit providing it is terminated in repeating coils. Furthermore, the pair may be simplexed or composited for d-c telegraph operation. The type H carrier terminals may also be arranged for operation over radio links.

Note. In the applications described in the following paragraphs the switchboard sides of the carrier terminals are terminated on a two-wire basis for connection to a switchboard, two-wire extension, or two-wire voice-frequency carrier telegraph equipment. If desired, however, either or both of the carrier terminals can be terminated on a four-wire basis for connection to another carrier system, a voice-frequency repeater, or a four-wire voice-frequency carrier telegraph terminal.

9. Application to Two-Wire Physical Circuit (fig. 12)

This application illustrates the use of type H carrier equipment with voice-frequency telephone repeaters and d-c composite telegraph sets. Type H carrier equipment is inclosed within heavy lines and other equipment which must be provided in addition is inclosed within dashed lines. Note that voice-frequency ringing equipment must be provided for the carrier telephone circuit, and that protector equipment must be provided separately. The following variations of this application may also be utilized:

a. Without a Carrier Repeater at the Intermediate Point. In this case the high-pass filters of the two carrier line panels at the intermediate point are connected together directly.

b. Without Voice-frequency Telephone Repeaters. If the line is to be composited for telegraph operation, the voice-frequency ringing equipment must be retained, the voice-frequency telephone repeaters are replaced by repeating coils, and the line filter network portion of carrier line panel is not used. If the line is to be simplexed for telegraph operation, the voice-frequency ringing equipment for the voice-frequency telephone circuit and the composite sets are eliminated, and the voice-frequency telephone repeaters are replaced by repeating coils.

10. Application to Two-Wire Phantom Group (fig. 13)

Type H carrier operation over each side circuit of a phantom group is entirely satisfactory within the limitations of an H system provided the pairs are transposed for both carrier and phantom operation (par. 16*b*). This application illustrates the use of type H carrier equipment on the side circuit of a phantom group with voice-frequency telephone repeaters. Type H carrier equipment is inclosed within heavy lines and other equipment which must be provided in addition is inclosed within dashed lines. The arrangement of the type H carrier balancing network equipment has been omitted from figure 13 for clarity, but is shown in figure 14. The following variations of application shown in figure 13 may also be used:

a. Without a Carrier Repeater at the Intermediate Point. In this case the high-pass filters

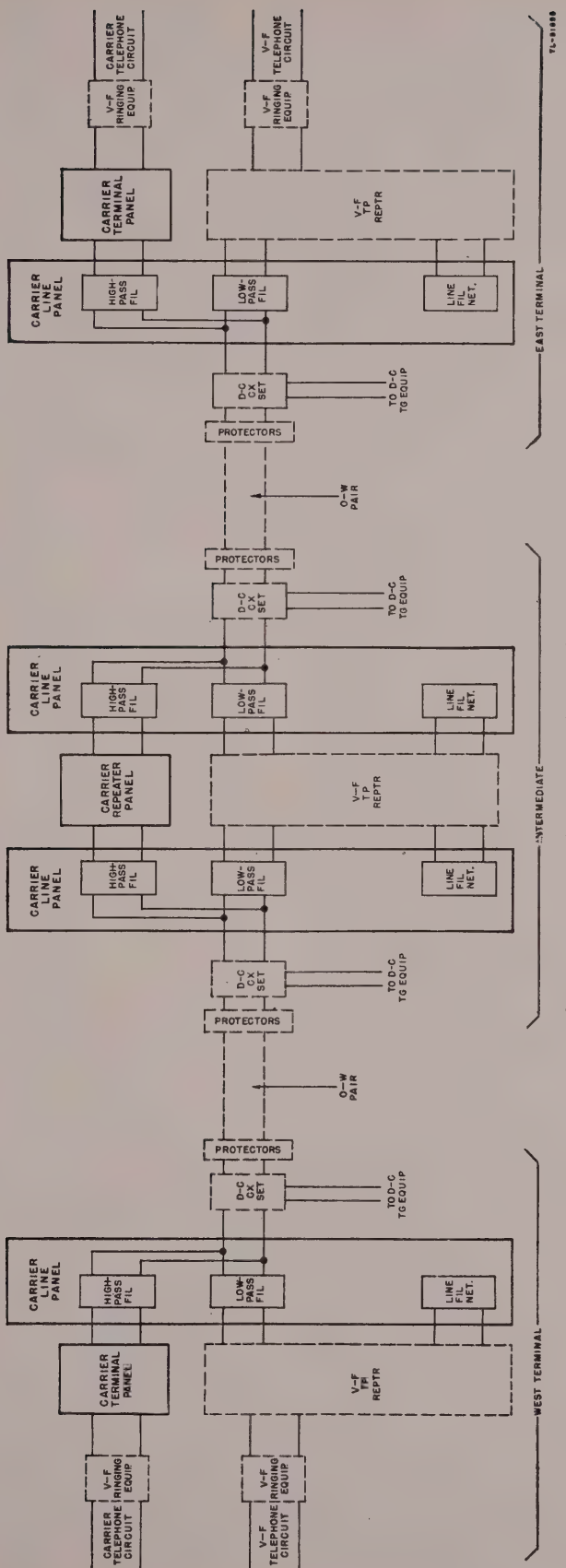


Figure 12. Application to two-wire physical circuit.

of the two carrier line panels at the intermediate point are connected together directly.

b. Without Voice-frequency Telephone Repeaters. If the line is to be composited for telegraph operation, the voice-frequency ringing equipment must be retained, the voice-frequency telephone repeaters are replaced by repeating coils, and the line filter networks are not used. If the line is to be simplexed for telegraph operation, the voice-frequency ringing equipment for the voice-frequency telephone circuits and the composite sets are eliminated and the voice-frequency telephone repeaters are replaced by repeating coils.

c. Type H Carrier on Both Side Circuits. In this case each side circuit is arranged in the same manner. The line filter balance units are not used since the line filters will balance each other.

d. Type H Carrier on One Side Circuit, Another Type of Carrier on the Other Side Circuit. In this case the arrangement of the type H carrier side circuit is similar to that shown in figure 13 except that a line filter balance unit and a line filter network, to balance the other carrier line filter, are connected into the line and network sides, respectively, of the voice-frequency telephone repeater line equipment. An application with type H carrier on one side circuit and type C carrier on the other side is shown in figure 15.

11. Application with Radio Link (fig. 16)

This application illustrates the use of type H carrier equipment with a four-wire radio link, providing two telephone channels in addition to the existing voice-frequency channel on the radio link. The arbitrary terminal designation 1A, 2A, 1B, and 2B agree with those discussed in paragraph 4*d* (figs. 8 and 9). Any or all of the channels may be used for voice-frequency telegraph operation, but if only one channel is so used, the original voice-frequency radio channel should be used and connected on a four-wire basis, as shown. Since two carrier terminals are required at each end of the link, full utilization is generally obtained by operating two type H channels over the link. If voice-frequency telegraph operation is not desired, the four-wire radio circuit either must be terminated on a two-wire basis or connected to a voice-frequency telephone repeater on a four-wire basis.

12. System Lay-out

The operation of a type H carrier system over an open-wire line presents transmission problems not encountered in voice-frequency transmission due to the higher frequencies used by the type H system.

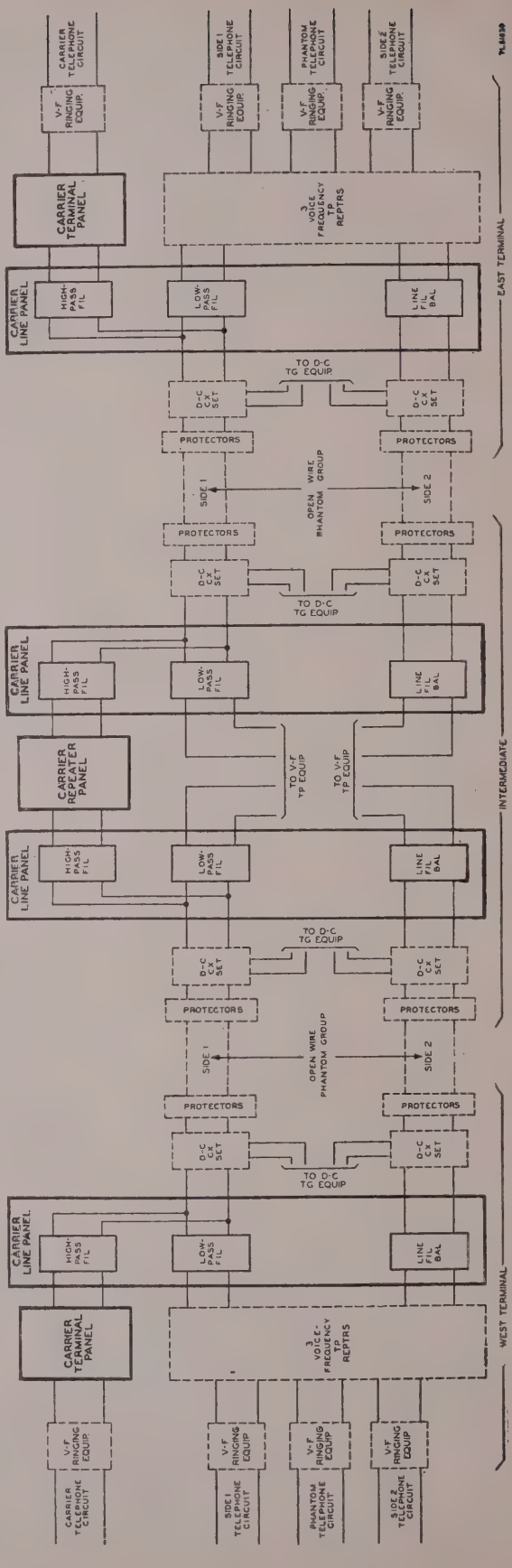


Figure 13. Application to two-wire phantom group.

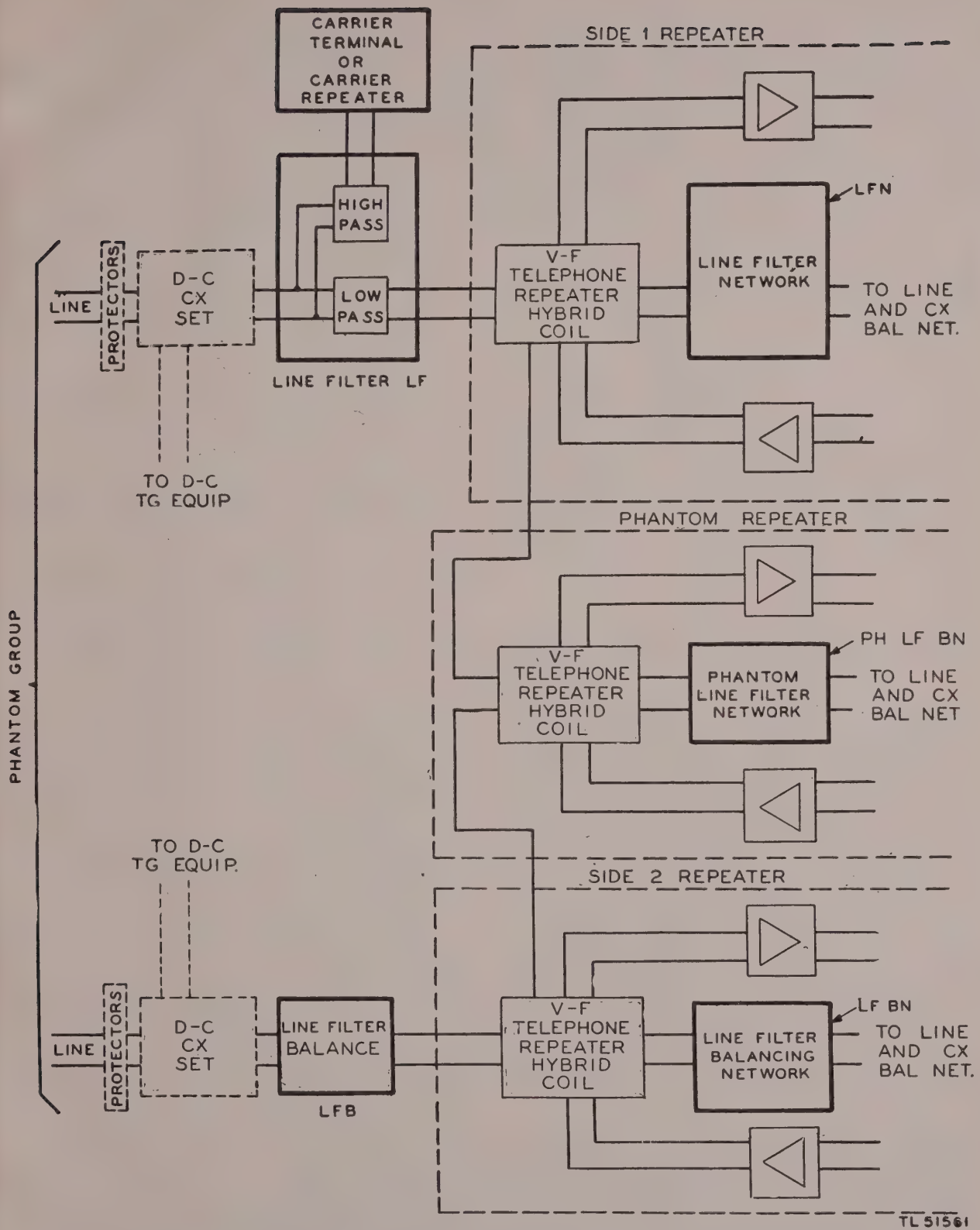


Figure 14. Arrangement of balancing network equipment for phantom group operation.

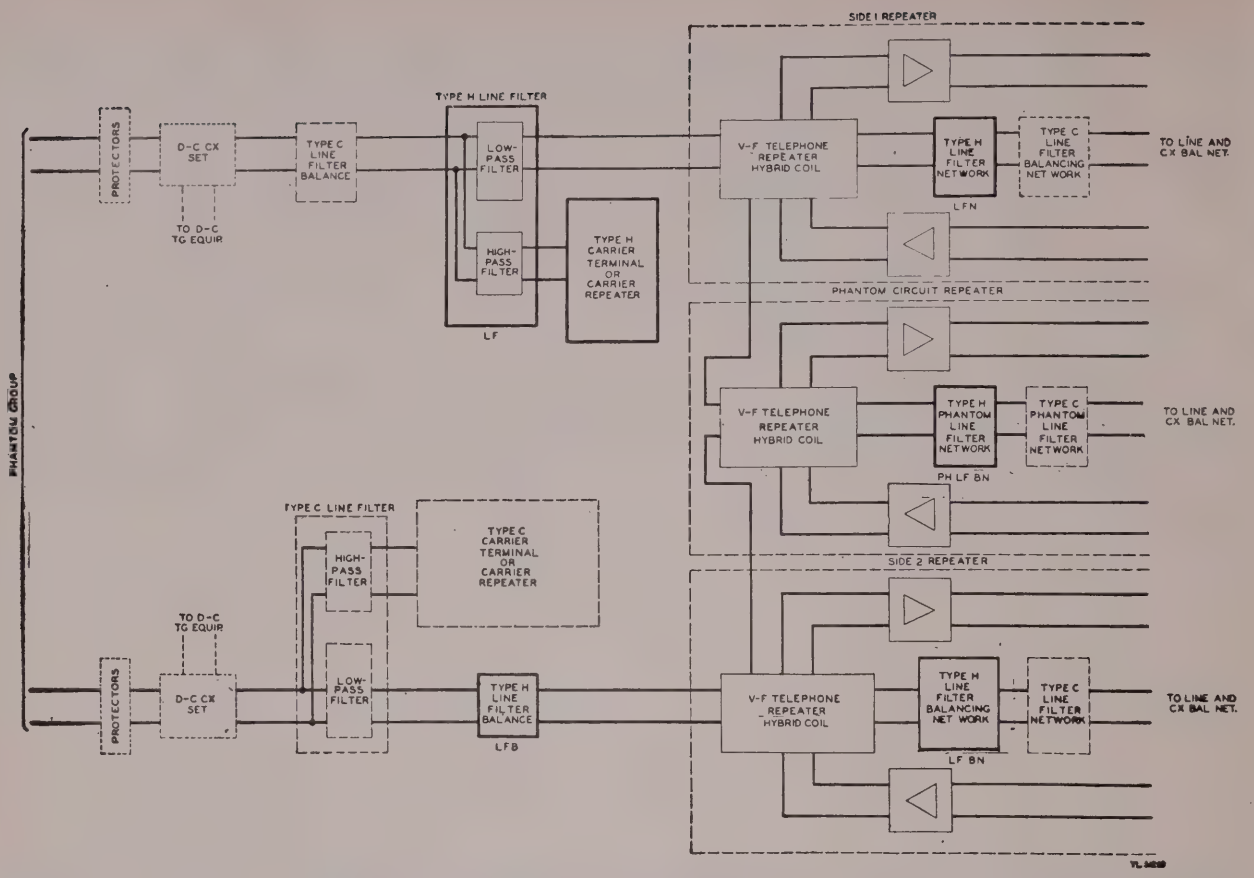


Figure 15. Arrangement of balancing network equipment for phantom group operation, type H carrier on one side circuit, type C carrier on the other.

Preliminary to the establishment of such a system, it is desirable that a survey be made of the facilities over which the system is intended to work. If the system is to be laid out by personnel in the field, this survey provides the basis for other considerations such as attenuation, impedance, noise, crosstalk, and operating distances. If the system is not to be laid out by personnel in the field, the survey data will be submitted to Office of the Chief Signal Officer, Army Communication Service, Plant Engineering Agency. This agency will lay out the system and provide the necessary equipment for operation of the system. Transposition lay-outs and drawings, if necessary, will be prepared to retranspose existing open-wire lines or for the construction of new lines.

13. Preliminary Survey

Satisfactory operation of the system will depend to a large extent upon the degree of thoroughness with which the preliminary survey is made. The data to be compiled are listed below.

a. Geographical Lay-out. (1) Location of system terminals.

(2) Location of intermediate points where repeater equipment may be installed and maintained conveniently.

(3) Mileage of the line between each location in (1) and (2) above.

b. Line Facilities. (1) Decide whether a new line is required or an existing line will be used. Give details of plans in this respect.

(2) Information concerning gauge and composition of wire, and pin locations available for the system in each section.

(3) Length of crossarms, spacing between pins, and spacing between crossarms.

(4) Transposition system, whether existing or proposed.

c. Cable. (1) Type, length, gauge, number of quads, or pairs.

(2) Location of all intermediate and entrance cables involved.

(3) Type of loading, if any (loading coil inductance or type, and spacing).

d. Other Carrier Systems Involved. Where other carrier systems are existing or proposed on the line involved, supply information concerning:

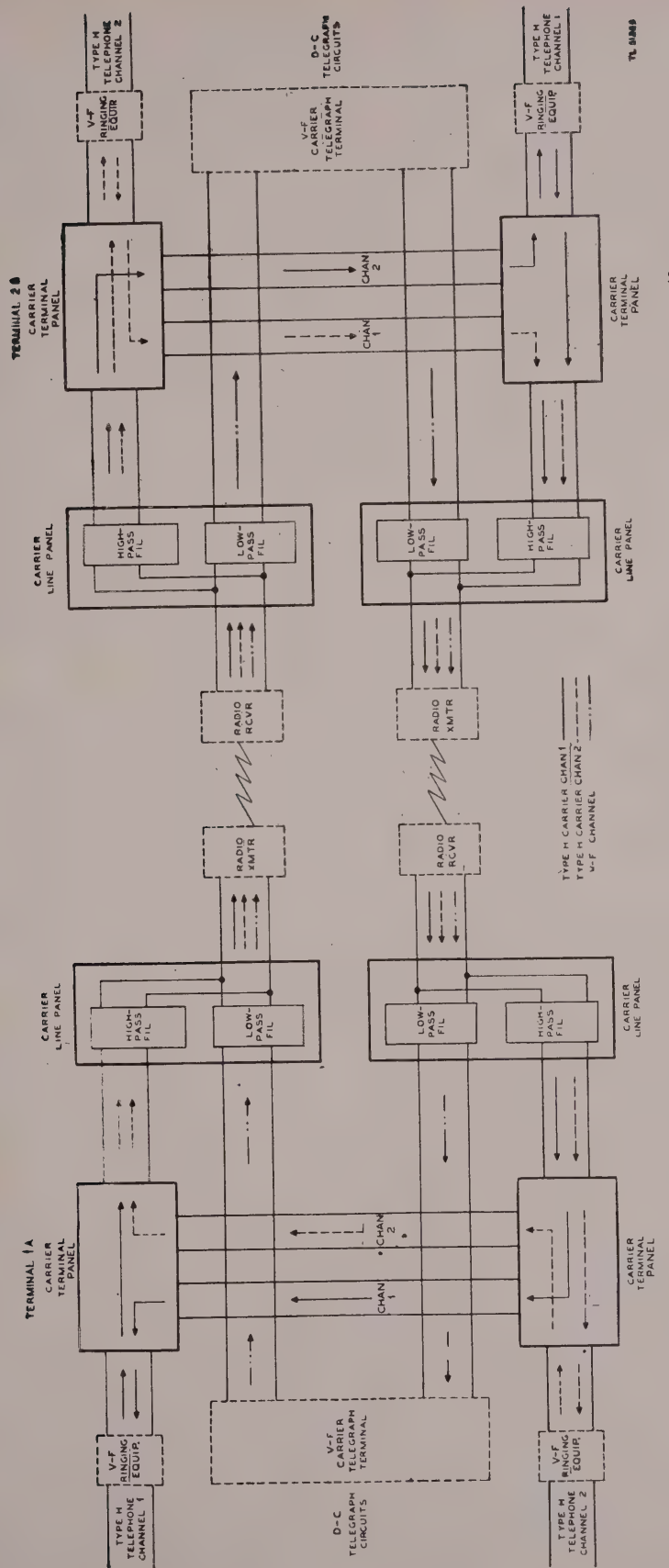


Figure 10. Application with radio link, block diagram.

(1) Type and frequency allocation of systems.

(2) Location of terminals and repeaters.

(3) Direction of transmission of frequency bands.

(4) Pin locations; gauge and composition of wire used by the systems in each section.

(5) Output power used on other systems.

e. Voice-frequency Terminations of Carrier Circuits. (1) Desired circuit net loss.

(2) Location of terminating switchboards. State whether they are adjacent to carrier terminals or reached by a second carrier channel or by voice-frequency extensions over cable or open-wire lines In the latter case give the length of the extension, the gauge of wires and whether the circuit is to be extended on a two-wire or four-wire basis.

(3) Number of voice-frequency ringers required and their proposed location.

(4) If system is to be used for transmission of voice-frequency carrier telegraph, state number of telegraph channels required in each direction.

f. Voice-frequency Circuit Terminating or Carrier Transfer Points. When line terminating and carrier transfer equipment is required, supply the following information:

(1) Number and location of transfer points.

(2) Whether the voice-frequency circuit terminates or transfers to another line at the transfer point.

(3) Whether composite or simplex telegraph circuits terminate or transfer to another line at the transfer point.

(4) Whether the carrier circuit transfers to another line at the transfer point.

(5) Indicate which pairs are physical and which are phantomed.

(6) If voice-frequency ringers are required on the voice-frequency circuits, give the number of ringers required.

g. Availability of Power. (1) Estimate whether the available power source will carry the additional load required by the type H carrier systems.

(2) Give voltage and frequency of power sources available at terminals and possible repeater points. Include capacity of generators.

14. Open-wire Lines

The characteristics of open-wire lines vary widely, depending upon the size and type of wire, spacing of wires on the crossarm, and the type of transposition system used. Since it is physically impossible to present data for all types of lines which may be encountered, data given in this manual is for lines constructed in accordance with TM 11-2253. Such lines are designed to carry normally two 88-inch crossarms, each with four pairs of copper or copper-steel wire and with a spacing of 8 inches between the wires of the pairs and 16 inches between pairs, which are suitable for carrier operation. The distance between poles will usually be approximately 150 feet.

a. Attenuation. The attenuation of open-wire pairs increases rapidly with frequency, so that losses in the carrier-frequency range usually will be appreciably greater than losses at voice frequencies. The attenuation of open-wire lines of the type described above is given for a number of representative frequencies in table II. Data are given both for dry and wet weather. In laying out a type H system, frequencies of 6,000 and 8,000 cycles ordinarily are considered, since these frequencies roughly represent the modulated 1,000-cycle points in the upper and lower transmitted bands, and wet weather values should be used in the calculation.

Table II. Approximate attenuation of open-wire line facilities

Description	Attenuation (db/mi)									
	Dry					Wet				
	1 kc	3 kc	6 kc	8 kc	11 kc	1 kc	3 kc	6 kc	8 kc	11 kc
080 copper-steel (40%)	0.23	0.29	0.30	0.31	0.32	0.25	0.30	0.32	0.34	0.35
104 do.	0.16	0.20	0.20	0.20	0.20	0.18	0.21	0.22	0.22	0.23
128 do.	0.12	0.13	0.14	0.14	0.14	0.13	0.14	0.15	0.16	0.16
080 copper	0.11	0.12	0.13	0.13	0.14	0.13	0.14	0.15	0.15	0.17
104 do.	0.074	0.077	0.084	0.089	0.099	0.083	0.087	0.096	0.11	0.12
128 do.	0.052	0.055	0.064	0.071	0.080	0.061	0.064	0.075	0.088	0.10
165 do.	0.034	0.038	0.051	0.056	0.064	0.042	0.047	0.060	0.072	0.083

b. Impedance. The characteristic impedance of open-wire pairs in the type H frequency range is about 550 to 650 ohms, and is of approximately constant value. Type H carrier equipment on the line side has an impedance of approximately 600 ohms and therefore a satisfactory impedance match is obtained.

15. Intermediate and Entrance Cables

a. The characteristic impedance of nonloaded cable is much lower than that of open-wire pairs in the type H frequency range. The characteristic impedance of the more commonly used gauges of nonloaded paper-insulated cable is approximately 120 to 140 ohms. Occasionally short lengths of intermediate or entrance cable may be required for lead-ins to offices or for spanning rivers, etc. The large difference between the impedance of the open-wire pairs (approximately 600 ohms) and of the nonloaded cable (approximately 130 ohms) will result in reflections at junction points. Reflections will also occur between the carrier equipment (approximately 600-ohm impedance) and the nonloaded cable. These reflections appear as far-end crosstalk between systems working on different pairs, and the amount of crosstalk will govern the amount of cable which can be tolerated.

b. Figure 17 shows the losses which will be obtained by introducing short lengths of nonloaded paper-insulated cable, having a capacitance of about 0.062 microfarads per mile, in a 600-ohm open-wire line. The mileage shown is that of the length of cable inserted. The losses shown include both the cable attenuation losses and the reflection losses at each end. Where several short pieces of cable are used with only a small amount of open-wire between them, the losses per length of cable may be somewhat less than the values shown in the curves. If rubber-insulated cable is used, greater losses will be obtained.

c. On lines where only one carrier system is to be operated, there will be no crosstalk problem, and the length of intermediate or entrance cable which can be tolerated is determined largely by the overall transmission loss. On lines where two or more carrier systems are to be operated, the amount of crosstalk which can be tolerated will limit the length of intermediate or entrance cable. The length of nonloaded, paper-insulated cable, having a capacitance of 0.062 microfarads per mile, should be limited to about 700 feet per repeater section. If cable with higher capacitance is used, the permissible length is reduced accordingly.

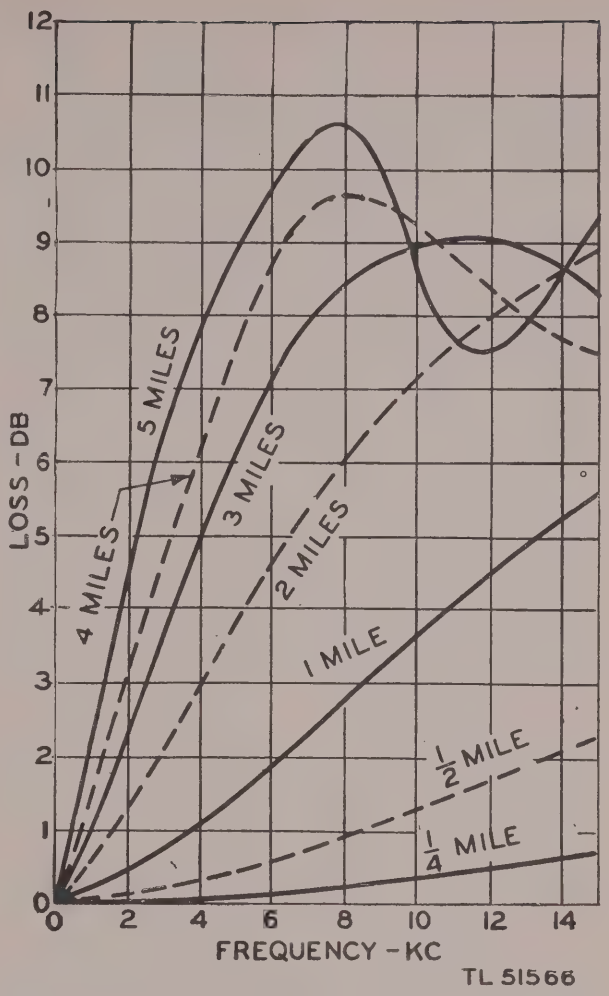


Figure 17. Insertion losses due to short lengths of nonloaded cable.

16. Noise and Crosstalk

Crosstalk resulting from the operation of other systems on the same pole line depends upon the types of systems involved, the relative energy levels, and the transposition layout. With the system properly lined up, the crosstalk coupling between the carrier circuit and the voice-frequency circuit on which the carrier is superposed is such that its contribution to the noise at the voice termination of either circuit should not be important. The type H system is designed to operate at high-frequency line powers which should be sufficient to keep the transmission relatively free from line noise likely to be encountered. The noise contributed by the terminal or repeater equipment should likewise be unimportant.

a. Noise. The type H system has been designed to operate at transmission power levels which should be sufficient to keep the system above the line noise likely to be encountered. Ordinarily, therefore, noise trouble should not be experienced unless very long

systems with high circuit net losses are utilized. In general, for a circuit having an over-all loss of 6 db, the over-all noise limit is 35 db RN (db above reference noise as read on a Western Electric Co. 2B noise measuring set with LINE weighting).

b. Crosstalk. All pairs on the same line are electrically coupled and therefore any currents transmitted over one pair will induce currents in all other pairs. If the amount of coupling is sufficiently great and the current induced in the other pairs is sufficiently large, conversation or telegraph signals on one pair can be overheard on another pair either as noise or in the original form. Crosstalk coupling between pairs is greater at carrier frequencies than at voice frequencies. To minimize crosstalk, open-wire facilities are ordinarily transposed either for voice-frequency or for carrier operation.

(1) When only one type H system is to be operated on a line, no crosstalk problem will result when either type of transposition system is used. However, crosstalk difficulties may arise where more than one type H system or type H and type C systems are to be operated on the same line. Ordinarily two type H carrier systems or a type H and type C system cannot be operated on adjacent horizontal, vertical, or diagonal pairs unless these pairs are carrier-transposed. On the other hand, when carrier pairs are widely separated physically, satisfactory operation may be possible when the pairs are transposed for voice-frequency operation only.

(2) Satisfactory crosstalk performance on any type of line requires that the directions of transmission of the same frequencies on a line be the same. The type H and type C systems have been designed with this in mind. Consequently all systems should be set up so that the East-to-West and West-to-East directions of transmission are the same for all systems. In addition, the outputs of all carrier systems in each direction of transmission should be as nearly equal as possible. Any differences in output will increase the crosstalk into systems with lower outputs by the amount of the difference. Where systems terminate at an intermediate point in a repeater section or branch off to another line, it is desirable that the output power of all systems be made equal at that point by adjusting the gain pads of adjacent repeaters or terminals.

(3) Under certain conditions it may be necessary to select pairs by actual test to obtain satisfactory crosstalk performance. It may also be necessary to reduce the repeater spacings. Pole pairs, since the crosstalk between them and other pairs on the line is high, generally are not suitable for type H operation when more than one carrier system is to be operated over the line.

(4) Since the frequencies used by tactical carrier telephone equipment do not coordinate with the type H frequencies, carrier systems using these equipments ordinarily cannot be operated on the same line with type H systems without excessive crosstalk.

17. Operating Distances

a. Transmission Range. Since the maximum length of line depends so largely upon the attenuation of the line facility utilized, it is customary to express transmission range in terms of the maximum line attenuation which can be spanned rather than in terms of geographical length. Line attenuation is measured in decibels (db), and tables are available in TM 11-462, 11-486, and 11-2022 showing losses in decibels per mile for various types of wire. The carrier repeaters and terminals provide gain (also indicated in db) which, within certain limitations, is used to offset the line losses. It is desirable that the over-all loss of circuits obtained by use of type H carrier equipment be kept to 6 to 12 db. In laying out a type H system, therefore, the decibel distance between terminals and repeaters will be governed by the amount of loss the gain provided by the terminals and repeaters can overcome to provide a circuit between 6 and 12 db loss. The permissible decibel line losses between terminals or terminals and repeaters represent the maximum attenuation which can be spanned. The geographical length in any specific case can then be determined from the attenuation per unit length of the line. Thus the main factors involved in determining the operating distance of a type H system are line attenuation, terminal gains, and repeater gains. In computing line attenuation for type H carrier the wet weather attenuation at 8,000 cycles ordinarily is used. Attenuation at this frequency for the more usual types of lines is given in table II. Based on the values of line attenuation, the maximum operating distances for the more usual type of open-wire lines which can be spanned with circuit net losses of 6 db and 12 db are given in table III.

b. Conditions Affecting Variations in Circuit Net Loss. The principal variation in the over-all circuit net loss will result from variations in line attenuation. For a circuit 200 miles in length the change between dry and wet weather may be as much as 4 db. Additional line changes due to variations of temperature also occur, but since such changes are usually gradual, they can be compensated for by adjustment of the REC GAIN po-

tentiometers. The adjustment provided should make it possible to maintain the circuit net loss to within 2 db of the desired value. When the carrier system is operated over a line less than about 75 miles long, no adjustments of the gain controls should ordinarily be required.

Table III. Maximum operating distances

Line facilities	Miles					
	Without repeater		One intermediate repeater		Two intermediate repeaters	
	6 db	12 db	6 db	12 db	6 db	12 db
080 Copper-steel (40%)	95	110	160	175	220	240
104 Copper-steel (40%)	145	170	245	270	340	370
128 Copper-steel (40%)	200	240	335	375	470	510
080 Copper	215	250	360	400	500	545
104 Copper	290	340	490	545	690	740
128 Copper	360	430	610	680	860	930
165 Copper	440	530	750	830	1,050	1,135

c. Terminal Gains. For satisfactory circuit operation, and to prevent singing difficulties, the sum of the transmitting and receiving gains (loop gain) for any type H carrier terminal cannot exceed 26 db. Usually 16 db of the available 26 db are utilized for transmitting gain and up to 10 db utilized for receiving gain. Therefore to obtain a circuit with an over-all circuit loss of 6 db, there will be a maximum line loss of 32 db available between terminals. The factors governing these figures are explained below:

(1) The carrier terminal ordinarily transmits a high-frequency power of +16 dbm to the line, which normally results in a transmitting gain of 16 db (unless the carrier system is extended on a two-wire basis).

(2) The maximum available over-all receiving gain is likewise 16 db when the carrier terminal is arranged for two-wire operation on the switchboard side. The permissible loop gain, however, which can be used at a terminal is 26 db. Thus the maximum allowable receiving gain, for a transmitting gain of 16 db, is limited to 10 db.

(3) To obtain the desired circuit figure of —6 db, a maximum of 32 db can be spanned between terminals. A signal transmitted at +16 db can enter the receiving terminal at —16 db and be raised by the 10 db gain available in the receiving terminal to the desired —6 db. Thus the signal has traveled through a loss of 32 db (starts at +16 db, is received at —16 db).

d. Repeater Gains. (1) For satisfactory circuit operation, and to prevent singing difficulties, the sum of the East-to-West and West-to-East gains (loop gain) for any type H repeater must not exceed 45 db. For the most favorable signal-to-noise ratio and crosstalk performance the ideal transmitting power level is +16 dbm. A transmitting level of more than +16 dbm may result in crosstalk trouble and a transmitting level of less than +16 dbm may result in less favorable signal-to-noise ratio. From a practical standpoint, however, often it is not possible to lay out the circuit so there will be a transmitting level of +16 dbm. From a circuit design standpoint it is ideal to so locate the repeater that losses of the line sections on each side will be equal and that half the loop gain can be used for East-to-West amplification and half for West-to-East amplification. Because of practical considerations, such as available office sites, etc., it is seldom possible to lay out the circuit in such a way that the line losses will be equal in both directions. It is stressed therefore that the following discussion of repeater gains is for the purpose of illustrating the factors involved and is the ideal situation rather than one which may be encountered often in practical operation.

(2) The loop gain for a repeater cannot exceed 45 db, which permits 22.5 db gain for East-to-West amplification and 22.5 gain for West-to-East amplification. Since the desired repeater East-to-West transmitting output is +16 dbm, if the West-to-East receiving gain is to be 22.5 db the incoming signal can be no lower than —6.5 db (the difference between the output level, +16 dbm, and the available gain, 22.5 db). If the incoming signal were —16 dbm, for instance, a 32 db gain would be required to raise it to the transmitting power level of +16 dbm, leaving a 13 db gain available for the other direction of transmission. Thus, between a transmitting terminal and a repeater, the maximum loss which can be spanned is 22.5 db (signal starts at +16 dbm, is received at —6.5 dbm). Between a repeater and a receiving terminal, however, a loss of 32 db can be spanned since the signal which starts at +16 dbm can enter the receiving terminal at —16 dbm and be raised by the 10 db gain available at the receiving terminal to the desired —6 dbm.

e. Singing Limitations. The point of amplification at which singing occurs will limit the amount of gain which a terminal or repeater can furnish. Singing is caused by coupling between the output and input circuits of the amplifiers.

(1) There is a compromise balance network connected to the hybrid coil circuit to balance the switchboard and/or extension impedance. The better the balance the higher will be the loss across the singing path of the hybrid coil. (The path between amplifiers of a repeater or terminal in which currents circulate and contribute to singing is known as the singing path.)

(2) In practice, however, because of the varying types of terminations encountered, a fixed network usually does not balance the extension circuit perfectly and thus a certain amount of feed-back is present becoming more objectionable as gains are increased.

(3) When the gain provided by the amplifiers is greater than the total loss in the circuit (the loss across the hybrid coil, and the losses of the filters and other circuit components) the feedback circulating in the terminal or repeater will cause singing.

(4) The loop gain limits for terminals and repeaters given in *c* and *d* above ordinarily provide sufficient margin so that singing will not occur.

18. Transmission Diagram (fig. 18)

In laying out a type H system it will be desirable to prepare a transmission diagram, assuming the terminals to be terminated on a two-wire basis on their switchboard sides. Such a diagram will enable visualization of the output and input powers at various points along the system and permit ready computation of the terminal and repeater loop gains. The diagram can be constructed by plotting, for each direction of transmission, the input and output powers for each transmitting terminal, repeater, and receiving terminal respectively, starting with an input of 0 dbm at the transmitting terminal. Ordinarily wet weather attenuation at 6,000 cycles is utilized for computing losses in the West-to-East direction of transmission and at 8,000 cycles for the East-to-West direction.

a. Assume it is desired to operate a type H system with a 6-db circuit net loss over a 104 copper-steel (40 percent) open-wire line 200 miles in length. There is a type C system on the same line with a terminal at one end and a repeater 75 miles distant, at which point the type C system leaves the line. Sufficient pairs are available so that crosstalk is not a primary consideration. From table III it is determined that one repeater will be required. Obviously this repeater should be located at the type C repeater point. The loss of the line for each repeater section is next computed at 6,000 and 8,000 cycles (table II). Since the loss for 104 copper-steel (40 percent) is the same for each of these frequencies, the loss from the first terminal to the repeater in either direction of transmission will be the product of 0.22 and 75 or 16.5 db and that from the repeater to the second terminal the product of 0.22 and 125 or 27.5 db. The transmission diagram can now be prepared.

b. Starting with transmission in the West-to-East direction, a test power input of 0 dbm at the 2W HYB jacks of the West terminal is increased to an output power of +16 dbm to the line. Between the West terminal and repeater there is a line loss of 16.5 db (75 miles at 0.22 db loss per mile), which produces an input power of —0.5 dbm (+16 dbm minus 16.5 db equals —0.5 dbm) at the repeater

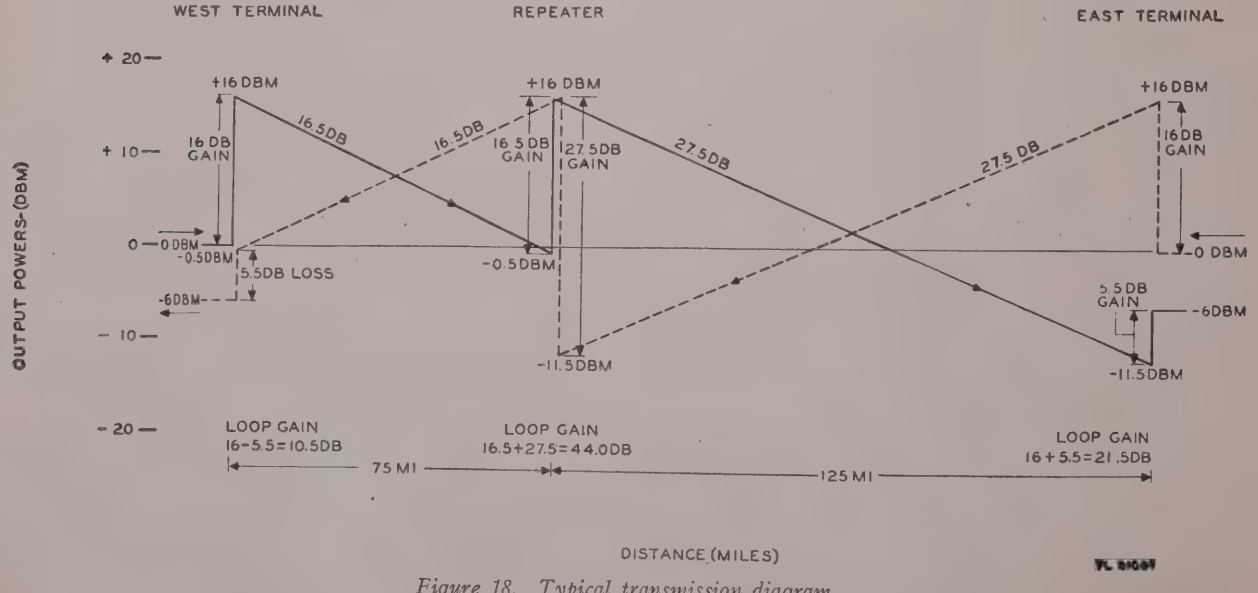


Figure 18. Typical transmission diagram.

where the power is amplified 16.5 db by the repeater to +16 dbm. Between the repeater and the East terminal there is a line loss of 27.5 db (125 miles at 0.22 db loss per mile), which produces an input power of —11.5 dbm (+16 dbm minus 27.5 db equals —11.5 dbm) at the East terminal where the power is amplified 5.5 db to bring it to the desired —6 dbm level (—11.5 dbm plus 5.5 db equals —6 dbm). In the East-to-West direction, the input power is raised from 0 dbm to +16 dbm at the East terminal, is attenuated 27.5 db in the line, and enters the repeater at —11.5 dbm. Here it is raised 27.5 db to +16 dbm, is attenuated 16.5 db in the line, and enters the West terminal at —0.5 dbm. In the West terminal the input power is attenuated 5.5 db to the desired —6 dbm level.

c. The loop gains can now be obtained from the transmission diagram by adding the gains and losses for each terminal and repeater in each direction of transmission. Thus the loop gain for the West terminal is the difference between 16 db and 5.5 db, or 10.5 db. (The 5.5 db is subtracted since the signal was attenuated at the West terminal.) For the repeater the loop gain is the sum of 16.5 and 27.5 db, or 44.0 db. For the East terminal the loop gain is the sum of 16 db and 5.5 db, or 21.5 db. These loop gains are within the required limits of 26 db for a terminal and 45 db for a repeater.

19. Transmission Measurement

a. When the equipment is placed in operation, the losses and gains of all components of the circuit and the over-all circuit net loss should be measured to determine the actual working conditions. An oscillator and a transmission measuring set may be used for this purpose. Usually a test power is applied to the input of the circuit to be measured, and then the output of the circuit is measured. It will generally be found that these measurements differ from the computed losses and gains. The transmission diagram and the equipment adjustments must then be changed accordingly. If an oscillator and a transmission measuring set are not available, the over-all circuit operation should be checked by conversing over the circuit and comparing its performance with other circuits.

b. The frequency of the test power used depends upon the circuit being measured. The loss of a line section is measured by using a frequency within the carrier range, but the over-all, terminal-to-terminal, loss is measured by using a frequency within the voice-frequency range (usually 1,000 cycles). Terminal gains are measured by applying voice-frequency test powers at the switchboard side and carrier-frequency test powers at the line side. Repeater gains are measured by applying carrier-frequency test powers. It is also important that the test power levels used correspond to the actual working levels of the circuits being measured.

c. When connected to a switchboard on a two-wire basis, the test power input to the carrier system from the switchboard is 0 dbm (assuming no voice-frequency extension) and the test power delivered to the switchboard normally is adjusted to —6 dbm as measured at the two-wire side of the carrier terminal. When connected in this manner the 1,000-cycle net loss of the circuit is 6 db. When the switchboard side of the terminal is connected on a four-wire basis the incoming voice-frequency testing power from the switchboard side is +4 dbm and the receiving circuit is adjusted to deliver +4 dbm to the switchboard side.

20. Coordination

a. If type C carrier or another type H system is used on another pair of the same open-wire line the systems must be coordinated. Such coordination has two main factors, power output and direction of transmission.

(1) All systems to be coordinated should be laid out in such manner that the power level at a given frequency at a given point in the line will be approximately equal for all systems. In any given location where type H terminals or repeaters of different systems are installed, there should be no more than 6 db difference in power output. (The use of two type H systems on adjacent pairs or on another pair in the same phantom group is not recommended. However, if two such systems are installed, the differences in power levels should be reduced to a minimum.) In all locations where type H and type C carrier equipment are installed, there should be no more than 6 db difference in output levels between the type H carrier high group of frequencies and the 8-kilocycle point in the type C carrier low group of frequencies.

(2) Frequencies in the same range should be transmitted in the same direction. For instance, if two type H systems are to be coordinated, each system should transmit its 7.4- to 10.1-kilocycle band in the East-to-West direction and its 4.1 to 6.9-kilocycle band in the West-to-East direction. If a type C system and a type H system are to be coordinated, the East-to-West 6.5- to 15.6-kilocycle band of the type C carrier and the East-to-West 7.4- to 10.1-kilocycle band of the type H carrier should be transmitted in the same direction because the two bands contain some of the same frequencies. The dissimilar type

C and type H carrier bands will then be transmitted in the West-to-East direction.

b. Type C carrier cannot be superposed on the same pair on which a type H carrier system is superposed because of overlapping of frequencies. The overlapping of frequency bands is shown in figure 19. The lower side band (4.1 to 6.9 kilocycles) of the H carrier system is shown as the W to E block, and the upper side band (7.4 to 10.1 kilocycles) as the E to W block.

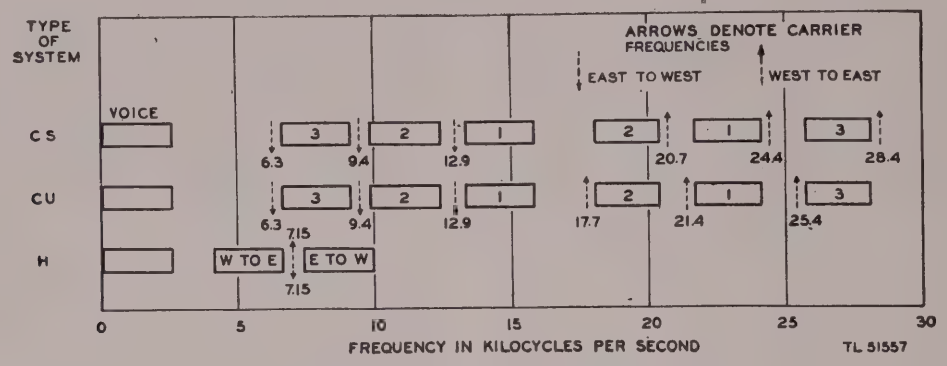


Figure 19. Frequency allocation of carrier systems.

21. Radio Link Lay-out

a. General. The radio circuit which is to be used as a link between two type H carrier terminals must be a high-fidelity, continuous two-way transmission type, able to handle a reasonably flat frequency band extending to at least 10 kilocycles. The transmitting and receiving radio equipment must be terminated separately and must be arranged to have an impedance of approximately 600 ohms where connection is made to the carrier line filters. The carrier equipment may be located with the radio equipment, or may be separated physically and connected with short open-wire lines or cable circuits, provided satisfactory crosstalk performance can be obtained. Ordinarily, of the three channels available when type H carrier is superposed on a radio link, the two carrier channels will be used for telephone and the radio (voice) circuit for voice-frequency carrier telegraph. No volume limiters are required on the type H telephone channels. The radio circuit, through the low-pass filters of the carrier line panel, connects to the voice-frequency carrier telegraph equipment on a four-wire basis. Either one or both of the type H carrier terminals may be used for voice-frequency carrier telegraph by connecting the switchboard sides of the terminals to the telegraph equipment on a four-wire basis.

b. Differences Between Wire and Radio Link. The problems of radio link transmission differ somewhat from the problems of wire transmission. In wire transmission initial amplification is provided by the carrier terminal. In radio link transmission amplification is provided by the radio transmitter. The design of the radio transmitter permits much greater amplification than does the design of the carrier terminal, but with this greater capacity of the radio transmitter for amplification there is a correspondingly greater problem of interference between channels. For this reason the signal must enter the radio transmitter at a lower power level than it enters the carrier terminal. The degenerative effect of intermodulation on telegraph signals is greater than on telephone transmission. For this reason, when any of the channels of a radio link with type H carrier superposed are used for telegraph transmission, the input level to the radio transmitter is adjusted to that level which will be most efficient for telegraph transmission.

c. Input and Output Power Levels. Definite input and output power levels for telephone and telegraph transmission over a radio link cannot be given since the capability of the radio transmitter and receiver is the governing factor. Proper input and output power levels for satisfactory transmission will have to be determined by trial.

(1) *Transmitting power levels. (a) Voice-frequency power levels for telegraph transmission.* When 12 channels are operated on the voice-frequency circuit, the power level per channel should be approximately —11 dbm transmitted to the radio or H carrier equipment. When fewer than 12 channels are used, the power level may be raised accordingly. The power level at the input to the radio transmitter cannot be specified definitely because it will be limited by overloading and intermodulation in the transmitter and thus will depend upon the characteristics of the particular transmitter used. However, the power level into the radio transmitter

may be controlled sufficiently by adjusting the input potentiometer of the radio transmitter.

(b) Type H carrier power levels. When the type H channels are used for telephone, the suggested power level from the switchboard is 0 dbm and the suggested level at the line side of the terminal is —10 dbm. When the type H channels are used for telegraph, the power level at the switchboard side should be —11 dbm per channel and the level at the line should be —10 dbm.

(2) *Receiving power levels.* The received power level at the REC LINE of the voice-frequency carrier telegraph terminal should be at least —11 dbm per channel. In adjusting the power level of the radio receiver ouput, the loss in any line between the receiver, carrier terminal, and voice-frequency telegraph equipment must be considered. The output power level from the receiver should be sufficient to overcome any such line loss and reach the telegraph equipment at a minimum of —11 dbm per channel. With the receiver output at this level the input power level at the line side of the carrier terminal will be satisfactory. The desired power level (generally —6 dbm) at the carrier terminal switchboard can then be reached by adjusting the receiving gain to raise the signal to the desired level.

22. Carrier Terminations and Extensions

a. General. Discussions of circuit loss up to this point have considered only the carrier terminal-to-carrier terminal portion of the circuit. When the carrier circuit is terminated at a switchboard adjacent to the carrier terminal, only these terminal-to-terminal considerations need be considered. However, if the carrier circuit is extended, either on a two-wire or four-wire basis, the over-all circuit (switchboard-to-switchboard) must be considered. Though it is desirable that the extension terminate at no less than a —6-dbm power level, it may often be necessary to accept a less favorable power level than —6 dbm at the terminating switchboard. The amount of loss greater than 6 db which can be tolerated will depend on transmission conditions. Distinction is made in this text between extension on a two-wire or four-wire basis and termination on a two-wire or four-wire basis. Both refer to arrangements on the switchboard side of the carrier terminal, but termination refers to actual connections and switch settings at the carrier terminal whereas extension refers to the facilities by which the circuit is extended. For example, if the type H system connects to a voice-frequency repeater adjacent to the terminal, the type H carrier terminal would be terminated on a four-wire basis for connection to one side of the repeater, and the circuit beyond the repeater would be extended either on a two-wire or a four-wire basis, depending on whether the extension facility were an open-wire pair or two cable pairs. The power levels and circuit losses indicated in the following paragraphs are examples of conditions most favorable to good transmission, but their use as examples does not mean that others may not be used with good results.

b. Terminations. A type H carrier terminal may be terminated on the switchboard side on a two-wire or a four-wire basis. When the terminal is terminated on a two-wire basis the voice currents pass through a hybrid coil circuit. When the carrier terminates on a four-wire basis, connection is made directly to the input and output of the associated equipment, thus making it unnecessary to use hybrid coil circuits. When talking circuits derived from a carrier system connect to a switchboard in the same office in which the carrier terminal is located, the carrier terminal will be connected to the switchboard on a two-wire basis (fig. 20).

(1) *Receiving.* The power level ordinarily will be adjusted to —6 dbm at the carrier receiving terminal and will be extended to the switchboard at the —6 dbm level.

(2) *Outgoing.* The power level transmitted from the switchboard to the carrier terminal will be about 0 dbm. (The carrier terminal equipment will modulate and amplify the signal for transmission over the line.)

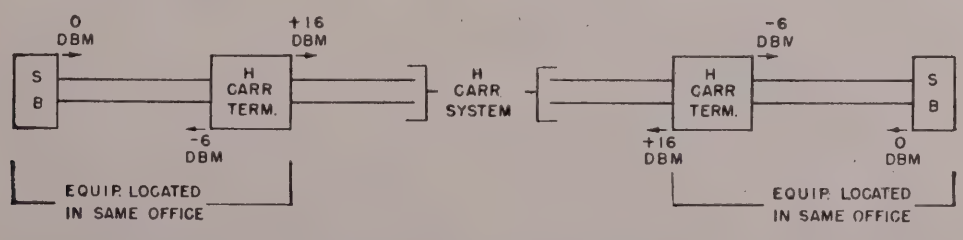


Figure 20. Switchboard termination.

c. Extensions. A type H carrier system may be extended either on a two-wire or a four-wire basis, depending on the facilities used. If extended on an open-wire pair, the type H system is terminated on a two-wire basis. On four-wire cable arrangements the type H system is terminated on a four-wire basis. The amount of loss in the extension and the amount of gain available at the carrier terminal will determine the design of the extension circuit. If there is sufficient receiving gain available at the carrier terminal so that the loss in the extension circuit can be overcome to obtain a satisfactory power level at the extension switchboard, the circuit may be designed without a repeater. Two of the factors which will govern the gain available for the extension circuit are the maximum permissible transmitting gain which a terminal can provide and the amount of gain remaining in the terminal after the carrier circuit power levels are met.

(1) *Maximum permissible transmitting gain.* The maximum terminal loop gain is +26 db and the most favorable transmitting level is +16 dbm. To these limitations must be added a limitation on the maximum amount of transmitting gain which a terminal can provide. This maximum transmitting gain for a type H carrier terminal is +20 db. That is, if a signal is to be transmitted at +16 dbm, it can enter the 2W HYB jacks of the terminal at a power level no lower than —4 dbm (if it enters the carrier terminal at less than —4 dbm, it will have to be transmitted at a power level lower than the desired +16 dbm). In using the maximum transmitting gain of +20 db it must be remembered that this will leave only 6 db of the 26-db loop gain available for amplification in the receiving direction.

(2) *Amount of gain remaining in terminal.* If the carrier circuit has been so designed that there is gain available in the carrier terminal, this gain may be utilized to obtain a more favorable power level at the extension termination. A circuit which terminates at —6 dbm at the carrier terminal and which has a 4.5-db gain available before the 26-db terminal loop gain is exceeded is shown in figure 18. The East terminal loop gain is 21.5 db, leaving 4.5 db available which may be applied to the extension circuit. This should be divided to give a gain of approximately 2 db in each direction for the extension circuit. Instead of leaving the carrier terminal at —6 dbm, the 2-db gain will raise the power level toward the switchboard to —4 dbm. If the extension circuit has a loss of 2 db the signal will arrive at the switchboard at the desired —6 dbm level. In the other direction of transmission, the signal transmitted from the extension switchboard at 0 dbm will lose 2 db between the terminating switchboard and the carrier terminal, arriving at —2 dbm. A transmitting gain of 18 db will be required to raise it to a power level of +16 dbm for transmission over the line. The loop gain at the carrier East terminal now totals 25.5 db (an increase of +2 db receiving and +2 db transmitting).

23. Extensions to Voice-frequency Telephone Repeaters and Other Carrier Telephone Systems

a. Four-wire Basis (fig. 21). All extensions to voice-frequency telephone repeater systems and other carrier telephone systems should be made on a four-wire basis to reduce input and output equipment losses and singing paths. The type H carrier system is laid out as though it would be terminated on a two-wire basis and have a circuit net loss of 6 db. It is assumed that each system connected in tandem can be operated with a 6-db circuit loss if terminated on a two-wire basis. If greater losses are encountered, the circuit must be considered from switchboard-to-switchboard, and deviations made in the individual systems involved as required. After the type H carrier system is laid out on a two-wire, 6-db loss basis, it is arranged for four-wire termination at the point of connection to the other system. The transmitting path of the type H system is connected to the receiving path of the other system, and the other system is adjusted to transmit a power level of +4 dbm to the type H system. The receiving path of the type H carrier system is connected to the transmitting path of the other system, and the type H system is adjusted to transmit a power level of +4 dbm to the other system. If the terminal equipment of both systems is not located in the same office and the interconnection is made with four-wire cable facilities, the connections are arranged as described above, but the loss contributed by the cable facilities must be considered. The receiving and transmitting equipment must be readjusted to compensate for this loss and to compensate for deviations from the nominal 4-db levels at the input to the transmitting path of each system. The desired circuit net loss from switchboard-to-switchboard is established by adjustment of the receiving equipment of the system to which the two-wire connection to the switchboard is made.

b. Two-wire Basis. Although two-wire interconnections between two systems are not recommended and should be avoided, it may at times be necessary to use them because the connecting equipment is not arranged for four-wire termination or the equipments are separated and are to be interconnected with open-wire facilities. However, the num-

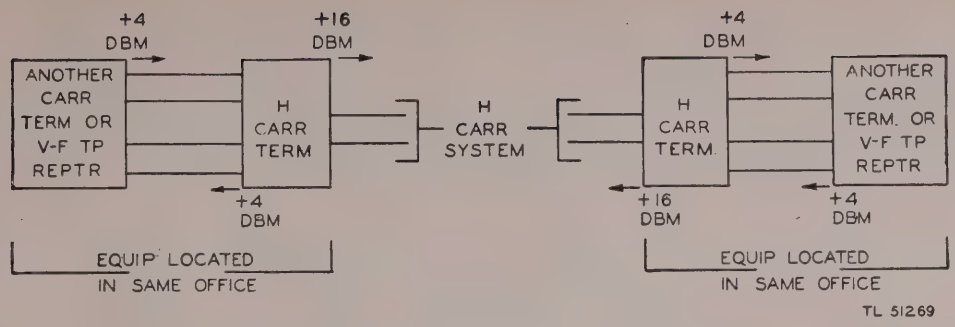


Figure 21. Four-wire extension to other systems.

ber of singing paths and the input and output equipment losses are increased since hybrid coil circuits must be used at the two-wire termination of each system. Furthermore, singing problems may be encountered in the type H system since the compromise balancing network for the type H carrier hybrid coil is designed to balance a switchboard termination. When two systems are interconnected on a two-wire basis, the over-all (switchboard-to-switchboard) loss will be the algebraic sum of the losses of the two systems. For example, if the over-all loss in one carrier system is —6 db and the over-all loss in the second carrier system is —6 db, the received power level at each switchboard will be —12 dbm. If the —12 dbm level at the switchboards cannot be tolerated, it will be necessary to raise the power levels in each carrier section. However, the highest over-all system net loss at which the type H carrier system should be operated is —3 dbm. Since the impedance of the interconnecting circuit and the circuit net losses of each system are the determining factors in determining the workable power levels at the point of interconnection, these levels will vary with individual cases and must finally be determined by actual trial.

24. Extensions to Voice-frequency Carrier Telegraph Systems

A type H channel may be used to provide the transmission path for a voice-frequency carrier telegraph system. The interconnection should be made on a four-wire basis.

a. Packaged Equipment (fig. 22). Frequency characteristics of the type H carrier band may prevent full use of the 6 or 12 two-way telegraph channels provided by voice-frequency carrier telegraph packaged equipment. The number of voice-frequency telegraph channels which can be operated over a type H carrier system will depend on the type H frequency characteristics, the net loss of the intervening open-wire line, the stability of the line, and the presence of type H carrier repeaters (repeaters tend to degrade carrier telegraph transmission). Even under favorable conditions it will seldom be possible to use a low-frequency telegraph channel of about 425 cycles. Channels in the middle of the voice-frequency band will be the best, degrading in quality as the lower and upper limits of the frequency band are reached. The type H carrier system is lined up in the usual manner for four-wire termination. The transmitting path of the type H carrier terminal is connected to the send path of the telegraph terminal, and the receiving path of the type H carrier terminal is connected to the receive path of the telegraph terminal. The nominal telegraph power output level (one channel marking) used is —11 dbm, although it may be raised slightly if a reduced number of channels (less than 12) is used and satisfactory operation is not obtained with the nominal level.

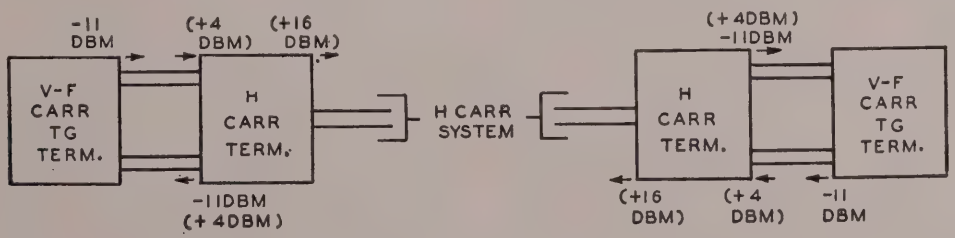


Figure 22. Extension to voice-frequency carrier telegraph packaged equipment.

b. Tactical Carrier Telegraph Equipment. Some models of this equipment are not arranged for four-wire connections and the connection to the type H carrier systems must be made on a two-wire basis. In this case the type H carrier system is set up to have a 6-db circuit net loss. Later models of this equipment are arranged for two- or four-wire connections. The four-wire connection is recommended, and in this case the type H system is arranged as described in *a* above. If desired, a two-wire connection may be made as described for the earlier models.

Section III. UNPACKING, SETTING UP, AND REPACKING

25. Location of Equipment

The building in which this equipment is installed should be dry, well ventilated, kept at reasonably constant temperature, and have solid flooring. Apparatus cabinets or 19-inch relay racks for mounting the type H carrier panels must be provided separately. If the equipment is installed with other items of packaged equipment, an office layout will have been prepared, as described in TM 11-2022. The main requirements for locating the equipment in a building are that the wiring be as short as possible, and that there be ample space for opening cabinet doors and working on the equipment. Whenever possible associated equipment panels should be mounted in the same cabinet with the type H carrier panels, and associated cabinets should be adjacent. This is extremely important for phantom group operation where it is desirable to keep the wiring of the two side circuits the same length. Since carrier frequencies are used, the type H carrier equipment should be located as close as possible to the open-wire or entrance cable terminal.

26. Unpacking Instructions

The H carrier terminal panel, repeater panel, and line panel are individually packed in waterproof, moistureproof, and vaporproof packing cases. Spare parts and installing materials are also packed within the packing cases. Physical dimensions for each of the units packed for export are shown in table IV.

Table IV. Packing data

Panel	Dimensions (in.)	Weight (lb.)	Shipping space (cu. ft.)
Carrier Terminal OA-13/FC	25 x 20 x 18	125	6.0
Carrier Repeater OA-10/FC	24 x 18 x 14	70	4.5
Carrier Filter OF-36/FC	24 x 18 x 12	40	2.9

a. Method of Packing (figs. 23, 24, and 25). Each of the panels is packed in approximately the same manner. Immediately inside the packing case (1) a waterproof bag (2), sealed with a rubber cement, provides protection against water damage to the equipment. Next an outer carton (3) of fiberboard acts to cushion the equipment from severe shocks. Inside this carton a paper foil barrier (4) affords the equipment protection from damage by moisture or vapor, which would cause rust and corrosion. The air in this barrier is evacuated before sealing. The inner carton (5) acts to further cushion the equipment from severe shocks, and both the inner and outer cartons protect the sealed moistureproof and vaporproof barrier from damage by sharp corners on the equipment or packing case.

Note. Item (5) in the terminal packing is made of wood, and is called a box, while in the repeater and line panel packings it is made of fiberboard.

Various inner details of fiber (6) protect the equipment from rough handling, and hold loose parts securely in place during shipment. The equipment (7) is held rigidly in place within the packing case by a wooden rack unit (8). Spare parts, installing materials, and bags of silica gel (9) are firmly packed around the equipment; spare parts for the line panel are inclosed in a separate carton. The silica gel provides the equipment with additional moisture protection, acting as an absorbent for any moisture which may enter the barrier.

b. Unpacking. Use care in unpacking the equipment, so that the packing materials may be re-used if the equipment is to be reshipped at a later date. Using the packing illustrations as a guide, unpack the equipment in the most practicable manner. The seams on the waterproof bag and the barrier can be broken by prying or pulling apart with the hands. These packing materials can also be opened by slitting along the top seam with a knife. This will allow their re-use after repair with tape. Discard the silica gel, as its absorbent quality deteriorates with age. When unpacking the spare parts and installing materials check them against the applicable list included with the equipment. After each unit is unpacked, place its packing materials within the packing case, nail the cover on again, and store the case in a convenient location.

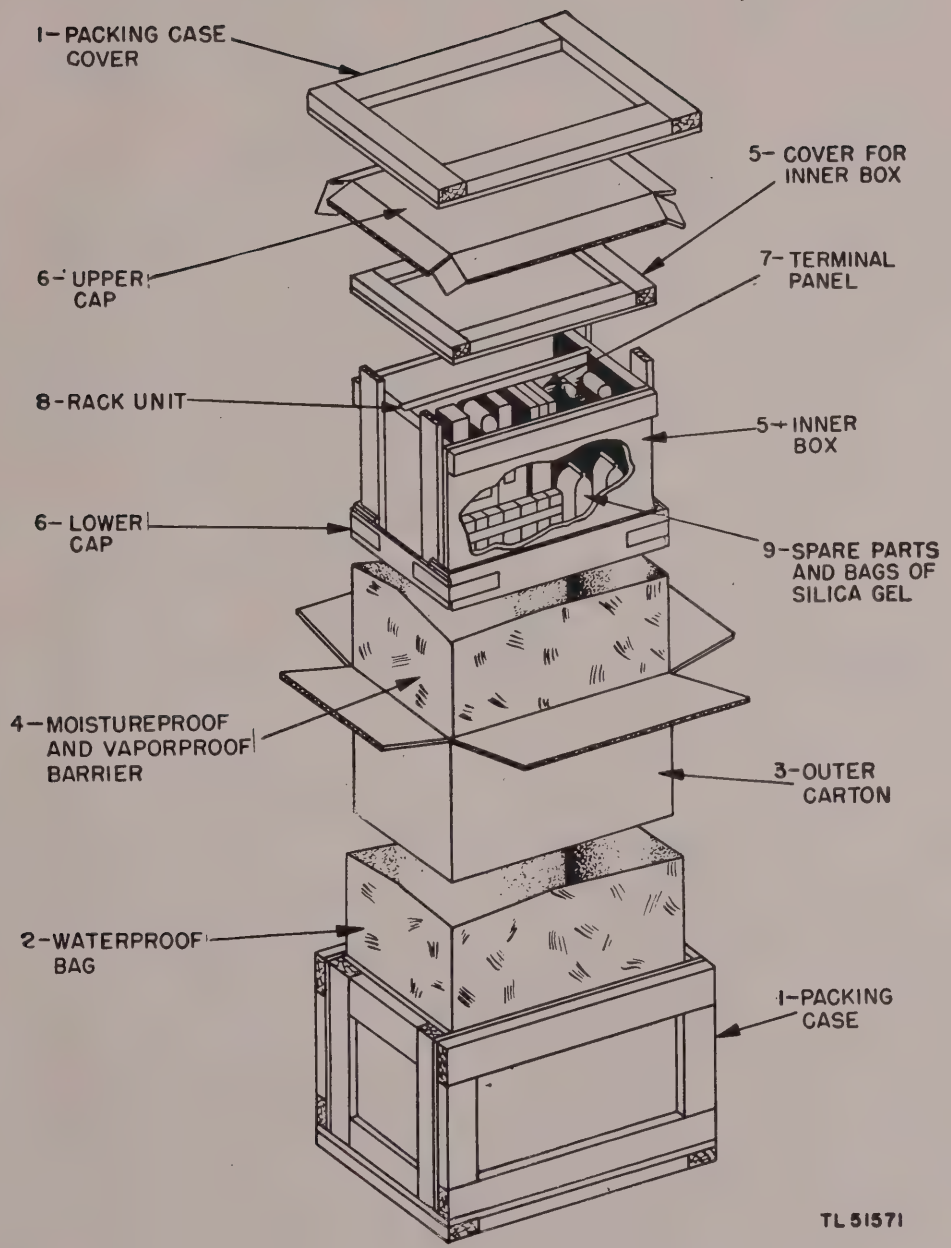


Figure 23. Packing details, terminal panel.

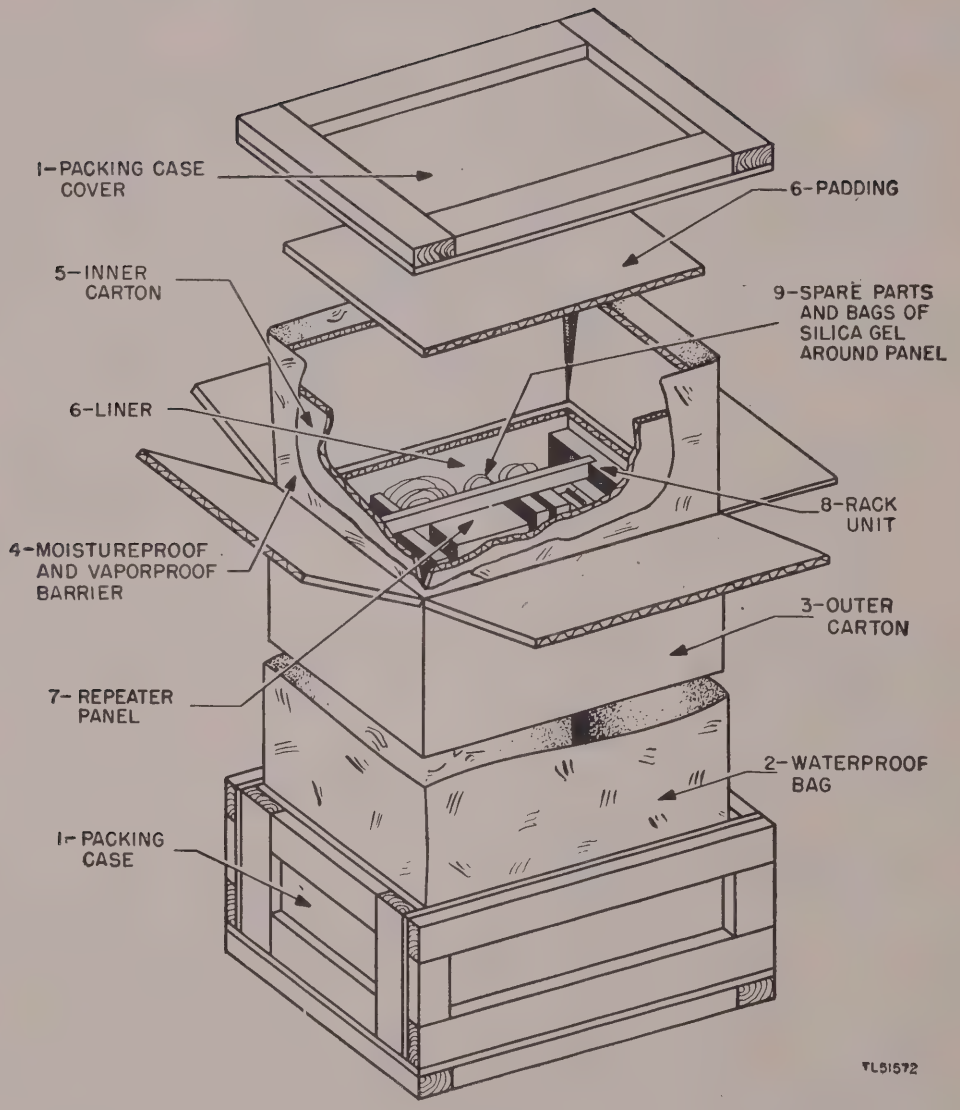


Figure 24. Packing details, repeater panel.

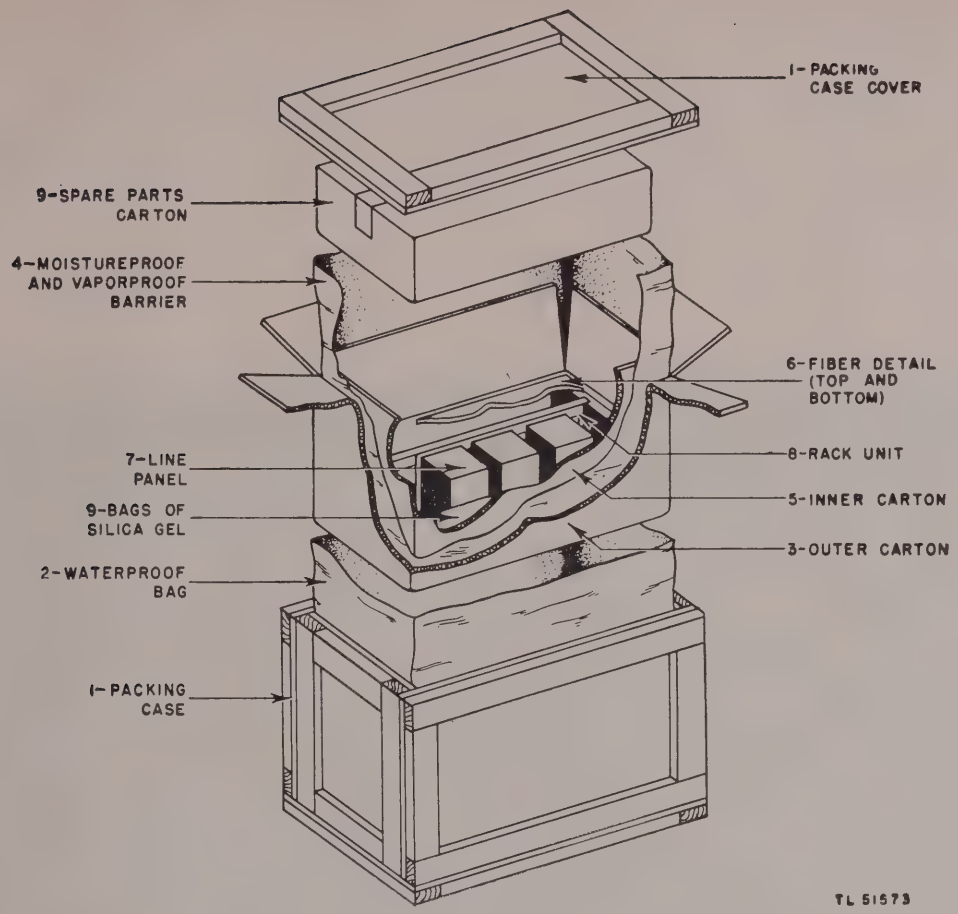


Figure 25. Packing details, line panel.

27. Setting-up Procedure

Mount the panels in an apparatus cabinet together with associated panel equipment. If no apparatus cabinet is available, the panels may be mounted on any standard 19-inch relay rack or wooden timbers similarly spaced and fastened rigidly to the floor and ceiling. Mount the terminal panel above its associated line panel (fig. 26). Note that a terminal installation requires 9 mounting plate spaces, 7 for the terminal panel and 2 for the line panel. Mount the repeater panel between its associated line panels (fig. 27). Note that a repeater installation also requires 9 mounting plate spaces, 5 for the repeater panel, and 2 for each of the line panels. At a radio link installation, mount the 2 terminal panels together between the 2 line panels. Note that this installation requires 18 mounting plate spaces, 7 for each terminal panel and 2 for each line panel. Screws for mounting the panels are not furnished with the panels.

28. Repacking Instructions

a. Disconnect all connecting wires and the plug to the external power supply.

b. Remove each panel from the cabinet or relay rack and place it in its rack unit, securing it firmly with the wooden details.

c. Slide the rack unit into the inner carton.

d. Collect all spare parts and installing materials and pack securely around the panel.

e. Seal the inner carton with gummed tape, replace the outer carton, and seal it with tape also.

f. Slip the waterproof bag over the outer carton and seal it with tape.

g. Place the entire unit in the packing case, put the remaining packing materials on top, and nail the cover on securely.

h. If the original packing materials have been discarded, construct a rack unit which will hold the panel securely, and place this unit within a suitable crate together with the spare parts and installing materials.

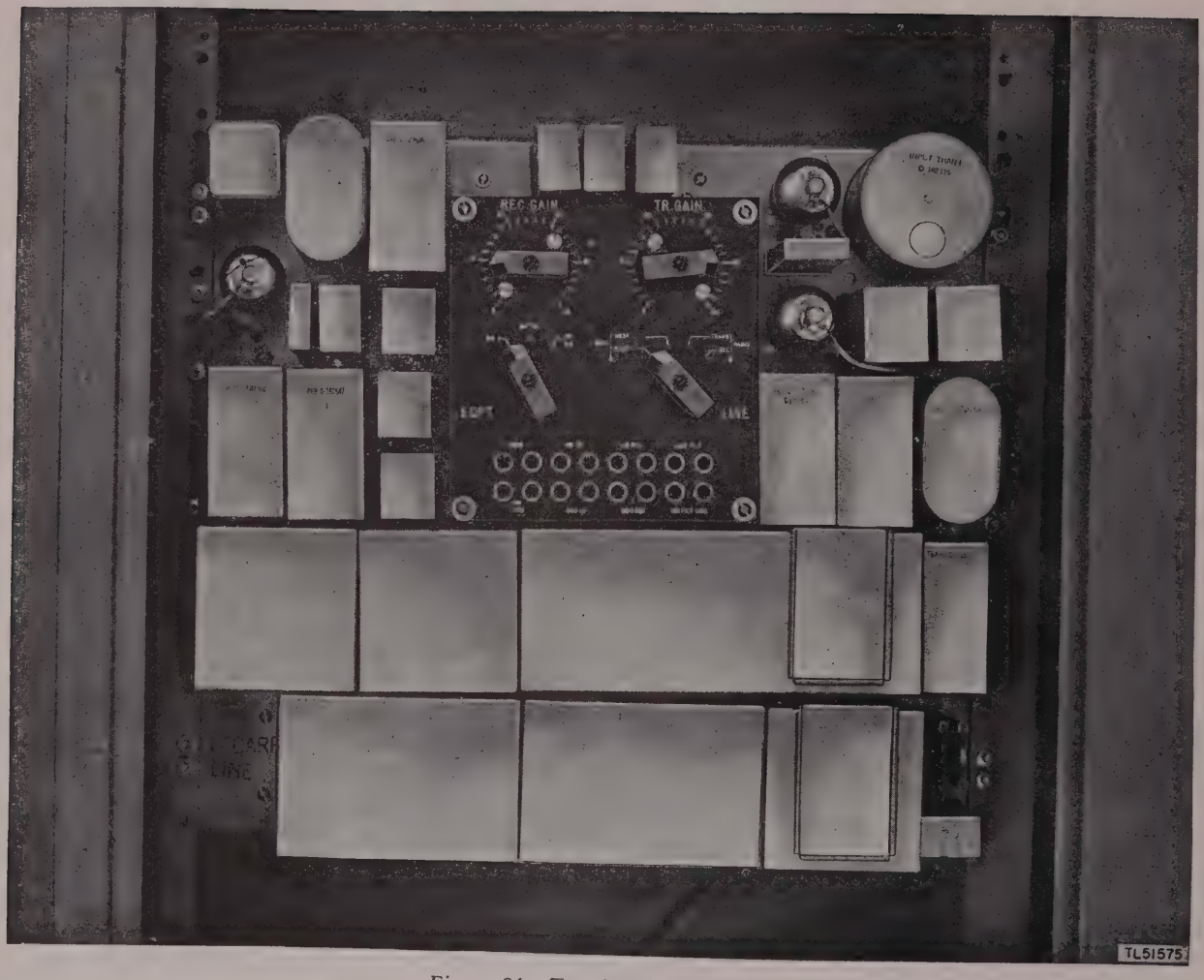


Figure 26. Terminal installation.

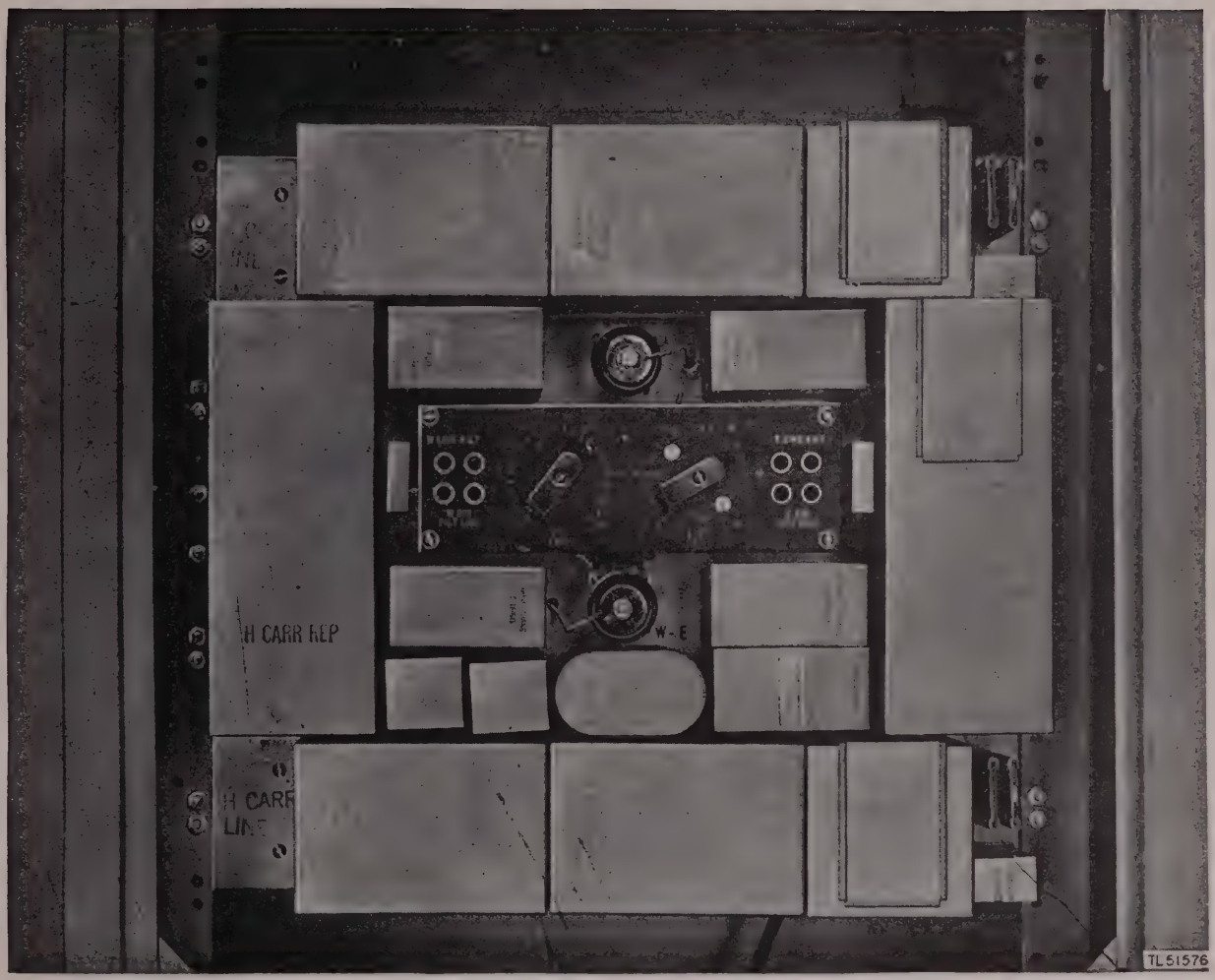


Figure 27. Repeater installation.

OPERATING INSTRUCTIONS

Note. For information on destroying this equipment to prevent enemy use, see the destruction notice at the front of this manual.

Section IV. EQUIPMENT CONNECTIONS AND PRELIMINARY ADJUSTMENTS

29. Connections and Adjustments

The equipment connections and adjustments contained in this section provide satisfactory operation in a minimum of time and are to be followed whenever placing the equipment in service. However, to obtain optimum performance, the detailed tests, adjustments, and line-up procedures contained in section V should be performed when time permits.

a. Terminal, Wire Operation. The connections, connecting arrangements, and adjustments required at a terminal for wire operation are listed below with paragraph references. The tests and adjustments should be performed in the order given.

Terminal connections and adjustments required:

Ground connections (pars. 30*a* through *d*).
Power connections (par. 31).
Voltage adjustments (par. 32).
Vacuum tube checks (par. 33).
Line switch setting (par. 34*a* and *b*).
Equipment switch setting (par. 35).
Gain adjustments (par. 36*a* and *b*).
Connecting arrangements (par. 37).
Terminating connections (par. 38).
External balancing network connections, if required (par. 39).
Line connections (par. 40*a*).

b. Repeater, Wire Operation. The connections, connecting arrangements, and adjustments required at a repeater for wire operation are listed below with paragraph references. The tests and adjustments should be performed in the order given.

Repeater connections and adjustments required:

Ground connections (par. 30*a* through *c* and *e*).
Power connections (par. 31).
Voltage adjustments (par. 32).
Vacuum tube checks (par. 33).
Gain adjustments (par. 36*a* and *c*).
Connecting arrangements (par. 37).
Line connections (par. 40*a*).

c. Radio Link Operation. The connections, connecting arrangements, and adjustments required for radio link operation are listed below with paragraph references. The tests and adjustments should be performed in the order given.

Connections and adjustments required for radio link operation:

Ground connections (par. 30*a* through *c* and *f*).
Power connections (par. 31).
Voltage adjustments (par. 32).
Vacuum tube checks (par. 33).
Line switch setting (par. 34*c*).
Equipment switch setting (par. 35).
Gain adjustments (par. 53).
Connecting arrangements (par. 37).
Terminating connections (par. 38).
External balancing network connections, if required (par. 39).
Line connections (par. 40*b*).

d. Carrier Transfer Equipment. The connections required at a carrier transfer point are given in paragraph 41.

e. Check of System Performance. After all connections and adjustments have been made, check the system to insure satisfactory performance (par. 42).

f. Testing Equipment. No equipment for testing is provided as part of type H carrier equipment. The following equipment, usually available at a central office or a voice-frequency telephone repeater installation, should be used for installation testing purposes.

Nomenclature	Signal Corps stock No.	Mfr's. No.	Description	Usage
Multimeter TS-380/U.	3F7127	WECo D-166852.	Volt-ohm-milliammeter.	Voltage, current, and resistance measurements.
Tube Tester I-171.	3F5681	Hickok model 560 (SPL).	Vacuum tube test set.	Test vacuum tubes.

30. Ground Connections

a. General. A common ground connection is provided in each cabinet and on each relay rack used to mount type H carrier equipment. Connection is made from the office grounding system to these common grounds. In turn, connections are made from this ground connection to each panel.

b. Office Grounds. (1) All office equipment must be connected to a common grounding system. A buried metallic water-supply system is preferable, but buried gas pipes or other metallic structures may be used. In either case, the neutral wire of the power distribution circuit should use the same ground.

(2) When a suitable existing ground system is not available, driven ground rods are used. Ground rods are not supplied as part of the type H carrier equipment. Five ground rods, at least 3 feet in length, should be used. Set the ground rods a minimum of 6 feet apart. Before installing the ground rods, clean the connecting surfaces of the rods and the wire to be used. If possible solder the joints. Bond the ground rods to the ground used for the neutral of the power system with 6- or 8-gauge copper wire. When rods are located in the basement of a building, drive them to within 6 inches of the floor level. Place the rods at least 2 feet from any wall. When ground rods are located outdoors, set them as near to the building as practicable but in no event closer than 2 feet. To set ground rods outdoors, dig a trench and drive the rods below ground level. After the connections are made, cover the trench with boards to permit ready periodic inspection of the ground leads. See TM 11-755 for more detailed instructions on the establishment of an office ground.

c. Grounding of Cabinets, Terminal or Repeater. Run a 6- or 8-gauge copper wire from the common office ground to the nearest cabinet, and from that point to the other cabinets. Connections are made to lugs in each cabinet.

d. Grounding of Terminal Panels, Wire Operation. (1) Clean one end of a 6-foot length of single-conductor copper wire and solder it to terminal 16 of terminal strip A on the terminal panel. Terminal strip A is located on the lower right rear of the terminal panel (fig. 28).

(2) Run the wire along the side of the cabinet to the line panel and loop the wire so as to make connection to terminal 8 of terminal strip A on the line panel. Terminal strip A is located on the rear of the line panel (fig. 29).

(3) Solder the loop connection made in (2) above.

(4) Run the wire to the cabinet ground connection, and solder.

(5) Tie the ground wire to the cabinet supports.

e. Grounding of Repeater Panels. (1) Clean one end of a 6-foot length of single-conductor copper wire and solder it to terminal 8 of terminal strip A on the upper line panel (fig. 29).

(2) Run the wire along the side of the cabinet to the repeater panel and loop the wire so as to make connection to terminal 8 of terminal strip A on the repeater panel (fig. 30).

(3) Solder the loop connection made in (2) above.

(4) Continue running the wire along the side of the bay to the lower line panel and loop the wire so as to make connection to terminal 8 of terminal strip A on the lower line panel (fig. 29).

(5) Solder the loop connection made in (4) above.

(6) Run the wire to the cabinet ground connection, and solder.

(7) Tie the ground wire to the cabinet supports.

f. Grounding of Terminal Panels, Radio Link. (1) Clean one end of a 6-foot length of single-conductor copper wire and solder it to terminal 8 of terminal strip A on the upper line panel. Terminal strip A is located on the rear of the line panel (fig. 29).

(2) Run the wire along the side of the bay to the upper terminal panel and loop the wire so as to make connection to terminal 16 of terminal strip A on the terminal panel. Terminal strip A is located on the lower right rear of the terminal panel (fig. 28).

(3) Solder the loop connection made in (2) above.

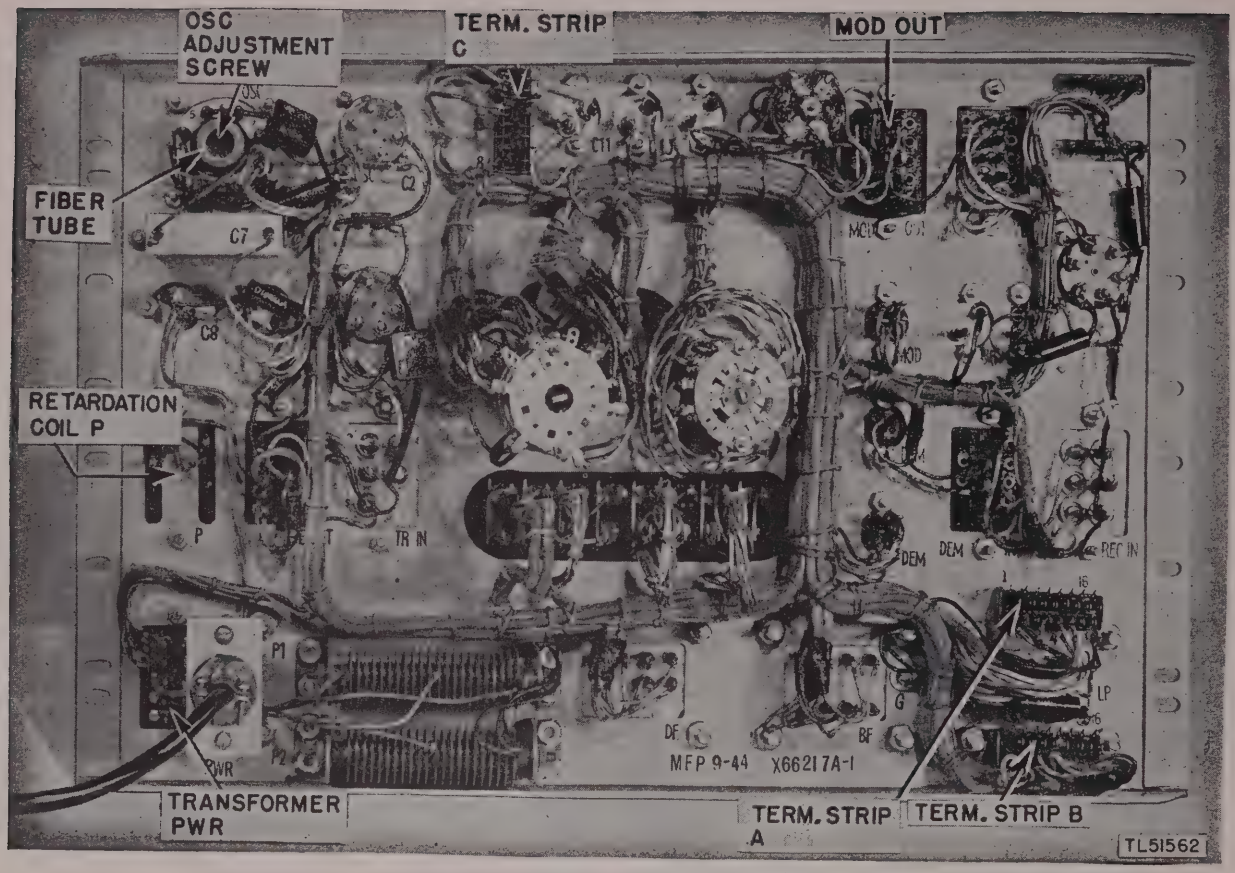


Figure 28. Terminal panel, rear view.

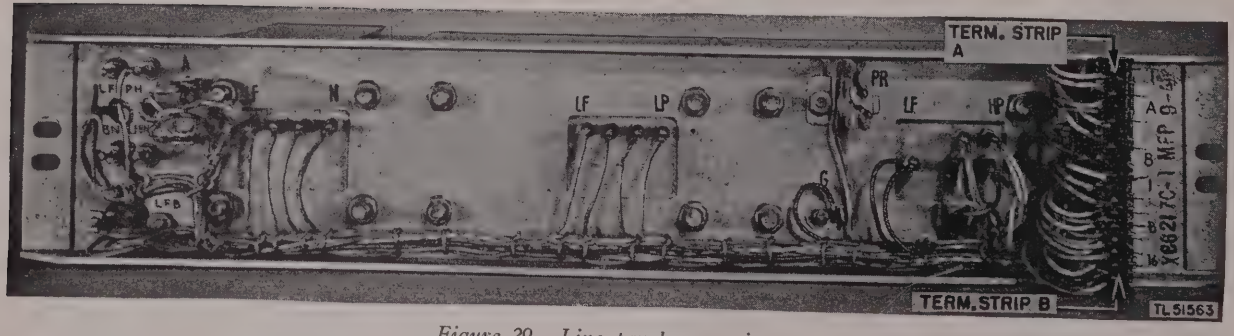


Figure 29. Line panel, rear view.

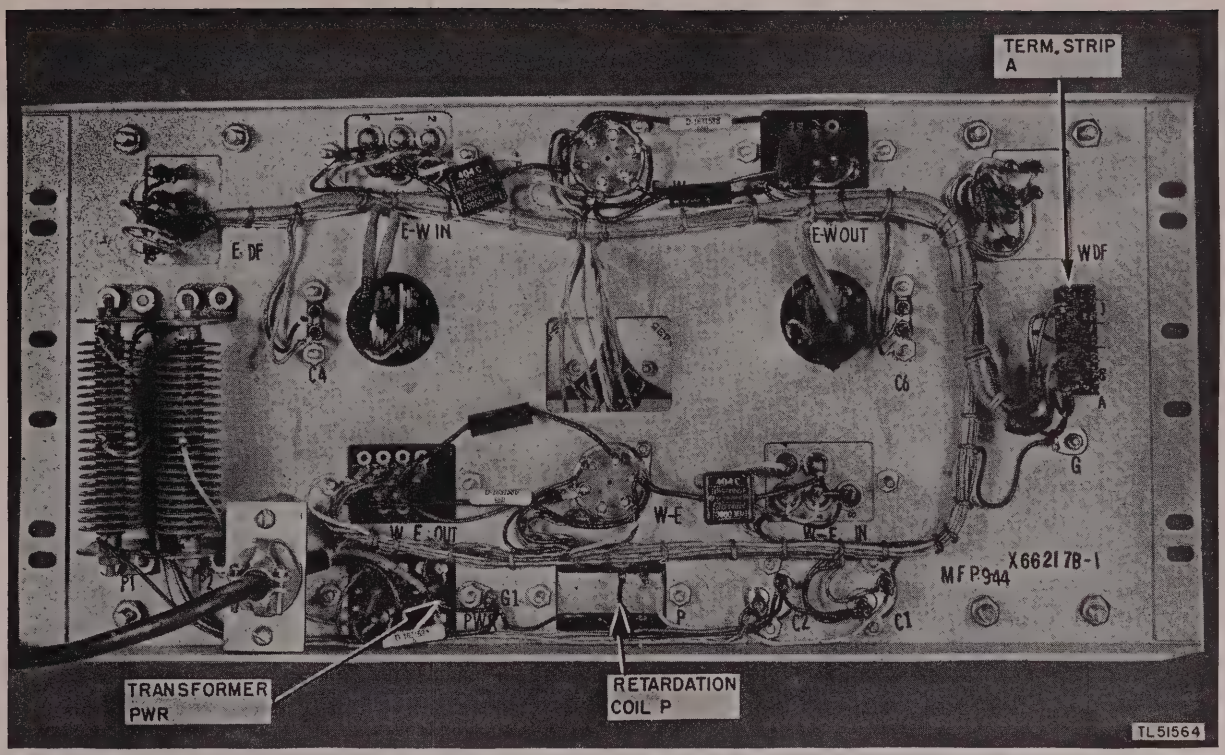


Figure 30. Repeater panel, rear view.

(4) Repeat the procedure given in (2) and (3) above for the lower terminal panel.

(5) Continue running the wire along the side of the bay to the lower line panel and loop the wire so as to make connection to terminal 8 of terminal strip A on the lower line panel (fig. 29).

(6) Solder the loop connection made in (5) above.

(7) Run the wire to the cabinet ground connection, and solder.

(8) Tie the ground wire to the cabinet supports.

31. Power Connections

a. General. (1) Two methods are used for supplying 105- to 125-volt, 50- or 60-cycle alternating current to the cabinets. Earlier model cabinets used the direct-wiring method while later model cabinets use the cord and plug method for connection to the a-c power. With either method, it is necessary to determine which wire of the office supply is the grounded or identified lead. Normally, the white or identified lead is the grounded power lead and the black lead is the ungrounded or live power lead. The grounded lead may be determined by measuring the voltage between each wire and ground.

(2) The terminal and repeater panels are provided with power cords and plugs that are plugged into convenience outlets. These convenience outlets, which are contained on the plug-in strip at the rear of the 3-foot 6-inch and 7-foot cabinets, are protected with a fuse located at the bottom of the cabinet. Appliances should not be connected to the plug-in strip since a blown fuse due to a faulty appliance will put the terminal or repeater out of service. No plug-in strip is provided on the 2-foot 4-inch cabinets; instead the power cord plugs of the terminal or repeater panels are inserted into one of the UT & T outlets. Since the UT & T outlets are not fused, appliances should not be plugged into these outlets.

b. Connecting Cabinets, Cord and Plug Arrangement. (1) Run one pair of power leads from the office distribution panel to the near end of the cabinet line-up.

(2) Terminate the pair or power leads at the cabinet, by connecting the short length of power cord attached to the polarized twist-lock connector body (receptacle) furnished, in the following manner:

(*a*) Splice the grounded side of a grounded power supply, or the identified side of a nongrounded power supply, to the identified lead of the polarized connector body.

(*b*) Splice the other power lead to the remaining lead of the polarized connector body.

(*c*) Solder and properly tape the splices.

(3) Run the power cord associated with the first

cabinet of a line-up along the cable run to the polarized connector body and insert the polarized plug into the polarized connector. Lock the plug by turning it to the right.

(4) Run the power cord associated with the second cabinet along the cable run to the first cabinet and insert the power cord plug into one of the PWR receptacles of the first cabinet. Lock the plug by turning it to the extreme right. This is important because accidental removal of the plug disconnects power from all succeeding cabinets.

(5) Repeat the procedure given in (4) above for all other cabinets in the line-up. *Accidental removal of a plug will cut off the power supply to all succeeding cabinets in the line-up.*

c. Connecting Cabinets, Direct Wiring Arrangement. (1) Run one pair of power leads from the office distribution panel to the near end of the line-up; continue running the wires in the cable run under the cabinets to the far end of the line-up. Keep the power leads as far as possible from other wiring in the cable run.

(2) After removing the cover from the front of the outlet box assembly of the first cabinet in the line-up, splice the leads in the outlet box to a short length of power wire. Splice the identified leads together and splice the black leads together.

(3) Remove a knock-out from the bottom of the outlet box of the first cabinet of the line-up and pull the short length of power wire through the knock-out opening.

(4) Splice the short length of wire to the power leads in the cable run, connecting the identified wire to the grounded power lead of a grounded power system or to the identified lead of a nongrounded power system. Connect the black leads together.

(5) Repeat the procedure given in (2), (3), and (4) above for each cabinet to which power is required.

(6) Solder and properly tape all splices; replace the outlet box covers.

d. Fuse Checks. Check to see that the required 10-ampere fuses are installed in fuse receptacles of the 3-foot 6-inch cabinet or the 7-foot cabinet. If fuses are not supplied, unscrew the fuse holder from each socket, insert a cartridge-type fuse in the open end, and replace the fuse holder in the socket. The small hole in the other end of the fuse holder permits the insertion of a nail, or similar implement, to aid in the removal of a blown fuse.

e. Connecting Terminal or Repeater Panels. Insert the power cord plugs of the terminal or repeater panels into the outlets in the plug-in strip at the rear of the 3-foot 6-inch and 7-foot cabinets, or into one of the UT & T outlets of a 2-foot 4-inch cabinet. *Do not connect appliances to the plug-in strip;* appliances such as testing instruments, soldering irons, etc., may be connected to the APPLIANCE outlets of the outlet box. *Do not use the spare outlet of the 2-foot 4-inch cabinet for appliances unless absolutely necessary as no fuse is provided in the outlet circuit.*

32. Voltage Adjustments (figs. 28 and 30)

Caution: When power is connected, voltages existing on certain terminals of the equipment are sufficiently high to be dangerous. Accordingly, attendants are cautioned against touching any live terminal and any other terminal or ground at the same time. When checking and adjusting the equipment, disconnect the a-c power whenever possible. If it is necessary to turn on the power for the purpose of making measurements, proceed with extreme caution. The type H carrier terminal and repeater are designed to operate from a 50- to 60-cycle, 105- to 125-volt a-c power source. Taps are provided on the primary of power transformer PWR which supplies alternating current to the heaters of the vacuum tubes and the varistor rectifier. At the time of installation the line voltage must be measured, the tap lead of the transformer primary adjusted, if necessary, and the d-c output of the varistor rectifier measured.

a. Apparatus Required. Multimeter TS-380/U.

b. Adjustment of Power Transformer Primary. (1) Disconnect the power cord plug.

(2) Using the 300V a-c scale of the multimeter, measure the a-c supply voltage at the outlet box or plug-in strip.

(3) The tap lead on the primary of transformer PWR is connected at the factory to terminal 5. Reconnect the tap lead, if necessary, to meet the line voltage requirements shown below.

A-c line voltage	Connect tap lead to terminal
Less than 112	3
112 to 118	4
Greater than 118	5*

* Tap lead is connected to this terminal during manufacture.

(4) Insert the power cord plug into the convenience outlet.

c. Check of Rectifier Output. (1) Allow sufficient time for the tubes to heat.

(2) Using the 300V d-c scale of the multimeter, measure the rectifier output voltage between terminal 1 of retardation coil P and ground.

Requirement: The output voltage should be between 125 and 190 volts.

(3) If the requirement given above is not met, see paragraph 46.

33. Vacuum Tube Checks

The terminal and repeater panels are shipped with the vacuum tubes mounted in the sockets. Spare vacuum tubes are provided in a separate container. Check to see that the tubes are seated properly in the sockets. Check the vacuum tubes with a tube tester.

34. Line Switch Setting

The line switch, designated LINE, can be set to any one of four positions: WIRE EAST, WIRE WEST, RADIO TRANS, and RADIO REC (fig. 3). For radio link operation, switch LINE of the upper terminal panel is set to RADIO TRANS while switch LINE of the lower terminal panel is set to RADIO REC. For wire operation, the setting of switch LINE generally is specified. If no specifications are given, the correct switch setting is determined on the basis of the particular operating line conditions. When operating over wire facilities, once the direction of transmission and the position of switch LINE are determined, neither can be changed without interfering with the operation of the other carrier systems on the line.

a. When Setting Is Specified, Wire Operation. If an East terminal is specified, set switch LINE to WIRE EAST; if a West terminal is specified, set switch LINE to WIRE WEST.

b. When Setting Is Not Specified, Wire Operation. (1) *With Another H Carrier System or a C Carrier System on Same Open-Wire Line.* Switch LINE must be set so that the direction of transmission of both systems corresponds. Set switch LINE accordingly.

(2) *With Carrier Systems Other Than H or C Carrier on Same Open-Wire Line.* If the other carrier systems have one direction of transmission in the frequency range of 7 to 10 kilocycles, switch LINE must be set so that the East-to-West direction of transmission of the type H carrier system is in the same direction as the 7- to 10-kilocycle band of the other systems. Set switch LINE accordingly. If the other carrier systems do not utilize the frequency range of 7 to 10 kilocycles, follow the procedure given in (3) below.

(3) *With No Other Carrier System on Same Open-Wire Line.* The setting of switch LINE is determined by geographical location. The terminal which is at the north or east end of the system is the East terminal; the terminal which is at the south or west end of the system is the West terminal. Set switch LINE accordingly.

c. Radio Link Operation. Set switch LINE of the upper terminal panel to RADIO TRANS and set switch LINE of the lower terminal panel to RADIO REC.

35. Equipment Switch Setting

The equipment switch, designated EQPT, has three switch positions; 2W, 4W TEL, and 4W TLG. The switch is set in accordance with the terminating arrangement. For the procedures given, switch position 4W TLG is not used. It is provided for cases where it is desired to eliminate the 8-db pad from the transmitting path.

a. Two-wire Termination. For all conditions where the channel is terminated on a two-wire basis, set switch EQPT to position 2W.

b. Four-wire Termination. For all conditions where the channel is terminated on a four-wire basis, set switch EQPT on position 4W TEL.

36. Gain Adjustments

a. General. (1) The gains of the terminals and repeaters should be adjusted in accordance with the characteristics of the adjacent open-wire line sections. The adjustments given below are to be performed when the system is first installed. Since these adjustments are based on average line characteristics, optimum performance will not result. When time permits, perform the detailed tests and adjustments given in section V in order to obtain optimum performance.

(2) The receiving gain adjustments are given in tables V and VI for a terminal and repeater, respectively. The gain adjustments given in both tables are based on the characteristics of average lines and assume that each line section is composed entirely of the same gauge of copper or copper-clad steel wire. However, if a line section is composed of different gauges of wire, the line facility, so far as the gain adjustments are concerned, may be considered as composed entirely of the most common wire gauge used. Though the settings given in the tables assume dry weather line conditions, the tables may be used when setting up the system during wet weather providing the detailed tests and adjustments given in section V are performed as soon as practicable.

(3) These adjustments do not apply for radio link operation. Instead, perform the detailed tests and adjustments given in section V.

b. Terminals. (1) Set control TR GAIN to 44.

(2) Set control REC GAIN in accordance with table V, observing the limitations given in *a*(2) above.

Note. Do not set control REC GAIN to a position greater than 44.

c. REPEATERS. (1) Set control E-W and W-E GAIN in accordance with table VI observing the limitations given in *a*(2) above.

(2) Add the numerical value of the settings of controls E-W GAIN and W-E GAIN.

Requirement: The sum of the E-W GAIN and W-E GAIN settings should not exceed 82.

(3) If the requirement is not met, reduce the setting of each gain control an equal amount until the requirement is met.

Table V. REC GAIN Control settings at terminal

Open-wire facility			REC GAIN setting
Type	Gauge (mils)	Length of line section (miles)	
Copper-steel	080	25 to 35	20
		35 to 45	22
		45 to 55	26
		55 to 65	30
		65 to 75	32
		75 to 85	34
		85 to 95	38
		95 to 105	42
Copper-steel	104	25 to 45	18
		45 to 65	22
		65 to 85	26
		85 to 105	30
		105 to 125	32
		125 to 145	38
		145 to 165	42
Copper-steel	128	30 to 60	16
		60 to 90	20
		90 to 120	26
		120 to 150	30
		150 to 180	32
		180 to 210	38
		210 to 240	42
Copper	080	25 to 50	16
		50 to 75	18
		75 to 100	20
		100 to 125	26
		125 to 150	28
		150 to 175	30
		175 to 200	34
		200 to 225	38
		225 to 250	40
Copper	104	20 to 50	12
		50 to 90	16
		90 to 130	20
		130 to 170	24
		170 to 210	26
		210 to 250	30
		250 to 290	34
		290 to 330	36
		330 to 370	42
Copper	128	25 to 75	14
		75 to 125	18
		125 to 175	20
		175 to 225	24
		225 to 275	28
		275 to 325	30
		325 to 375	36
		375 to 425	38
Copper	165	25 to 75	14
		75 to 125	16
		125 to 175	18
		175 to 225	22
		225 to 275	24
		275 to 325	26
		325 to 375	30
		375 to 425	32
		425 to 475	36
		475 to 525	40

Table VI. E-W GAIN and W-E GAIN control settings at repeater

Open-wire facility			E-W or W-E GAIN settings
Type	Gauge (mils)	Length of preceding line section (miles)	
Copper-steel	080	25 to 35	26
		35 to 45	30
		45 to 55	32
		55 to 65	36
		65 to 75	38
		75 to 85	42
		85 to 95	46
Copper-steel	104	45 to 65	28
		65 to 85	32
		85 to 105	36
		105 to 125	40
		125 to 145	44
Copper-steel	128	60 to 90	28
		90 to 120	32
		120 to 150	36
		150 to 180	40
		180 to 210	44
Copper	080	25 to 50	22
		50 to 75	26
		75 to 100	28
		100 to 125	32
		125 to 150	36
		150 to 175	38
		175 to 200	42
		200 to 225	44
Copper	104	50 to 90	24
		90 to 130	26
		130 to 170	30
		170 to 210	34
		210 to 250	38
		250 to 290	40

Open-wire facility			E-W or W-E GAIN settings
Type	Gauge (mils)	Length of preceding line section (miles)	
Copper	128	75 to 125	24
		125 to 175	28
		175 to 225	30
		225 to 275	34
		275 to 325	38
		325 to 375	42
Copper	165	75 to 125	22
		125 to 175	26
		175 to 225	28
		225 to 275	32
		275 to 325	34
		325 to 375	38
		375 to 425	40
		425 to 475	44

37. Connecting Arrangements

The terminals to which connections are to be made at an H carrier terminal installation are shown in figure 31, and those to be made at a repeater installation in figure 32. These over-all illustrations are supplemented by specific terminating and line-connection illustrations in the paragraphs which follow.

a. Identification of Wires. The type H carrier equipment is wired internally so that each wire of a pair can be readily identified. One wire of a pair, designated tip (T), is a solid-colored wire while the other wire of the pair, designated ring (R), is identified by a tracer-color. The terminal strips are wired so that the tip (T) wire of each pair is connected to the right-hand (lower-numbered) terminal while the ring (R) wire of the pair is connected to the left-hand (higher-numbered) terminal. The paired connecting wire, supplied with the installing materials, is similarly color-coded. To facilitate maintenance and trouble location, whenever using the paired connecting wire, connect the equipment so as to maintain the system of color-coding.

b. Use of Shielded Wire. It is desirable that shielded wire be used for all connections where carrier frequencies are involved because of the greater coupling that occurs at the higher frequencies. Though a short length of color-coded shielded wire is supplied with type H carrier line panels, it may be necessary to obtain additional shielded wire locally. Whenever shielded wire is used, one end of the shield must be connected to the designated ground terminal. If the other end of the shield is not grounded, it must be taped for protection. Use the following procedure to ground the shield in the manner shown in figure 33.

(1) Remove about 2 inches of the cloth outer braid of the shielded wire from the end of the paired wire, exposing the braided tinned copper shield.

(2) Cut the exposed shield back about 1½ inches from the end of the wire.

(3) Bunch together the frayed ends of the shield.

(4) Using about 6 inches of single-conductor cross-connecting wire, clean one end and wrap it around the bunched ends of the copper shield, making four or five close wraps.

(5) Solder the joint.

(6) Pull the cloth outside braid over the exposed copper shield and hold it in place by wrapping friction tape around the wire, making certain to cover the soldered connection.

(7) After cutting the single-conductor wire to the proper length, clean and solder it to the proper ground terminal on the terminal strip as indicated.

38. Terminating Connections

a. The type H carrier channel may be terminated on either a two-wire or a four-wire basis. When terminated on a two-wire basis, the channel may be connected to an adjacent switchboard, a two-wire voice-frequency telegraph system, or a two-wire extension. When terminated on a four-wire basis, the channel may be connected to a four-wire voice-frequency telegraph system or it may be extended over a voice-frequency repeatered circuit, a channel of a type C carrier system, or another type H carrier system.

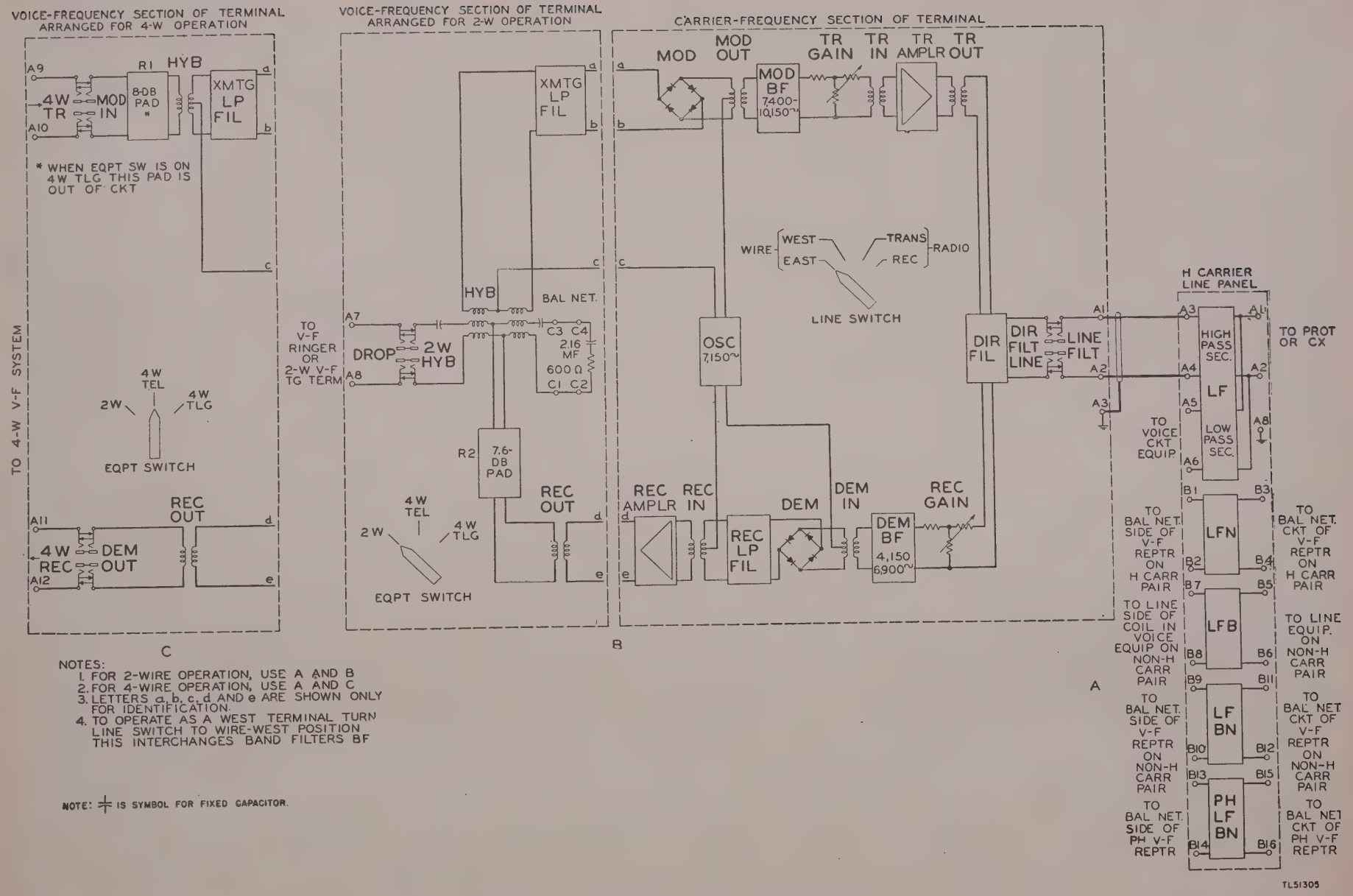
b. The terminating connections required are indicated by means of illustrations which show the terminating connections in diagrammatic and tabular form. The illustrations are so arranged that either the diagram or the table may be used, as desired. Connection designations of specific terminals are given only for the type H carrier equipment. Connection designations of specific terminals on other equipment shown may be obtained by seeing the Technical Manual of the particular equipment.

Condition	*See figure*
Two-wire termination	34 A.
Four-wire termination	34 B.

c. The connections required to extend one H carrier system to another H carrier system when the two terminals are adjacently located are shown in figure 35. For operating advantages, the four-wire method of operation is used at the point at which the interconnection is made.

39. External Balancing Network Connections

Occasionally, when the type H carrier system is extended by means of extremely long voice-frequency



NOTES:
1. FOR 2-WIRE OPERATION, USE A AND B
2. FOR 4-WIRE OPERATION, USE A AND C
3. LETTERS a, b, c, d AND e ARE SHOWN ONLY FOR IDENTIFICATION.
4. TO OPERATE AS A WEST TERMINAL TURN LINE SWITCH TO WIRE-WEST POSITION THIS INTERCHANGES BAND FILTERS BF

NOTE: ⊣⊢ IS SYMBOL FOR FIXED CAPACITOR.

Figure 31. Terminal connections, wire operation.

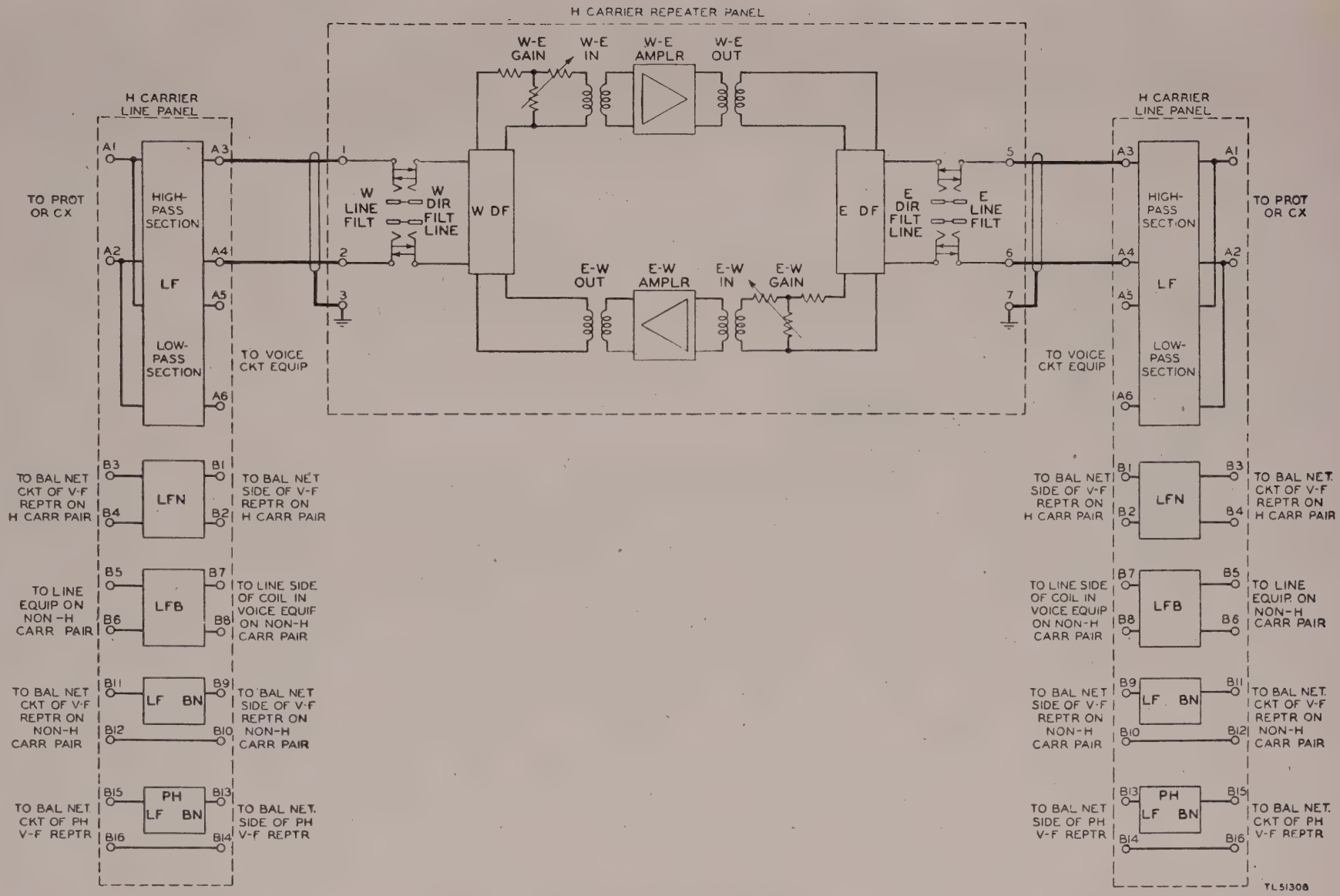


Figure 32. Repeater connections.

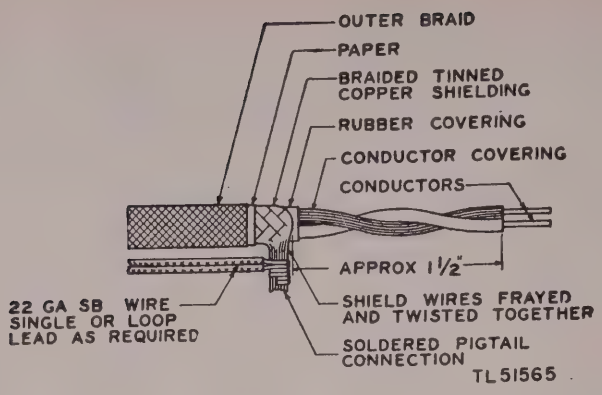
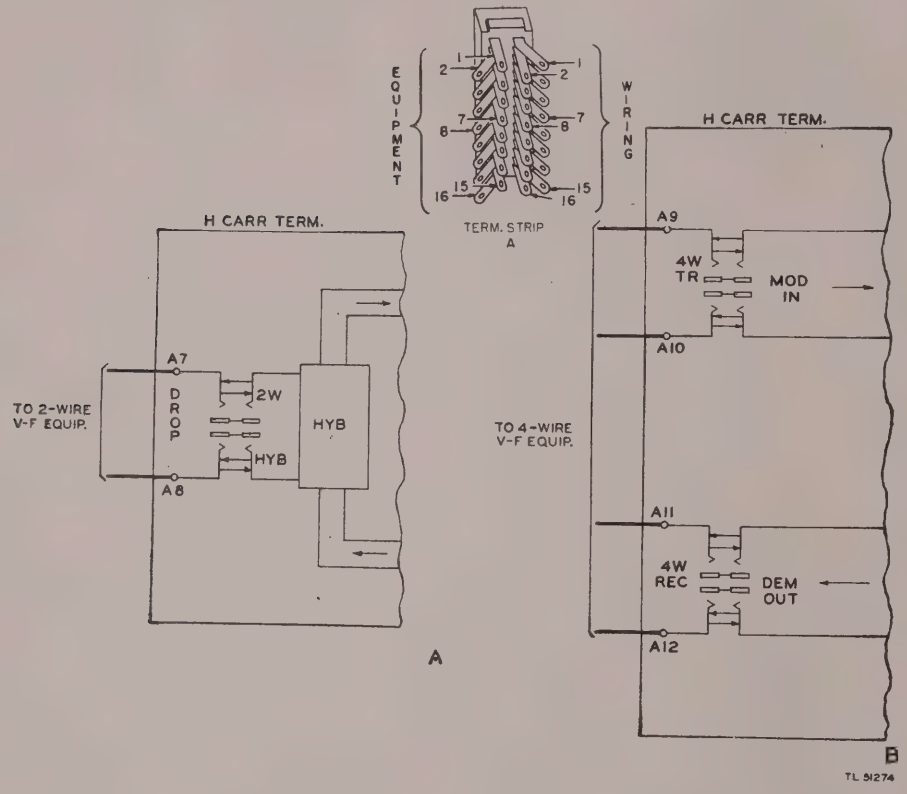


Figure 33. Method of grounding the shield of shielded wire.



A. Connections for two-wire termination.

Connect from				To	
Step	Terminal	Strip	Location		Use
1	7 and 8	A	Terminal panel.	Two-wire v-f tp equip. or two-wire v-f tg term.	Paired wire.

B. Connections for four-wire termination.

Connect from				To	
Step	Terminal	Strip	Location		Use
1	9 and 10	A	Terminal panel.	Send side of four-wire v-f tp or tg equip.	Paired wire.
2	11 and 12	A	Terminal panel.	Receive side of four-wire v-f tp or tg equip.	Paired wire.

Figure 34. Terminating connections.

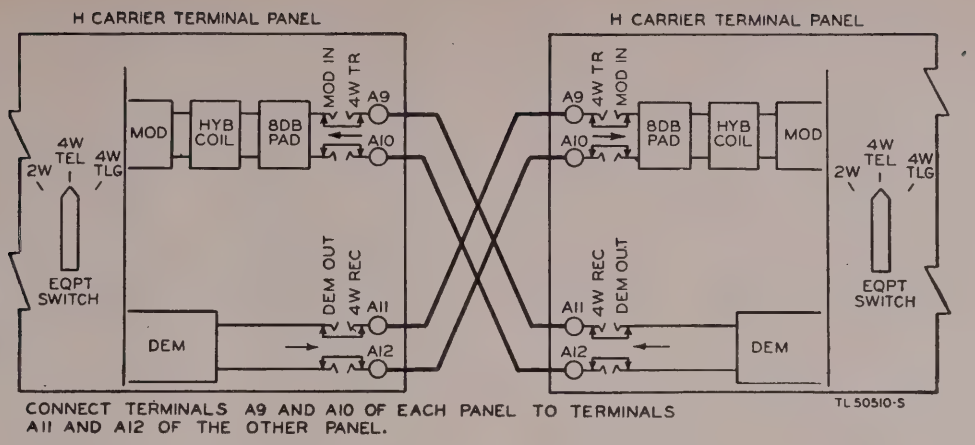


Figure 35. Connection of two type H carrier terminals on a four-wire basis.

facilities, it may be desirable to use an external balancing network. To connect an external balancing network, remove the strap between terminals C1 and C2 and the strap between terminals C3 and C4 of terminal strip C on the terminal panel (fig. 28) and connect a suitable external balancing network to terminals C1 and C3.

40. Line Connections

a. Wire Operation. Though the type H carrier equipment can be connected for wire operation in many ways, this paragraph is concerned only with the line connections required for the more common arrangements in a physical circuit. The line connections required for operation on a voice-frequency repeatered physical circuit, a composited physical circuit, and a simplexed physical circuit are shown by means of figures. Connection designations of specific terminals are given only for the type H carrier equipment. Connection designations of specific terminals on other equipment shown may be obtained by seeing the Technical Manual of the particular equipment or to TM 11-2037. The more common arrangements on a physical circuit are listed below together with corresponding references to figures showing the line connections required.

Condition	*East terminal or West side of repeater*	*West terminal or East side of repeater*
Physical circuit with voice-frequency telephone repeater and composite telegraph.	Figure 36	Figure 37
Physical circuit with composite telegraph.	Figure 38	Figure 39
Physical circuit with simplex telegraph.	Figure 40	Figure 41

b. Radio Link Operation. Various line connections and interpanel connections are required for radio link operation. The line and interpanel connections required for radio link operation are indicated by means of an illustration which shows the terminating connections in diagrammatic and tabular form. The illustration is so arranged that either the diagram or the table may be used, as desired (fig. 42). Connection designations of specific terminals are given only for the type H terminal equipment. Connection designations of specific terminals of the radio equipment may be obtained by seeing the Technical Manual of the particular radio equipment used.

41. Carrier Transfer Equipment Connections

If it is necessary to terminate the voice or d-c telegraph circuit, or to transfer the carrier circuit at an intermediate point where a carrier repeater is not provided, two carrier line panels and associated terminating equipment are required. The connections required for the carrier transfer equipment only are given below. No vacuum tubes or power supply is required.

a. Ground Connections. (1) Clean one end of a 6-foot length of single-conductor copper wire and solder it to terminal 8 of terminal strip A on the upper line panel (fig. 29).

(2) Run the wire along the side of the cabinet to the lower line panel and loop the wire so as to make connection to terminal 8 of terminal strip A on the lower line panel.

(3) Solder the loop connection made in (2) above.

(4) Run the wire to the cabinet ground connection and solder.

(5) Tie the ground wire to the cabinet supports.

b. Equipment Connections.

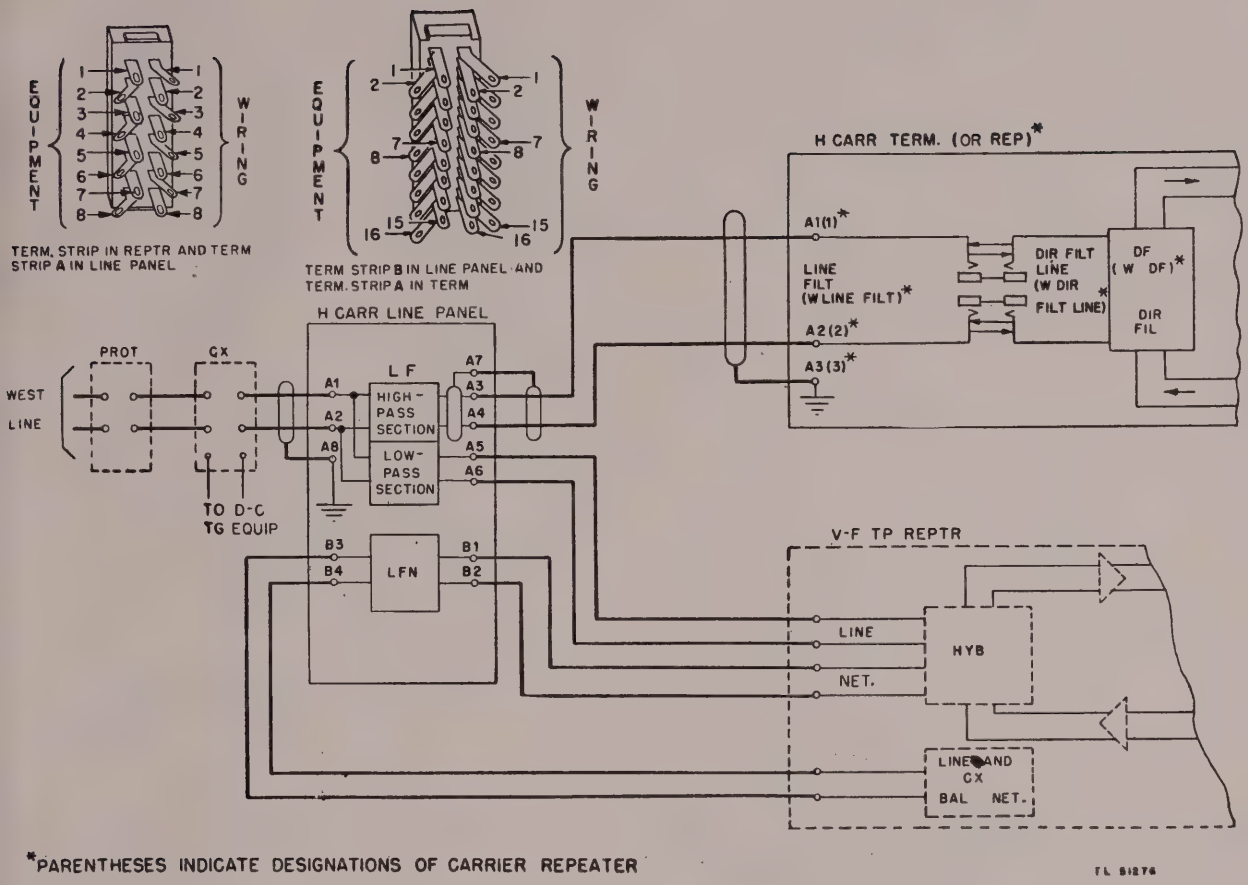
Condition	*West side*	*East side*
Physical circuit with voice-frequency telephone repeater and composite telegraph.	Figure 43	Figure 44
Physical circuit with composite telegraph.	Figure 45	Figure 46
Physical circuit with simplex telegraph.	Figure 47	Figure 48

42. Check of System Performance

A check of system performance is made after completion of the equipment connections and adjustments to insure satisfactory system performance. This is done by talking between terminals on a two-wire basis and by ringing over the circuit if the channel is terminated at an adjacent switchboard or in a telephone set.

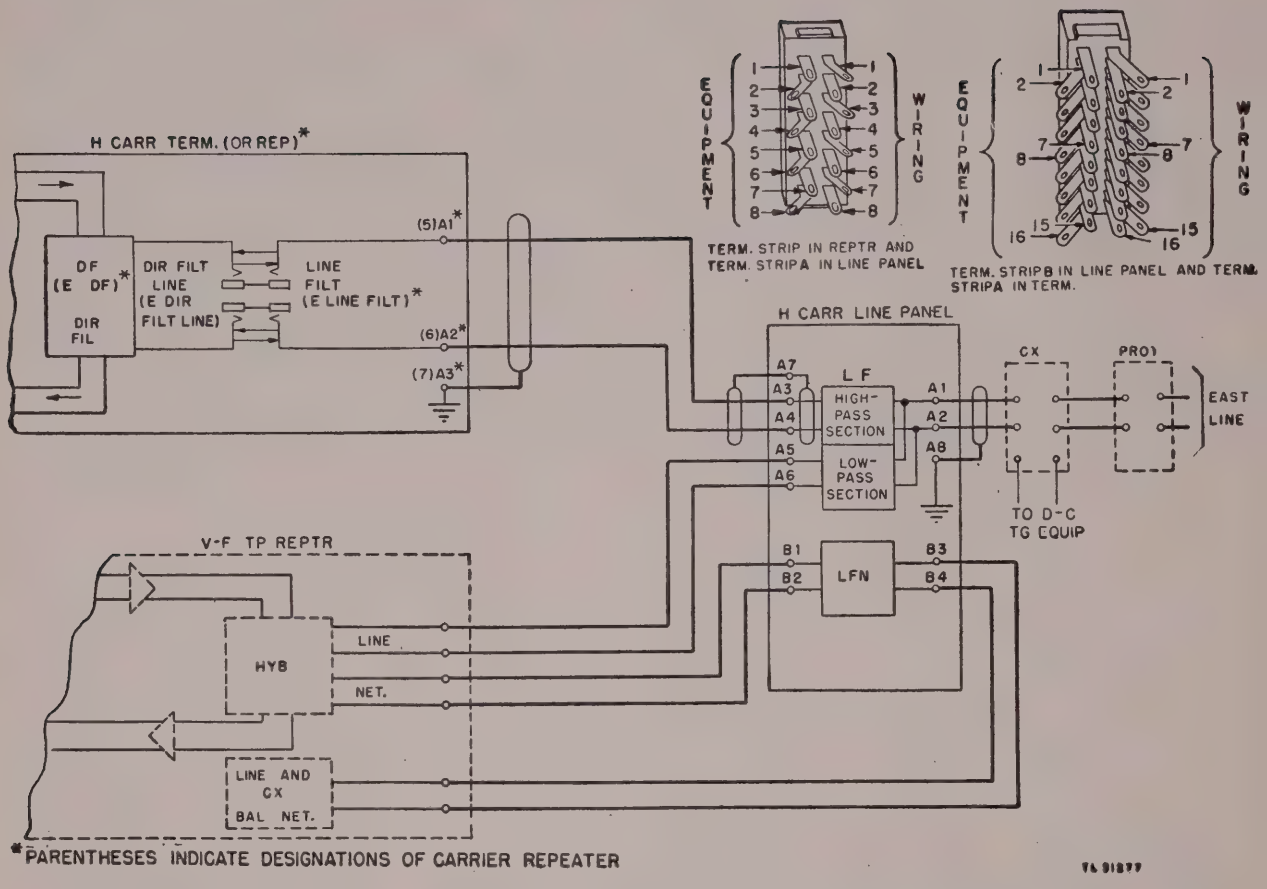
a. Talking. Set switches EQPT at both terminals on position 2W to permit talking on a two-wire basis. A magneto telephone may be patched into jacks 2W HYB at each terminal to talk. If the type H carrier terminal is located near a type C carrier terminal, the telephone set of the C carrier terminal may be used. Upon completion of conversation, restore switch EQPT at each terminal to the original position. Before undertaking extensive tests or repairs, perform the detailed tests, adjustments, and line-up procedure contained in section V. If, after these tests and adjustments have been performed, irregularities in performance persist, see section XV.

b. Signaling. If the channel is terminated at an adjacent switchboard or in a telephone set, ring over the circuit to check the signaling. In the event of failure, see section XV.



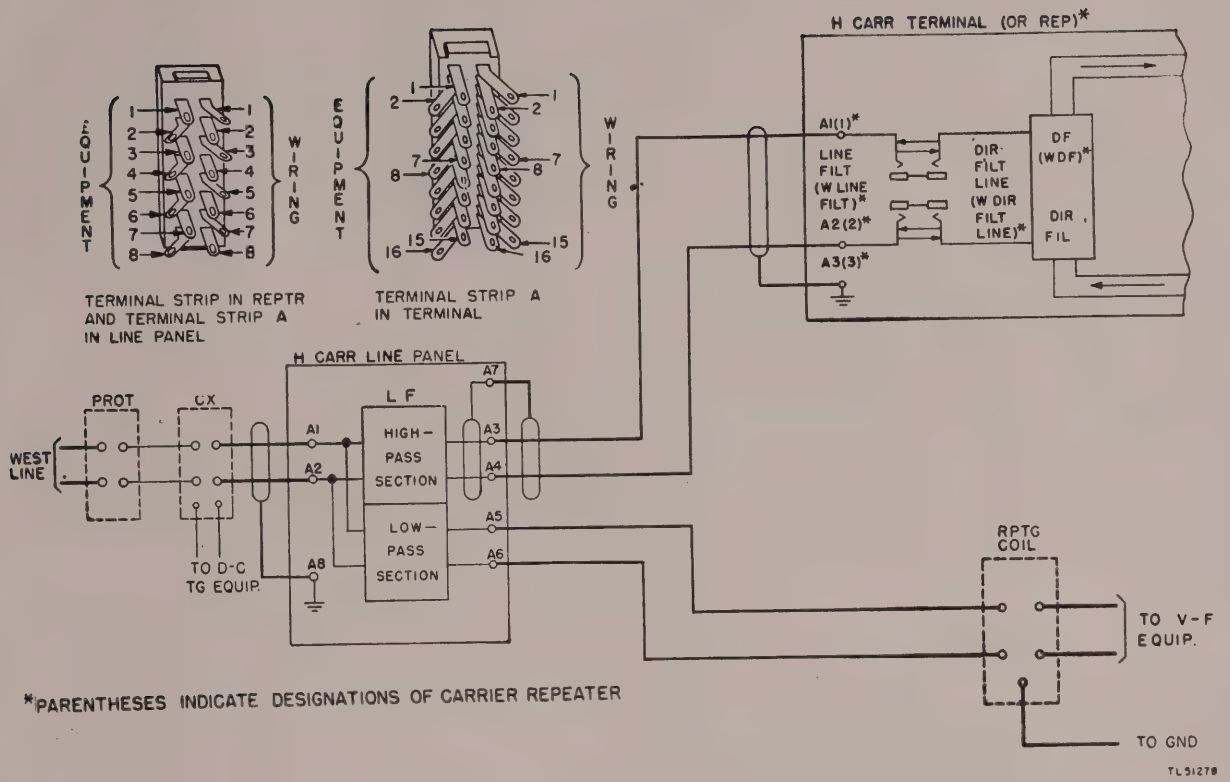
Connect from				To			
Step	Terminal	Strip	Location	Terminal	Strip	Location	Use
1	WEST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2 or 1 and 2	A ..	Terminal panel. Repeater panel.	Shielded wire.
4	5 and 6	A	Line panel.	V-f tp reptr (hyb line).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	1 and 2	B	Line panel.	V-f tp reptr (hyb net).			Paired wire.
8	3 and 4	B	Line panel.	V-f tp reptr (line and cx bal net).			Paired wire.
9	3 or 3	A ..	Terminal panel. Repeater panel.	Shield of wire in step 3.			Insulated wire.

Figure 56. Connections for East terminal or West side of repeater, with voice-frequency telephone repeater and composite telegraph.



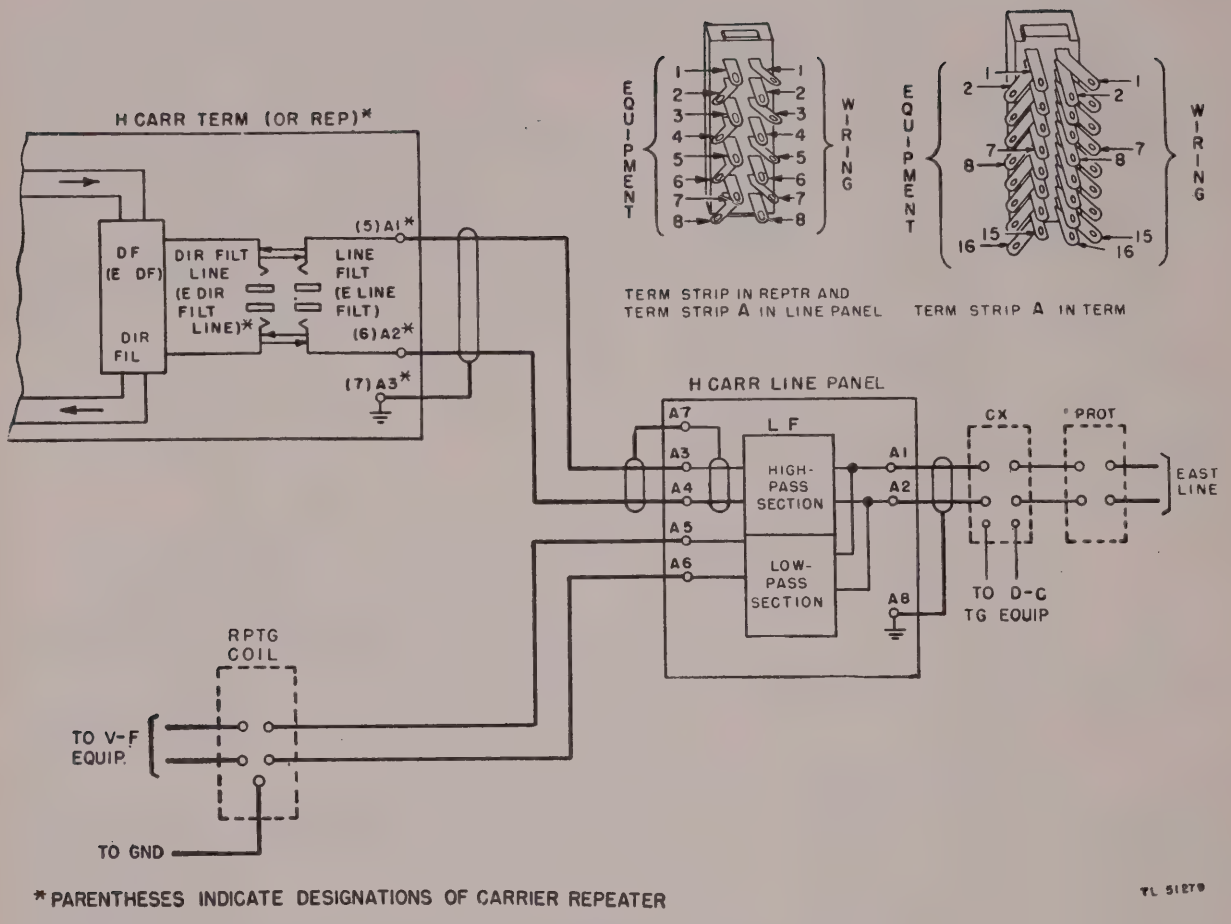
Connect from				To			
Step	Terminal	Strip	Location	Terminal	Strip	Location	Use
1	EAST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2	A	Terminal panel.	Shielded wire.
				or 5 and 6	..	Repeater panel.	
4	5 and 6	A	Line panel.	V-f tp reptr (hyb line).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	1 and 2	B	Line panel.	V-f tp reptr (hyb net).			Paired wire.
8	3 and 4	B	Line panel.	V-f tp reptr (line and cx bal net).			Paired wire.
9	3 or 7	A ..	Terminal panel. Repeater panel.	Shield of wire in step 3.			Insulated wire.

Figure 37. Connections for West terminal or East side of repeater, with voice-frequency telephone repeater and composite telegraph.



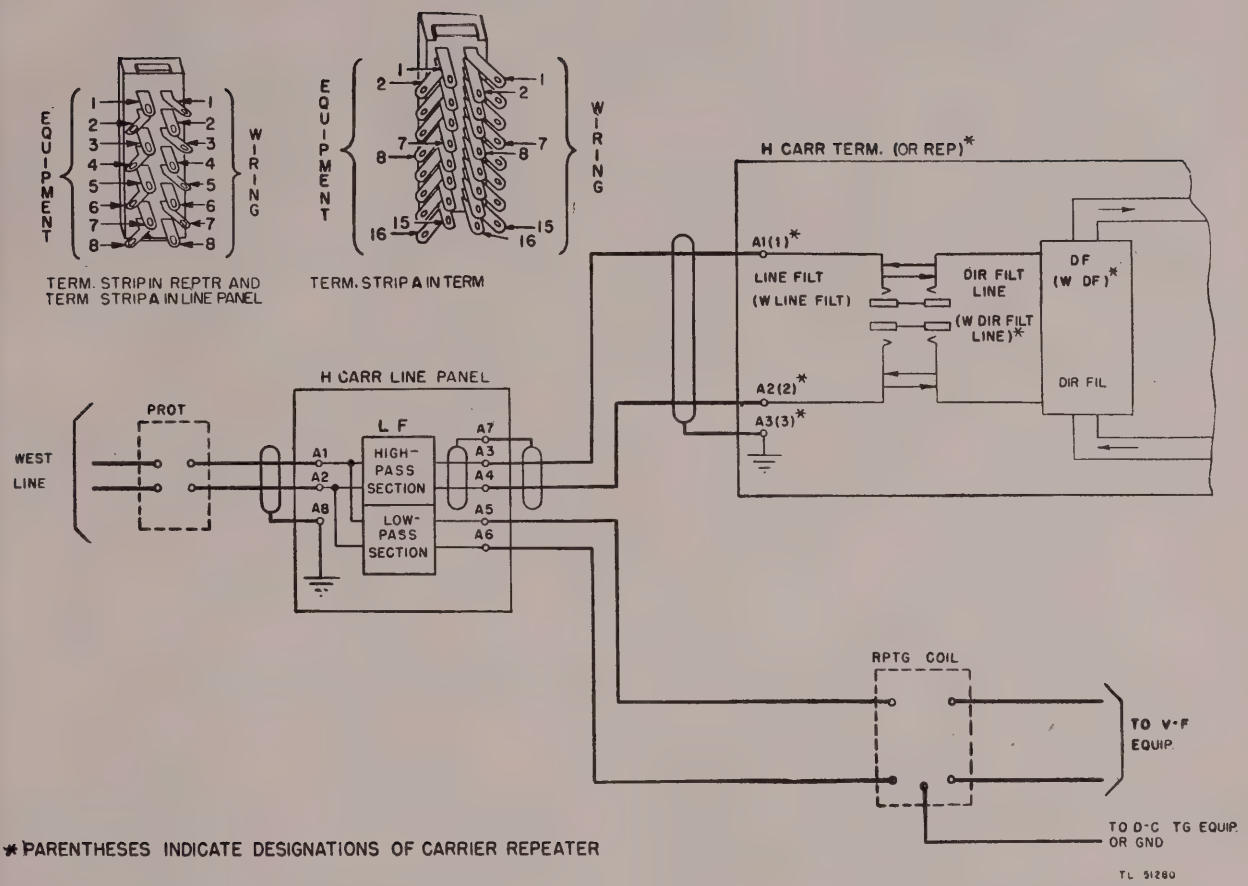
Connect from				To			
Step	Terminal	Strip	Location	Terminal	Strip	Location	Use
1	WEST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2	A	Terminal panel.	Shielded wire.
				or 1 and 2	..	Repeater panel.	
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	3	A	Terminal panel.	Shield of wire in step 3.			Insulated wire.
	or 3	..	Repeater panel.				

Figure 38. Connections for East terminal or West side of repeater, with composite telegraph.



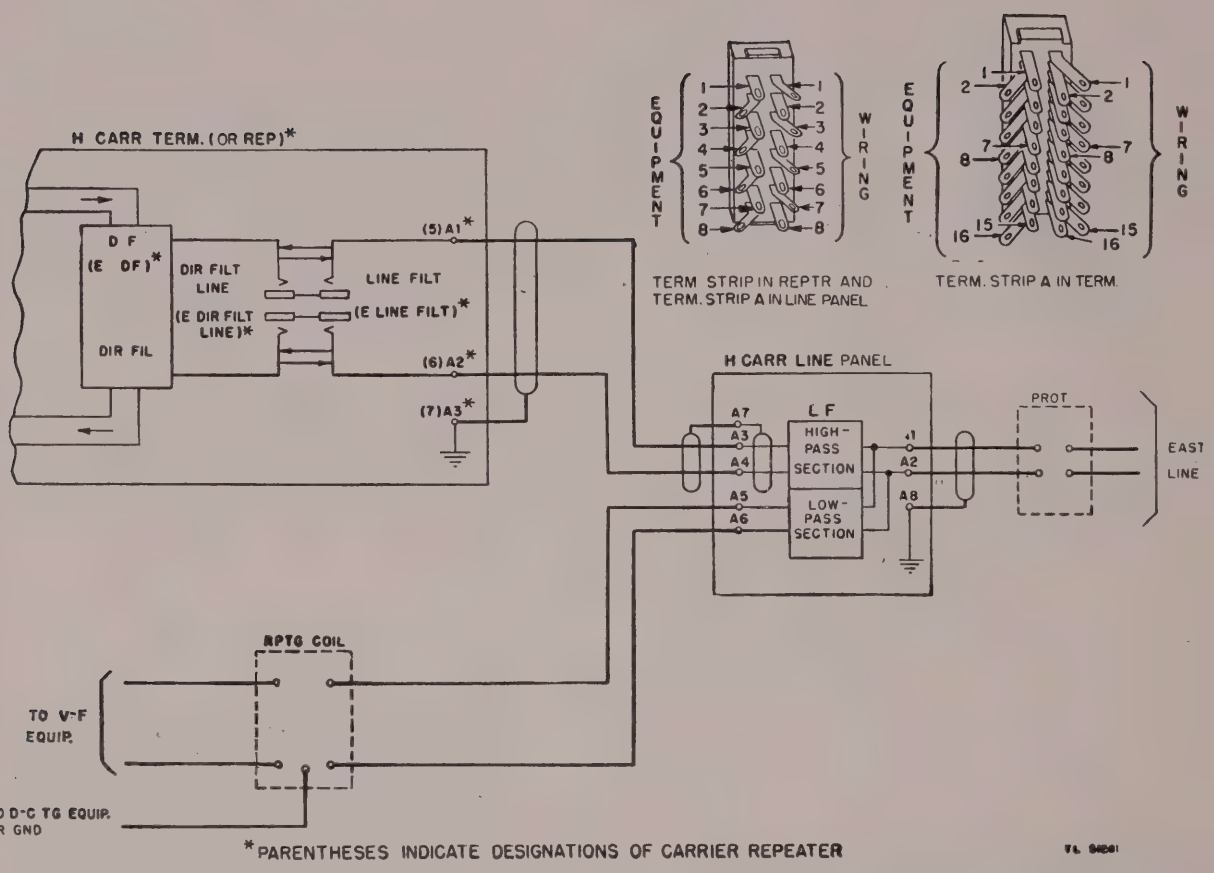
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	EAST line pair			Through prots to CX (line side).		—	Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2	A	Terminal panel.	Shielded wire.
				or 5 and 6	..	Repeater panel.	
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	3 or 7	A ..	Terminal panel. Repeater panel.	Shield of wire in step 3.			Insulated wire.

Figure 39. Connections for West terminal or East side of repeater, with composite telegraph.



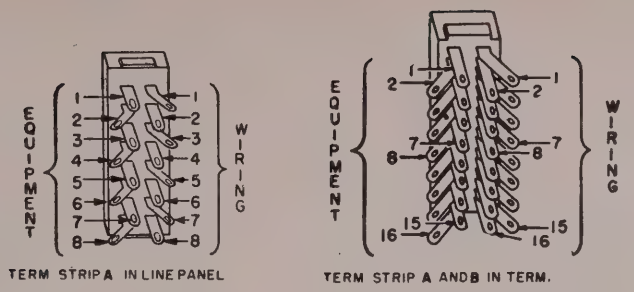
Connect from				To			
Step	Terminal	Strip	Location	Terminal	Strip	Location	Use
1	WEST line pair			Prots (line side).			Shielded wire.
2	1 and 2	A	Line panel.	Prots (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2	A	Terminal panel.	Shielded wire.
				or 1 and 2	..	Repeater panel.	
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	3	A	Terminal panel.	Shield of wire in step 3.			Insulated wire
	or 3	..	Repeater panel.				

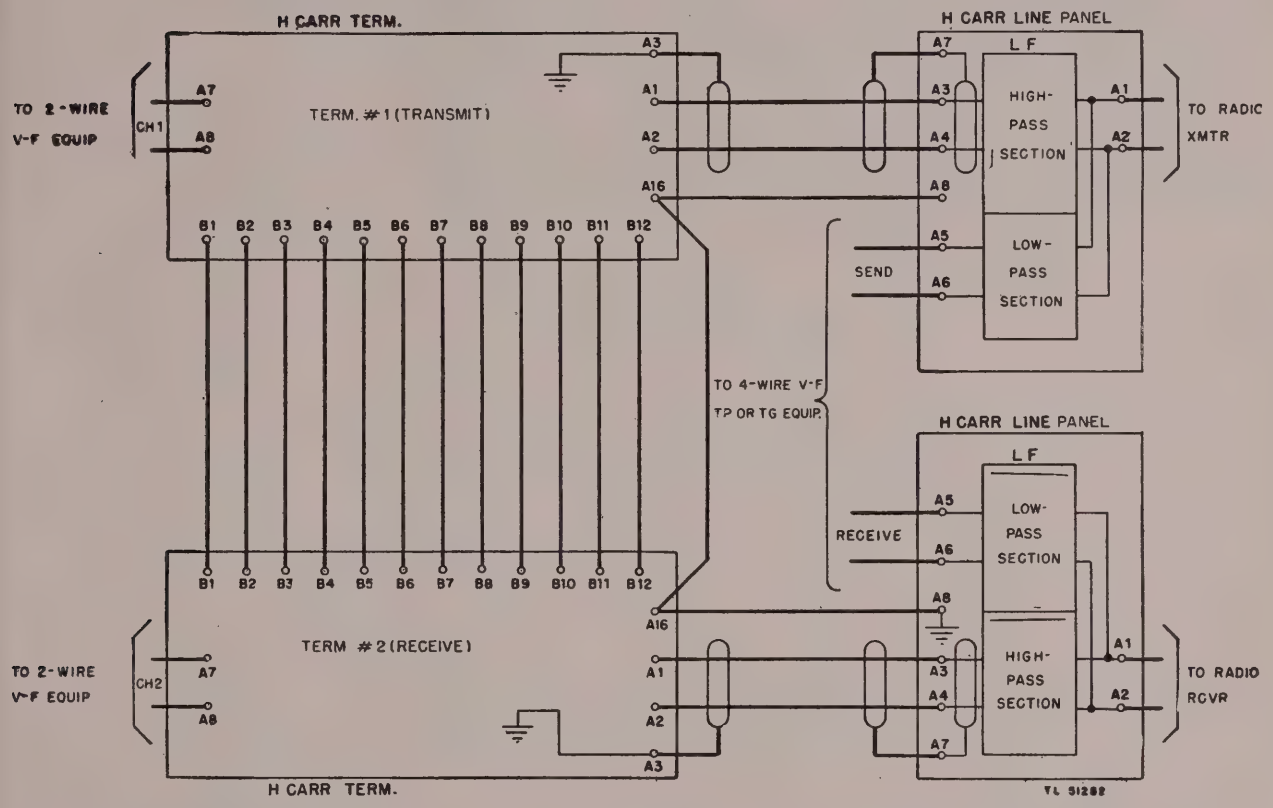
Figure 40. Connections for East terminal or West side of repeater, with simplex telegraph.



Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	EAST line pair			Prots (line side).			Shielded wire.
2	1 and 2	A	Line panel.	Prots (drop side).			Shielded wire.
3	3 and 4	A	Line panel.	1 and 2 or 5 and 6	A ..	Terminal panel. Repeater panel.	Shielded wire.
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
7	3 or 7	A ..	Terminal panel. Repeater panel.	Shield of wire in step 3.			Insulated wire.

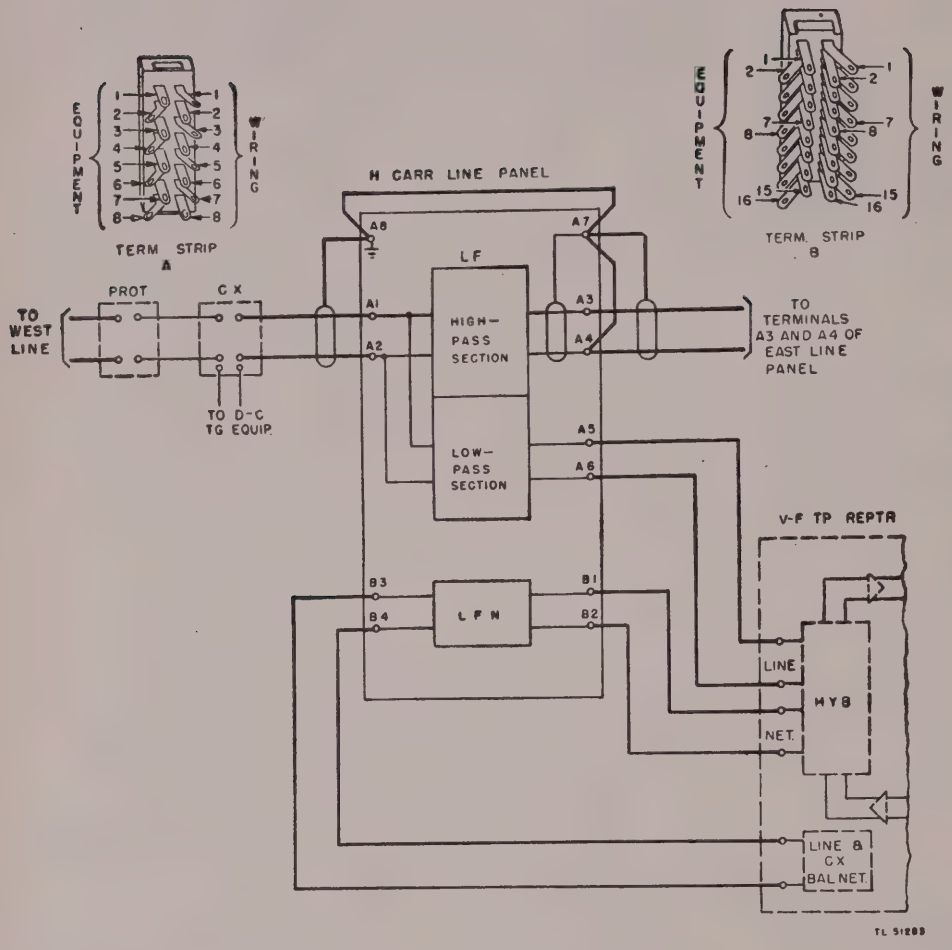
Figure 41. Connections for West terminal or East side of repeater, with simplex telegraph.





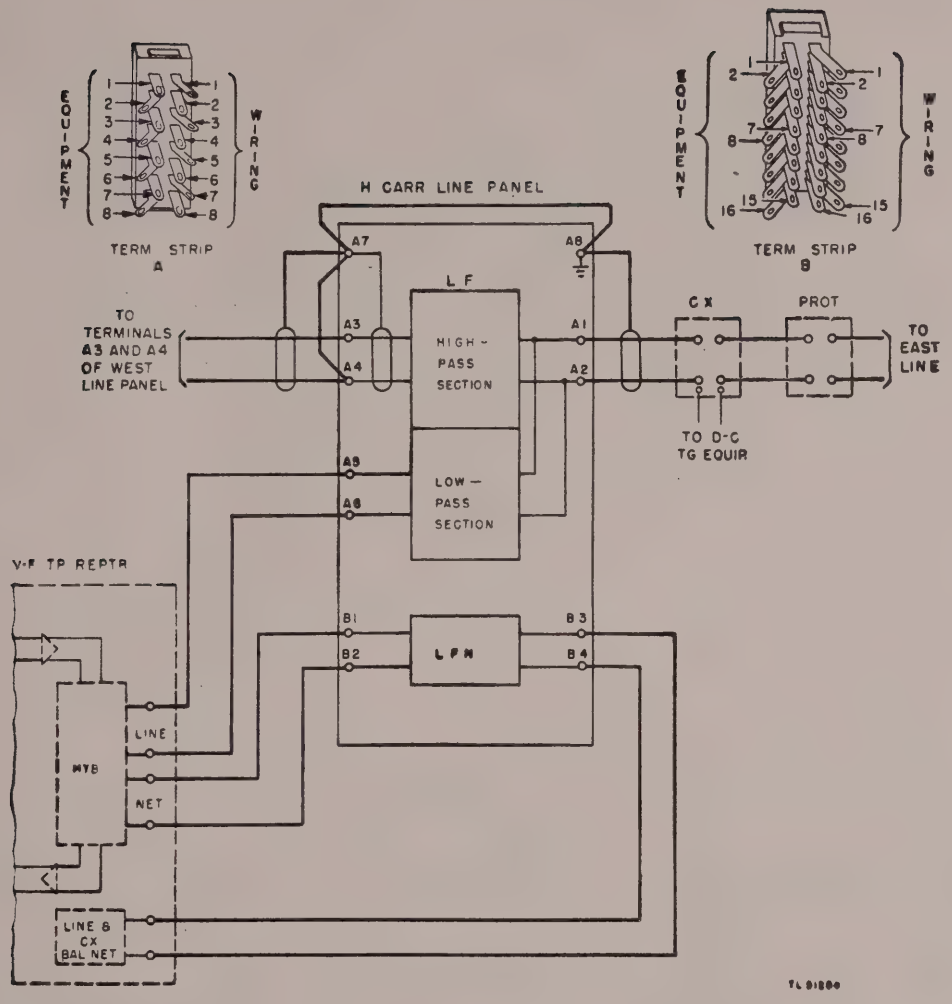
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	1 and 2	B	Terminal (1).	1 and 2	B	Terminal (2).	Paired wire.
2	3 and 4	B	Terminal (1).	3 and 4	B	Terminal (2).	Paired wire.
3	5 and 6	B	Terminal (1).	5 and 6	B	Terminal (2).	Paired wire.
4	7 and 8	B	Terminal (1).	7 and 8	B	Terminal (2).	Paired wire.
5	9 and 10	B	Terminal (1).	9 and 10	B	Terminal (2).	Paired wire.
6	11 and 12	B	Terminal (1).	11 and 12	B	Terminal (2).	Paired wire.
7	1 and 2	A	Terminal (1).	3 and 4	A	Line panel (1).	Shielded wire.
8	3	A	Terminal (1).	Shield of wire in step 7.			Insulated wire.
9	7 and 8	A	Terminal (1).	2-wire v-f equip.			Paired wire.
10	16	A	Terminal (1).	8	A	Line panel (1).	Paired wire.
11	1 and 2	A	Line panel (1).	Radio xmtr.			Paired wire.
12	5 and 6	A	Line panel (1).	Send side of 4-wire v-f tp or tg equip.			Paired wire.
13	7	A	Line panel (1).	Shield of wire in step 7.			Insulated wire.
14	1 and 2	A	Terminal (2).	3 and 4	A	Line panel (2).	Shielded wire.
15	3	A	Terminal (2).	Shield of wire in step 14.			Insulated wire.
16	7 and 8	A	Terminal (2).	2-wire v-f equip.			Paired wire.
17	16	A	Terminal (2).	16	A	Terminal (1).	Insulated wire.
18	16	A	Terminal (2).	8	A	Line panel (2).	Insulated wire.
19	1 and 2	A	Line panel (2).	Radio rcvr.			Paired wire.
20	5 and 6	A	Line panel (2).	Receive side of 4-wire v-f or tg equip.			Paired wire.
21	7	A	Line panel (2).	Shield of wire in step 14.			Insulated wire.

Figure 42. Connections for radio link operation.



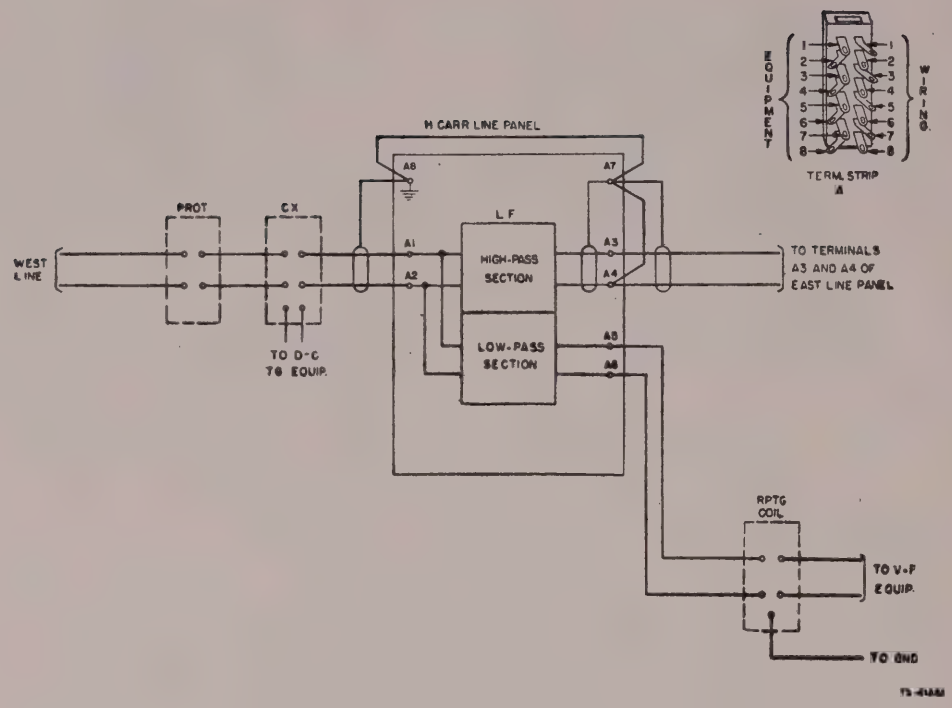
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	WEST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel (WEST).	3 and 4	A	Line panel (EAST).	Shielded wire.
4	5 and 6	A	Line panel.	V-f tp reptr (hyb line).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
9	1 and 2	B	Line panel.	V-f tp reptr (hyb net).			Paired wire.
10	3 and 4	B	Line panel.	V-f tp reptr (line and cx bal net).			Paired wire.

Figure 43. Connections for West side at transfer point, with voice-frequency telephone repeater and composite telegraph.



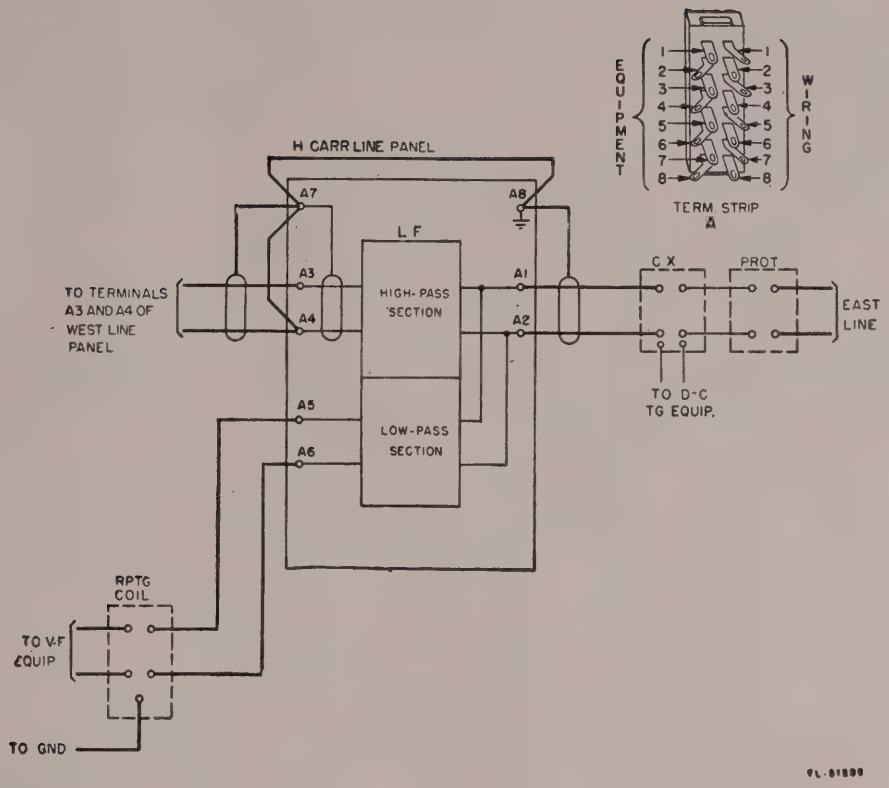
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	EAST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel (EAST).	3 and 4	A	Line panel (WEST).	Shielded wire.
4	5 and 6	A	Line panel.	V-f tp reptr (hyb line).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.
9	1 and 2	B	Line panel.	V-f tp reptr (hyb net).			Paired wire.
10	3 and 4	B	Line panel.	V-f tp reptr (line and cx bal net).			Paired wire.

Figure 44. Connections for East side at transfer point, with voice-frequency telephone repeater and composite telegraph.



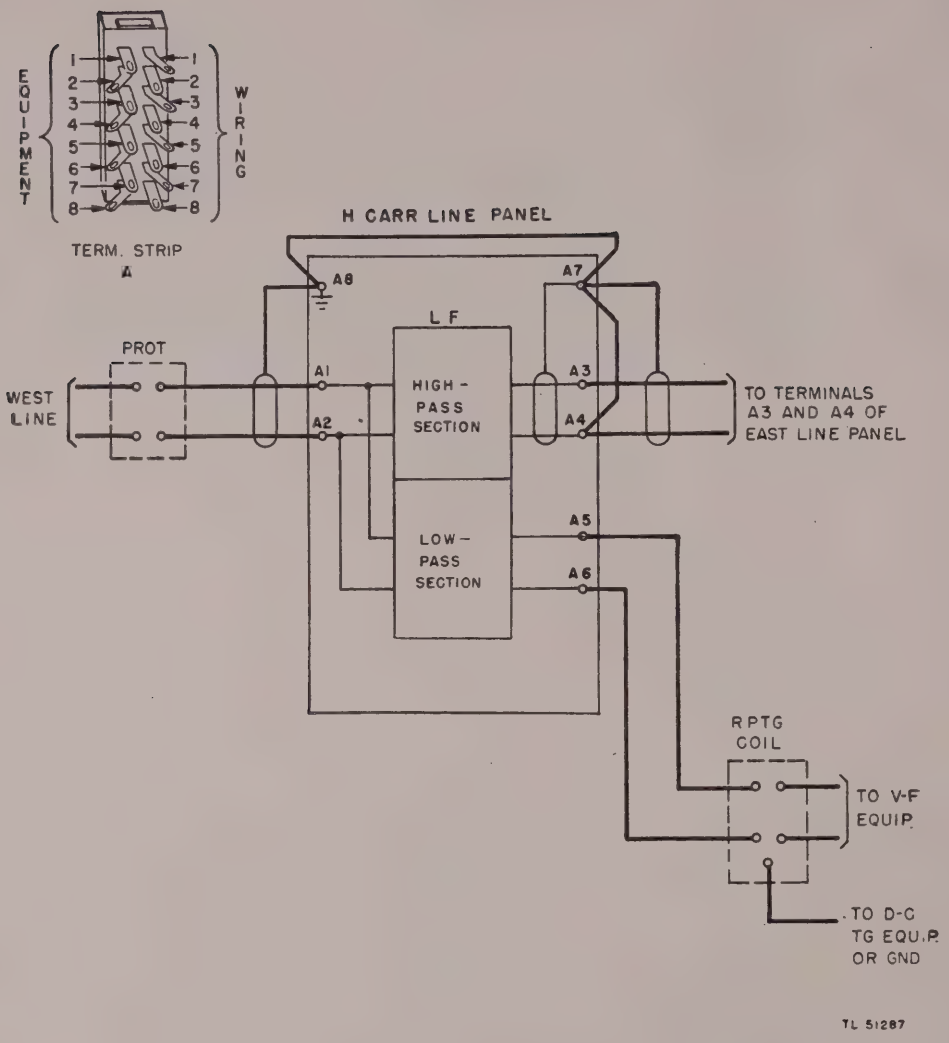
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	WEST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel (WEST).	3 and 4	A	Line panel (EAST).	Shielded wire.
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.

Figure 45. Connections for West side at transfer point, with composite telegraph.



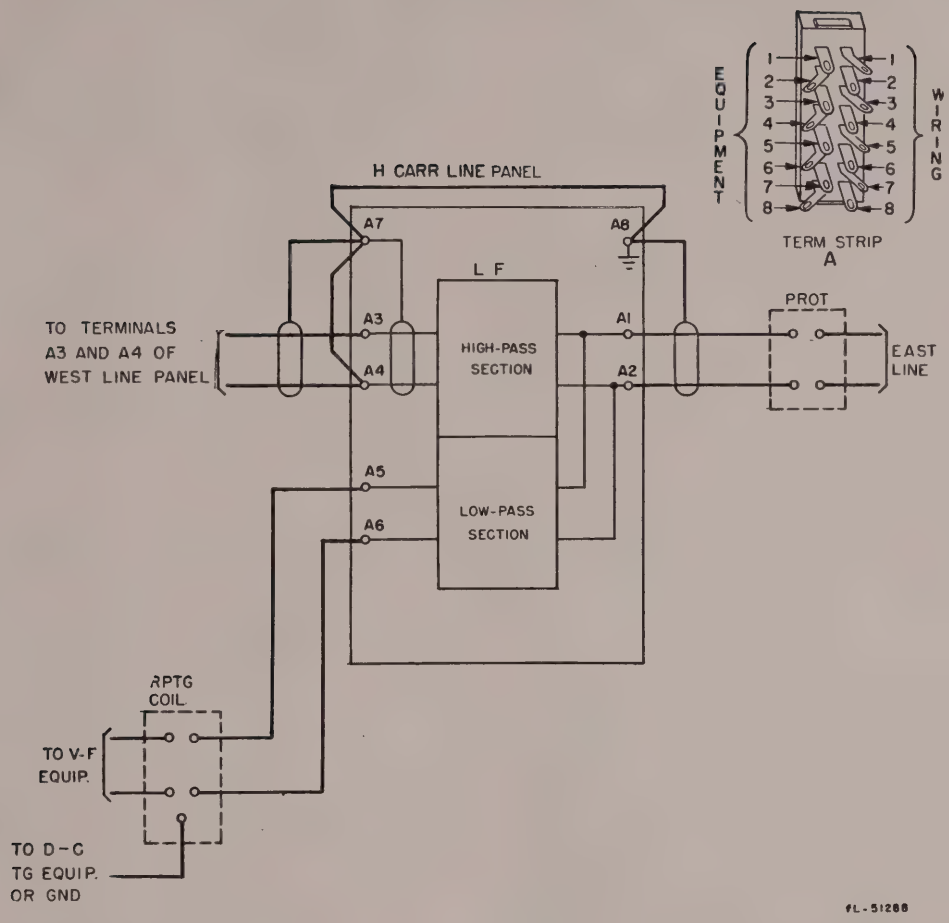
Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	EAST line pair			Through prots to CX (line side).			Shielded wire.
2	1 and 2	A	Line panel.	CX (drop side).			Shielded wire.
3	3 and 4	A	Line panel (EAST).	3 and 4	A	Line panel (WEST).	Shielded wire.
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.

Figure 46. Connections for East side at transfer point, with composite telegraph.



Connect from				To			
Step	Terminal	Strip	Location	Terminal	Strip	Location	Use
1	WEST line pair			Prots (line side).			Shielded wire.
2	1 and 2	A	Line panel.	Prots (drop side).			Shielded wire.
3	3 and 4	A	Line panel (WEST).	3 and 4	A	Line panel (EAST).	Shielded wire.
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire

Figure 47. Connections for West side at transfer point, with simplex telegraph.



Step	Connect from: Terminal	Strip	Location	To: Terminal	Strip	Location	Use
1	EAST line pair			Prots (line side).			Shielded wire.
2	1 and 2	A	Line panel.	Prots (drop side).			Shielded wire.
3	3 and 4	A	Line panel (EAST).	3 and 4	A	Line panel (WEST).	Shielded wire.
4	5 and 6	A	Line panel.	Rptg coil (line side).			Paired wire.
5	7	A	Line panel.	Shield of wire in step 3.			Insulated wire.
6	7	A	Line panel.	4	A	Line panel.	Strap wire.
7	7	A	Line panel.	8	A	Line panel.	Strap wire.
8	8	A	Line panel.	Shield of wire in step 2.			Insulated wire.

Figure 48. Connections for East side at transfer point, with simplex telegraph.

Section V. DETAILED TESTS, ADJUSTMENTS, AND SYSTEM LINE-UP

43. Testing Equipment

To perform the detailed tests and adjustments given in this section, the test equipment listed below (or the equivalent) is required. Though the equipment listed is not supplied with the type H carrier equipment, it should be available at locations where voice-frequency telephone repeaters are installed.

Nomenclature	Sig. Corps stock No.	Mfr's. No.	Description	Usage
Multimeter TS-380/U.	3F7127	WECo D-166852	Volt-ohm-milliammeter	Voltage, current, and resistance measurements
Audio Oscillator TS-379/U.	3F3570-1	WECo 19C(SPL)	Oscillator	Provide testing power
Attenuator TS-402/U.	3F1775	WECo 5A(SPL)	Attenuator	Insert losses
Decibel Meter TS-399/U.	3F4270-2	WECo 13A(SPL)	Transmission measuring set	Measure power levels
Tube Tester I-171.	3F5681	Hickok model 560 (SPL)	Vacuum tube test set	Test vacuum tubes
Test Set TS-190/U.	3F4316.1	WECo 67B(SPL)	Test receiver	Monitoring

44. Procedures for Transmission Measurements

Transmission measurements are required in order to obtain optimum system performance. Transmission measurements are made by sending a test tone of suitable frequency and power into the circuit under test by means of a test oscillator and then measuring the output power of the circuit with a transmission measuring set. An attenuator may be required to reduce the output power supplied by the oscillator to a suitable level or to reduce the input to the transmission measuring set so that it may be read. The frequency and power of the test oscillator required for transmission measurements will depend upon whether the circuit under test is designed to operate at voice or carrier frequencies.

a. Voice-frequency Circuits. All circuits and equipment on the switchboard side of an H carrier terminal are designed to operate at voice frequencies. Therefore, when transmitting a test tone into the switchboard side of an H carrier terminal, a test oscillator frequency of 1,000 cycles is used. Since the normal average speech level at the switchboard side is 1 milliwatt, a test power equivalent to 0 dbm is applied at the switchboard side.

b. Carrier-frequency Circuits. All circuits and equipment on the line side of a type H carrier terminal or repeater are designed to operate at carrier frequencies. Because of the different frequencies used for each direction of transmission, a test frequency of 6,000 cycles is used for the West-to-East direction while a test frequency of 8,000 cycles is used for the East-to-West direction of transmission. To prevent overloading of the demodulators at a terminal, or the amplifiers when transmitting test tone into the line side of an H carrier terminal or repeater, the output power of the oscillator is reduced further by inserting an attenuator between the output of the oscillator and the input to the circuit under test.

c. Test Instrument Requirements. (1) *Test oscillator.* The test oscillator required for the transmission measurements should have an output impedance of 600 ohms (or impedance-matching facilities to provide a 600-ohm impedance) and provide a stable output variable to approximately + 6 dbm into a 600-ohm load over a frequency range of 200 to 10,000 cycles.

(2) *Transmission measuring set.* The transmission measuring set required for the transmission measurements should have an input impedance of 600 ohms and be stable over a frequency range of 200 to 10,000 cycles.

(3) *Attenuator.* The attenuator required for the transmission measurements should have a 600-ohm impedance and be variable from 0 to approximately 30 db in 1-db steps.

d. Determining Transmission Measurements. If an attenuator is used when making transmission measurements, the reading of the transmission measuring set is not a true indication of the gain or loss of the circuit under test. To correct for the inser-

tion of the attenuator, the reading of the transmission measuring set is added to the setting of the attenuator if the reading of the transmission measuring set is above 0 dbm. If the reading of the transmission measuring set is below 0 dbm, the reading of the transmission measuring set is subtracted from the setting of the attenuator.

45. Outline of Detailed Tests, Adjustments, and System Line-up

To obtain optimum performance, the detailed tests, adjustments, and system line-up contained in the following paragraphs of this section should be made as soon after the equipment is installed as practicable.

a. Terminal Tests and Adjustments. The detailed tests and adjustments required at a terminal are listed below in the order in which they should be performed.

Terminal tests and adjustments required:

Voltage adjustments (par. 46).
Vacuum tube test (par. 47).
Oscillator output measurement (par. 48).
Receiving gain measurement (par. 49).
Transmitting gain measurement (par. 50).
Transmitting output adjustment (par. 51).

b. Repeater Tests and Adjustments. The detailed tests and adjustments required at a repeater are listed below in the order in which they should be performed.

Repeater tests and adjustments required:

Voltage adjustments (par. 46).
Vacuum tube test (par. 47).
Repeater gain measurement (par. 52).

c. Over-all System Line-up and Tests. (1) The over-all system line-up and tests require the cooperation of each repeater station and both terminal offices. Each test requires that one terminal office direct the testing procedure. Generally the control terminal coordinates the tests, though it may designate either the other terminal or one of the repeater stations to assume this duty.

(2) Each of the over-all tests requires that a talking circuit be established between each repeater and the East and West terminals. Since no talking facilities are provided with the type H carrier equipment, communication must be established over a voice circuit or a channel of another carrier system.

(3) The over-all system line-up and tests listed below should be made after the detailed terminal and repeater tests and adjustments given in *a* and *b* above are performed.

Over-all system line-up and tests:

System line-up (par. 53).
Loop gain measurement (par. 54).
Synchronization adjustment (par. 55).
Channel net loss-frequency test (par. 56).

46. Voltage Adjustments

a. General. (1) The type H carrier equipment is designed to operate from a 50- to 60-cycle, 105- to 125-volt a-c power source. Depending on the supply voltage, connection is made to one of three taps provided on the primary winding of power transformer PWR (figs. 28 and 30). The primary tap lead is adjusted during manufacture for operation from a 120-volt a-c source.

(2) The secondary of the power transformer has two windings. One winding supplies current for the heaters of the vacuum tubes. The other winding supplies a varistor-bridge rectifier which furnishes direct current for plate and screen voltages. This second winding is tapped to provide adjustment to compensate for the aging of the varistor units.

b. Apparatus Required. 1 Multimeter TS-380/U.

c. Adjustment of Power Transformer Primary (figs. 28 and 30). (1) Disconnect the power cord plug.

(2) Using the 300V a-c scale of the multimeter, measure the a-c supply voltage at the outlet box or plug-in strip.

(3) The tap lead on the primary of transformer PWR is connected at the factory to terminal 5. Reconnect the tap lead, if necessary, to meet the line voltage requirements shown below.

A-c line voltage	Connect tap lead to terminal
105 to 112	3
112 to 118	4
118 to 125	5*

* Adjustment made during manufacture.

(4) Insert the power cord plug into the convenience outlet.

d. Adjustment of Rectifier Output. (1) Allow sufficient time for the tubes to heat.

(2) Using the 300V d-c scale of the multimeter, measure the rectifier output voltage between terminal 1 of retardation coil P (figs. 28 and 30) and ground.

Requirement: The output voltage should be between 125 and 190 volts.

(3) If the voltage as measured is less than 125 volts, change the transformer tap lead, which is connected to terminal 7, to terminal 8.

(4) If the voltage as measured is greater than 190 volts change the primary tap adjusted in *c*(3) above to the next higher-numbered terminal.

e. CHECK OF HEATER VOLTAGE. (1) Using the 15V a-c scale of the multimeter, measure the heater voltage between terminals 1 and 6 of each vacuum tube socket.

Requirement: The heater voltage should be between 9 and 11 volts.

(2) If the requirement is not met, see paragraph 103.

47. Vacuum Tube Test

Tubes should be tested with tube tester I-171, or its equivalent, for shorts, transconductance, grid emission, and filament activity in accordance with TM 11-2047 which is furnished with the tube tester. In order to reduce service interruptions to a minimum, tube tests on a given system should be coordinated with all offices.

a. APPARATUS REQUIRED: 1 tube tester I-171.

b. PROCEDURE. (1) Using the tube tester test all vacuum tubes.

(2) Return the satisfactory tubes to the original sockets. If a tube is replaced use only a tested tube.

Note. If tube OSC is replaced at either terminal, the synchronization adjustment test given in paragraph 55 should be made before placing the system in service.

48. Oscillator Output Measurement

Satisfactory performance of the modulator and demodulator circuits is dependent to some extent upon the amount of carrier power impressed upon the varistor circuits. The amount of power varies with differences in the oscillator circuit, line voltage, and the varistor elements.

a. APPARATUS REQUIRED:

1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

b. PROCEDURE (fig. 49). (1) Connect one side of the attenuator input to terminal 4 of transformer OSC and connect the other side of the attenuator input to ground.

(2) Set the attenuator for a loss of 5 db.

(3) Connect the output of the attenuator to the input of the transmission measuring set.

(4) Read the transmission measuring set and determine the oscillator output.

Requirement: The oscillator output should be between +4.5 and +13.0 dbm.

(5) If the requirement is not met, replace tube OSC and determine the oscillator output as in (4) above. If the requirement is not met after tube OSC has been replaced with a satisfactory vacuum tube, see paragraph 105.

49. Receiving Gain Measurement

The measurement of receiving gain provides a means of checking the gain of the receiving circuit. The gain is measured by sending testing power at a frequency of 8,000 cycles at a West terminal, or 6,000 cycles at an East terminal, to jacks DIR FILT LINE and measuring the output at the voice-frequency side of the terminal. First the maximum receiving gain is measured and then the positions of control REC GAIN are checked. For radio link operation this test is performed at both terminal panels with switch LINE set to WIRE EAST.

a. APPARATUS REQUIRED:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.

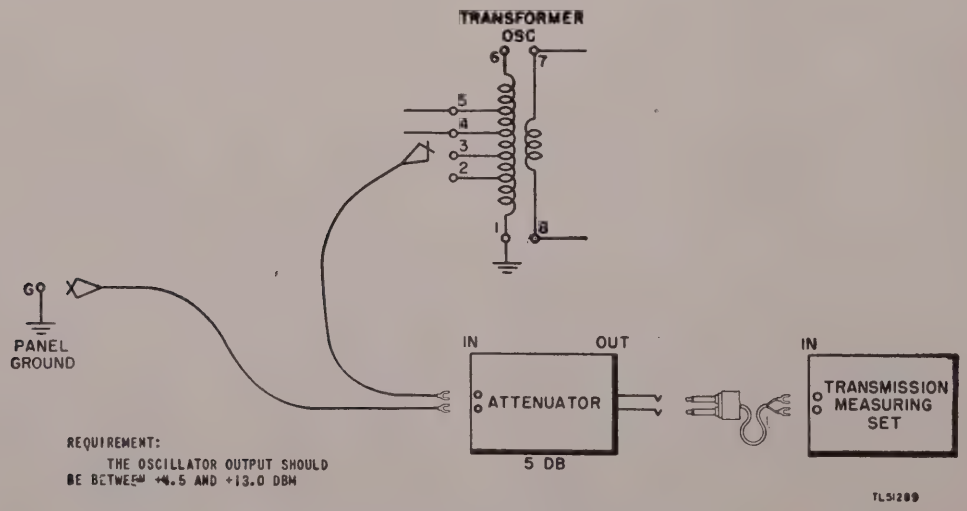


Figure 49. Oscillator output measurement.

1 Attenuator TS-402/U.
Patching cords.

b. PROCEDURE (fig. 50). If the line switch is set to a radio position, turn the control to the WIRE EAST position and use a testing frequency of 6,000 cycles.

(1) After noting the settings of the gain controls, set control REC GAIN to 50 and control TR GAIN to 0.

(2) Patch the output of the oscillator to the input of the attenuator.

(3) Set the attenuator for a loss of 20 db.

(4) Patch the output of the attenuator to jacks DIR FILT LINE.

(5) If switch EQPT is on the 2W position, patch jacks 2W HYB to the input of the transmission measuring set. If switch EQPT is on the 4W TEL position, patch jacks DEM OUT to the input of the transmission measuring set.

(6) Adjust the oscillator for an output of 0 dbm at 6,000 cycles for a line switch setting of WIRE EAST or 8,000 cycles for a line switch setting of WIRE WEST.

(7) Read the transmission measuring set and determine the receiving gain.

Requirement: The maximum receiving gain should be within ±3.5 db of the value as given in table VII with control REC GAIN set on 50.

(8) If the requirement is not met, see paragraphs 99 and 104.

(9) Set potentiometer REC GAIN to steps 40, 30, 20, and 10 and record the receiving gain on each of the steps. It is necessary to reduce the setting of the attenuator in order to obtain a reading on the transmission measuring set for the lower settings of control REC GAIN.

(10) Note the difference between the receiving gain obtained with control REC GAIN set on 50 and the receiving gain obtained on each of the other steps.

Requirement: The reduction in receiving gain for various settings of potentiometer REC GAIN as compared to the gain obtained with potentiometer REC GAIN set to 50 should be within ±1 db of the values given in table VII.

(11) Remove patching cords, set the controls to the operating positions, and restore the circuit to normal.

(12) For radio link operation, repeat the procedure given in (1) through (11) above at the other terminal panel.

Table VII. Receiving gain for various settings of control REC GAIN.

Setting of switches		REC GAIN control set	Reduction in receiving gain with REC GAIN control set on				
LINE	*EQPT.*	*50*	*40*	*30*	*20*	*10*	*0*
EAST	2W	17.0	10	20	30	39.7	*
	4W TEL	27.9	10	20	30	39.7	*
WEST	2W	16.6	10	20	30	39.7	*
	4W TEL	27.5	10	20	30	39.7	*

*Readings on this step may vary because of carrier leak and power noise.

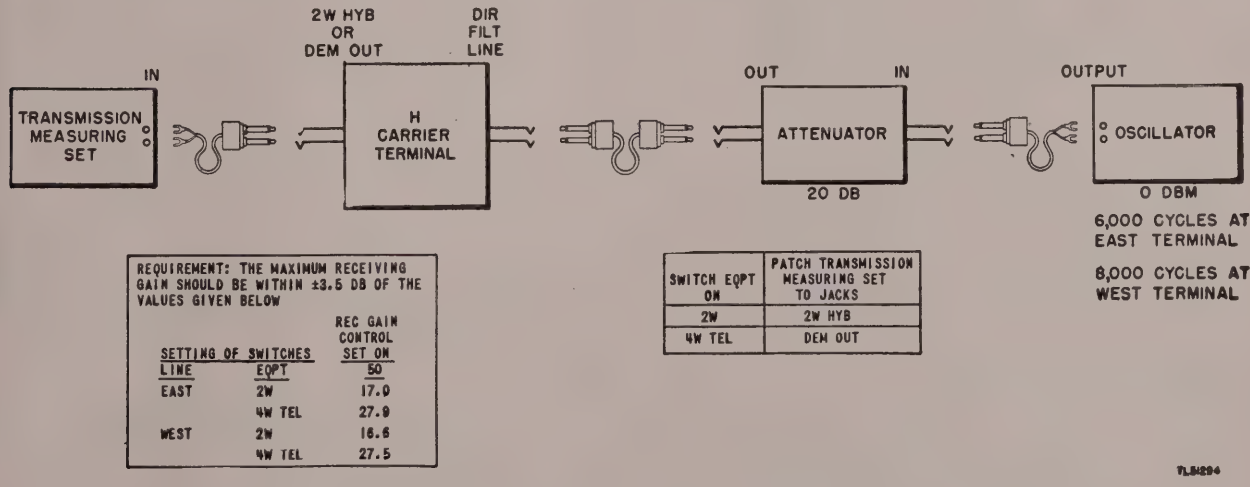


Figure 50. Receiving gain measurement.

50. Transmitting Gain Measurement

The measurement of transmitting gain provides a means for checking the gain of the transmitting circuit and associated equipment. The gain is measured by sending testing power at a frequency of 1,000 cycles into the voice-frequency side of the terminal and measuring the high-frequency output

at jacks DIR FILT LINE. First the maximum transmitting gain is measured and then the positions of potentiometer TR GAIN are checked. For radio link operation this test is performed on both terminal panels with switch LINE set to WIRE EAST.

a. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

b. Procedure (fig. 51). If the line switch is set to a radio position, turn the switch to the WIRE EAST position.

(1) After noting the settings of the gain controls, set control TR GAIN to 50 and control REC GAIN to 0.

(2) If switch EQPT is on the 2W position, patch the output of the oscillator to jacks 2W HYB. If switch EQPT is on the 4W TEL position, patch the output of the oscillator to jacks MOD IN.

(3) Patch jacks DIR FILT LINE to the input of the attenuator.

(4) Set the attenuator for a loss of 20 db.

(5) Patch the output of the attenuator to the input of the transmission measuring set.

(6) Adjust the oscillator to a frequency of 1,000 cycles at an output of 0 dbm for an equipment switch setting of 2W, or +4 dbm for an equipment switch setting of 4W TEL.

(7) Read the transmission measuring set and determine the transmitting gain.

Requirement: The maximum transmitting gain should be within ±3.5 db of the value as given in table VIII with control TR GAIN set to 50.

(8) If the requirement is not met, see paragraphs 99 and 104.

(9) Set control TR GAIN to steps 40, 30, 20, and 10 and record the transmitting gain on each of the steps. It is necessary to reduce the setting of the attenuator in order to obtain a reading on the transmission measuring set for the lower settings of control TR GAIN.

(10) Note the differences between the transmitting gain obtained with control TR GAIN set on 50 and the transmitting gain obtained on each of the other steps.

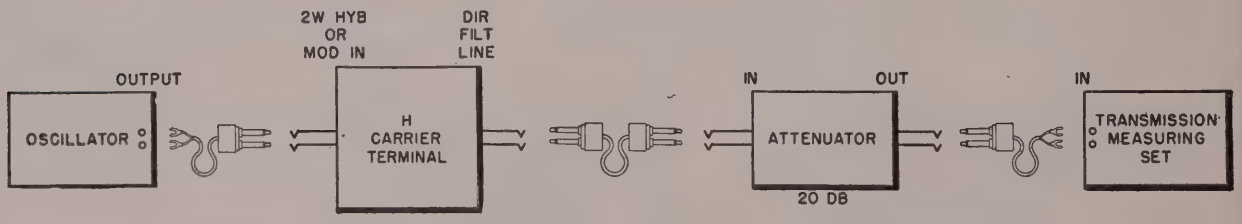
Requirement: The reduction in transmitting gain for various settings of control TR GAIN as compared to the gain obtained with control TR GAIN set to 50 should be within ± db of the values given in table VIII.

(11) Remove patching cords, set the controls to the operating positions, and restore the circuit to normal.

(12) For radio link operation, repeat the procedure given in (1) through (11) above at the other terminal panel.

Table VIII. Transmitting gain for various settings of control TR GAIN

Setting of switches		TR GAIN control set	Reduction in transmitting gain with TR GAIN control set on				
LINE	*EQPT.*	*50*	*40*	*30*	*20*	*10*	*0*
EAST	2W	21.0	9.4	17.3	29.3	39.3	49.3
	4W TEL	16.0	9.4	17.3	29.3	39.3	49.3
WEST	2W	21.3	9.4	17.3	29.3	39.3	49.3
	4W TEL	16.3	9.4	17.3	29.3	39.3	49.3



SWITCH EQPT ON	PATCH OSCILLATOR TO JACKS	OSCILLATOR OUTPUT LEVEL	OSCILLATOR FREQUENCY
2W	2W HYB	0 DBM	1,000 CYCLES
4W TEL	MOD IN	+4 DBM	1,000 CYCLES

REQUIREMENT: THE MAXIMUM TRANSMITTING GAIN SHOULD BE WITHIN ±3.5 DB OF THE VALUES GIVEN BELOW

SETTING OF SWITCHES LINE	EQPT	TR GAIN CONTROL SET ON 50
EAST	2W	21.0
	4W TEL	16.0
WEST	2W	21.3
	4W TEL	16.3

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Figure 51. Transmitting gain measurement.

51. Transmitting Output Adjustment

The transmitting gain is adjusted to meet the specified output. The test is performed by applying 1,000-cycle testing power to the voice-frequency side of the terminal and measuring the high-frequency output at jacks DIR FILT LINE. The transmitting gain then is adjusted to the specified output by means of control TR GAIN. For radio link operation the transmitting gain is adjusted at both terminal panels with switch LINE on the operating position.

a. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

b. Procedure (fig. 52). (1) If switch EQPT is on the 2W position, patch the output of the oscillator to jacks 2W HYB. If switch EQPT is on the 4W TEL position, patch the output of the oscillator to jacks MOD IN.

(2) Patch jacks DIR FILT LINE to the input of the attenuator.

Note. For radio link operation, use jacks DIR FILT LINE on the upper terminal panel for adjustment of the lower terminal panel as well as the upper terminal panel.

(3) Set the attenuator for a loss of 10 db.

(4) Patch the output of the attenuator to the input of the transmission measuring set.

(5) Adjust the oscillator for a frequency of 1,000 cycles at an output of 0 dbm for an equipment switch setting of 2W, or + 4 dbm for an equipment switch setting of 4W TEL.

(6) Read the transmission measuring set and determine the transmitting output.

(7) Adjust control TR GAIN until the transmitting output is within ±1.5 db of the specified output.

(8) If no output is specified, adjust control TR GAIN to give a transmitting output as shown below.

Operating condition	Transmitting output (dbm)
Wire, telephone or telegraph.	+14.5 to +17.5
Radio link, telephone.	—10*
Radio link, telegraph.	+5*

* Values indicated for radio link operation are average levels. Final operating levels will depend upon the radio equipment and transmission factors.

(9) Record the setting of control TR GAIN for future reference.

(10) Remove the patching cords.

(11) For radio link operation repeat the procedure given in (1) through (10) above at the other terminal panel.

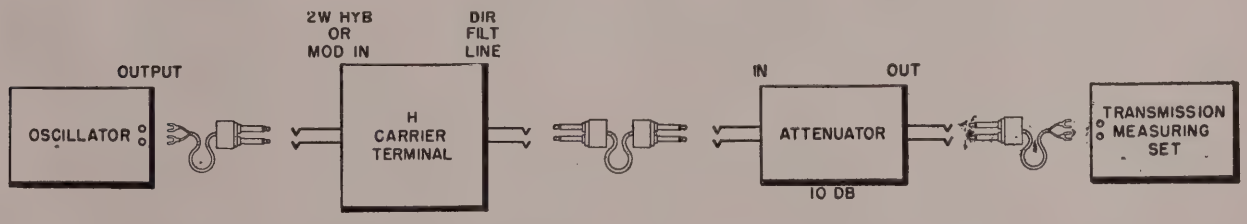
52. Repeater Gain Measurement

The measurement of repeater gain provides a means for checking the amplifier gains and associated equipment. The test is made for each direction of transmission. For the West-to-East direction of transmission a testing power of 6,000 cycles is applied to jacks W DIR FILT LINE and the output is measured at the opposite side of the repeater at jacks E DIR FILT LINE. For the East-to-West direction of transmission, a testing power of 8,000 cycles is applied to jacks E DIR FILT LINE and the output is measured at the opposite side of the repeater at jacks W DIR FILT LINE. First the maximum gain is measured and then the positions of the gain control are checked.

a. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

b. Procedure (fig. 53). (1) After noting the settings of gain controls W-E GAIN and E-W



SWITCH EQPT ON	PATCH OSCILLATOR TO JACKS	OSCILLATOR OUTPUT LEVEL	OSCILLATOR FREQUENCY
2W	2W HYB	0 DBM	1,000 CYCLES
4W TEL	MOD IN	+4 DBM	1,000 CYCLES

REQUIREMENT:
TRANSMITTING OUTPUT SHOULD BE WITHIN ±1.5 DB OF SPECIFIED OUTPUT

Figure 52. Transmitting output adjustment.

GAIN, set the control for the direction under test to 50 and set the other control to 0.

(2) Patch the output of the oscillator to the input of the attenuator.

(3) Set the attenuator for a loss of 25 db.

(4) Patch the output of the attenuator to jacks E DIR FILT LINE when testing the E-W direction of transmission, or to jacks W DIR FILT LINE when testing the W-E direction of transmission.

(5) Patch W DIR FILT LINE when testing the E-W direction of transmission, or jacks E DIR FILT LINE when testing the W-E direction of transmission, to the input of the transmission measuring set.

(6) Adjust the oscillator for an output of 0 dbm at 6,000 cycles when testing the W-E direction of transmission or at 8,000 cycles when testing the E-W direction of transmission.

(7) Read the transmission measuring set and determine the gain of the repeater.

Requirement: The maximum gain of the repeater in each direction of transmission should be within ±2.5 db of the value as given in table IX with the gain control for the direction under test set to 50.

(8) If the requirement is not met, see paragraphs 101 and 104.

(9) Set the gain control for the direction under test to steps 40, 30, 20, and 10 and record the gain of the repeater on each of the steps. It is necessary to reduce the setting of the attenuator in order to obtain a reading on the transmission measuring set for the lower settings of the gain control.

(10) Note the differences between the repeater gain obtained with the gain control set on 50 and the repeater gain obtained on each of the other steps.

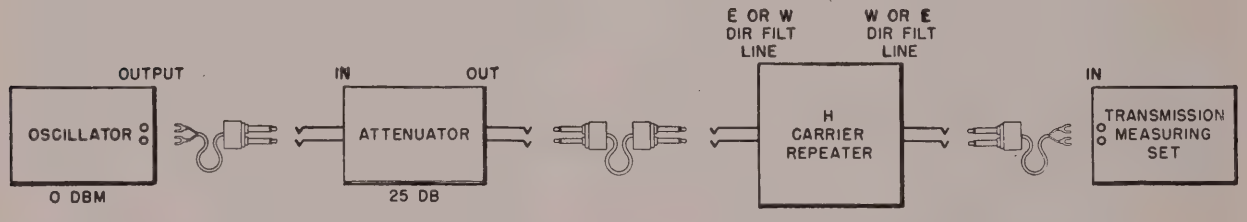
Requirement: The reduction in repeater gain for various settings of the gain control as compared to the gain obtained with the gain control set to 50 should be within ±1.0 db of the values given in table IX.

(11) Remove patching cords, set the controls to the operating positions, and restore the circuit to normal.

(12) Repeat the procedure given in (1) through (11) above for the other direction of transmission.

Table IX. Repeater gain for various settings of controls E-W GAIN or W-E GAIN

Control	Gain on step	Reduction in gain with control set on				
	50	*40*	*30*	*20*	*10*	*0*
E-W GAIN	31	10	20	30	40	50
W-E GAIN	32	10	20	30	40	50



DIRECTION OF TRANSMISSION	SETTING OF CONTROLS W-E GAIN	SETTING OF CONTROLS E-W GAIN	PATCH JACKS OUT OF ATTENUATOR TO JACKS	PATCH INPUT OF TRANSMISSION MEASURING SET TO JACKS	OSCILLATOR FREQUENCY
WEST TO EAST	50	0	W DIR FILT LINE	E DIR FILT LINE	6,000 CYCLES
EAST TO WEST	0	50	E DIR FILT LINE	W DIR FILT LINE	8,000 CYCLES

REQUIREMENT: THE MAXIMUM REPEATER GAIN SHOULD BE WITHIN ±2.5 DB OF THE VALUES GIVEN BELOW

CONTROL	GAIN ON STEP 50
E-W GAIN	31
W-E GAIN	32

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Figure 53. Repeater gain measurement.

53. System Line-up

a. GENERAL. (1) The system line-up provides a means for adjusting the outputs of the repeaters and the terminals so that maximum performance is obtained. The system is lined up in each direction of transmission from the transmitting terminal through each repeater to the receiving terminal.

(2) For radio link operation, the system line-up is made for the transmitting and receiving terminals of both carrier channels after the radio transmitters and receivers are adjusted.

b. Apparatus Required:

At each terminal	*At each repeater*
1 Audio Oscillator TS-379/U.	1 Decibel Meter TS-399/U.
1 Decibel Meter TS-399/U.	1 Attenuator TS-402/U.
Patching cords.	Patching cords.

c. Procedure at Transmitting Terminal (fig. 54). (1) Check, and if necessary adjust the transmitting output (par. 51).

(2) If switch EQPT is on the 2W position, patch the output of the oscillator to jacks 2W HYB. If switch EQPT is on the 4W TEL position, patch the output of the oscillator to jacks MOD IN.

(3) Adjust the oscillator for a frequency of 1,000 cycles at an output of 0 dbm for an equipment switch setting of 2W, or +4 dbm for an equipment switch setting of 4W TEL.

d. Procedure at First Repeater (fig. 54). (1) Patch jacks W DIR FILT LINE for the E-W direction of transmission, or jacks E DIR FILT LINE for the W-E direction of transmission, to the input of the attenuator.

(2) Set the attenuator for a loss of 10 db.

(3) Patch the output of the attenuator to the input of the transmission measuring set.

(4) Read the transmission measuring set and determine the repeater output.

(5) Adjust the gain control for the direction of transmission under test until the repeater output toward the receiving terminal is within ±1.5 db of the specified output.

(6) If no repeater output is specified, adjust the gain control for the direction of transmission under test to give a repeater output between +14.5 and +17.5 dbm.

(7) Record the setting of the gain control for future reference.

(8) Remove patching cords.

e. Procedure at Succeeding Repeater (fig. 54). Repeat the procedure given in subparagraph (d) above for the succeeding repeater.

f. Procedure at Receiving Terminal for Two-wire Termination (fig. 55). (1) Patch jacks 2W HYB to the input of the transmission measuring set.

(2) Read the transmission measuring set and adjust control REC GAIN until the transmission measuring set reads within ±1.5 db of the specified circuit net loss.

(3) If no circuit net loss is specified, adjust control REC GAIN for a reading between —4.5 and —7.5 dbm.

(4) Record the circuit net loss and the setting of control REC GAIN for future reference.

(5) Remove the patching cords.

g. Procedure at Receiving Terminal for Four-wire Termination (fig. 55). (1) Patch jacks DEM OUT to the input of the transmission measuring set.

(2) Read the transmission measuring set and adjust control REC GAIN to give an output as close as possible to +4 dbm as read on the transmission measuring set.

(3) Record the output and the setting of control REC GAIN for future reference.

(4) Remove the patching cords.

(5) Have the transmitting terminal remove test equipment and patching cords, and restore the circuit to normal.

h. Procedure for Other Direction of Transmission. Repeat the procedure given in *c* through *g* above for the other direction of transmission.

54. Loop Gain Measurement

After the system line-up has been completed for both directions of transmission, loop gain measurements are made at all repeaters and terminals. If the loop gain measurements do not meet the requirements, the gains are reduced until the requirements are met and then the over-all system line-up, as given in paragraph 53, is repeated.

a. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

b. Procedure at Repeater. (1) Measure the actual working repeater gain in each direction of transmission by following the procedure given in paragraph 52*b*(2) through (7).

(2) Add the two gains, as measured in (1) above, to determine the loop gain of the repeater.

Requirement: The loop gain of a repeater should not exceed 45 db.

(3) If the requirement given in (2) above is not met, decrease the gain in each direction an equal amount to meet the requirement. *Repeat the system line-up for both directions of transmission so as to meet the loop gain requirements at each repeater and receiving terminal.*

c. Procedure at Terminal. (1) Measure the

actual transmitting and receiving gains for the working settings of the gain controls by following the procedure given in paragraphs 49*b*(2) through (7) and 50*b*(2) through (7).

(2) If the circuit is terminated on a four-wire basis, record the working transmitting and receiving gains for future reference.

(3) If the circuit is terminated on a two-wire basis, add the two gains as measured in (1) above to determine the loop gain of the terminal.

Requirement: The loop gain of a terminal should not exceed 26 db.

(4) If the requirement is not met, decrease the receiving gain, thereby increasing the circuit net loss, until the requirement is met.

(5) Record the final setting of control REC GAIN and the circuit net loss for future reference.

(6) Remove the patching cords.

55. Synchronization Adjustment

The synchronization adjustment provides a means for synchronizing the carrier supplies of the two terminals. Since the same oscillator supplies the carrier frequency for both modulation and demodulation at each terminal, the synchronization adjustment is only made at one terminal.

a. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Test Set TS-190/U.
Patching cords.

b. Procedure for Wire Operation (fig. 56).

(1) *Distant Terminal.*

(*a*) After noting the setting of switch EQPT, set the switch to the 2W position.

(*b*) Insert a patching cord plug into jacks 2W HYB so as to open the circuit.

(2) *Terminal Under Test.* (*a*) After noting the setting of switch EQPT, set the switch to the 2W position.

(*b*) Patch the output of the oscillator to jacks 2W HYB.

(*c*) Adjust the output of the oscillator to 0 dbm at 1,000 cycles.

(*d*) Connect the test receiver to terminals 3T and 8T of hybrid coil HYB.

(*e*) Listen in the receiver for beats between the 1,000-cycle test tone from the oscillator and the demodulated test tone returning from the distant terminal.

Requirement: The number of beats heard in the test receiver should not exceed eight per second. The number of beats heard per second is twice the difference of the carrier frequencies between the terminals.

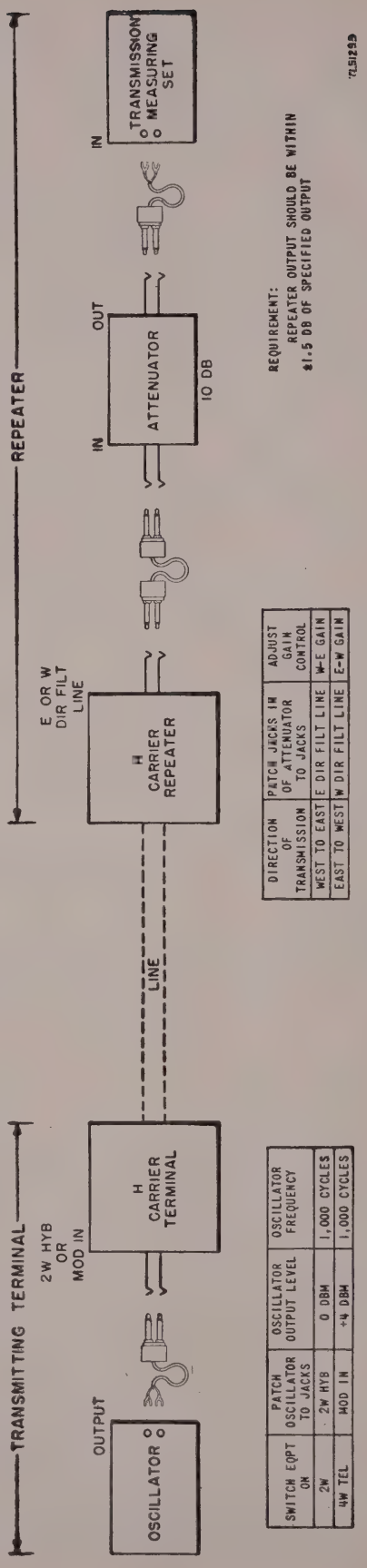
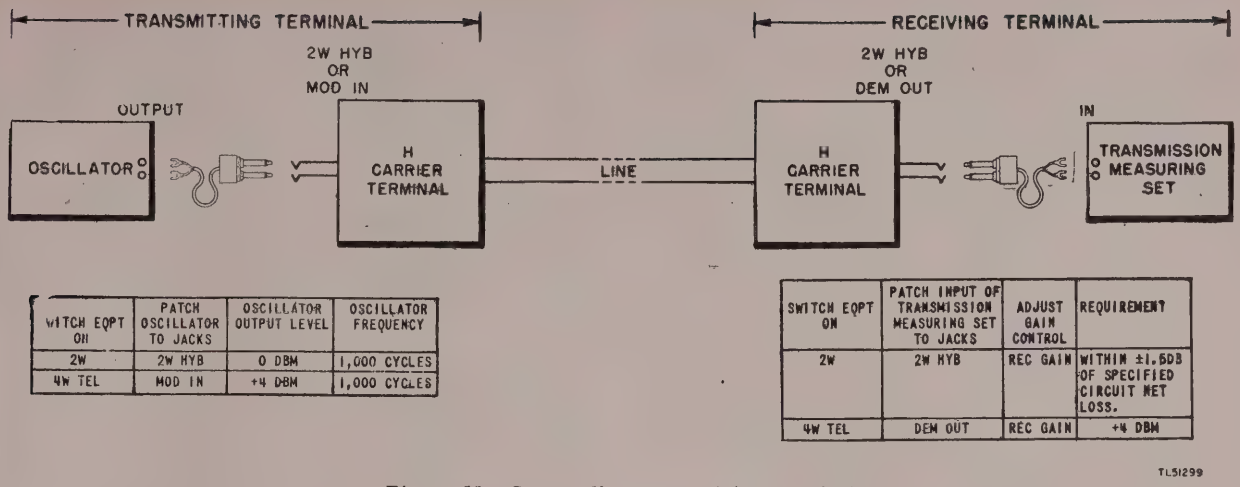


Figure 54. System line-up, repeater.



WITCH EQPT ON	PATCH OSCILLATOR TO JACKS	OSCILLATOR OUTPUT LEVEL	OSCILLATOR FREQUENCY
2W	2W HYB	0 DBM	1,000 CYCLES
4W TEL	MOD IN	+4 DBM	1,000 CYCLES

SWITCH EQPT ON	PATCH INPUT OF TRANSMISSION MEASURING SET TO JACKS	ADJUST GAIN CONTROL	REQUIREMENT
2W	2W HYB	REC GAIN	WITHIN ±1.5DB OF SPECIFIED CIRCUIT NET LOSS.
4W TEL	DEM OUT	REC GAIN	+4 DBM

TL51299

Figure 55. System line-up, receiving terminal.

(*f*) If the requirement is not met, unscrew the fiber tube on transformer OSC one turn (fig. 28). With the aid of a screwdriver, adjust the screw inside the fiber tube until the requirement is met. Only a small adjustment of the screw normally is required. Tighten the fiber tube after the adjustment is made.

(*g*) If the requirement cannot be met by following the procedure given in (*f*) above, the oscillator frequency at one terminal is out of limits. At the distant terminal, adjust the oscillator frequency as follows: Loosen the fiber tube on the back of transformer OSC. Turn the screw inside the fiber tube in as far as it will go. Then back off the screw nine turns. Tighten the fiber tube. When this is done, repeat the procedure at the testing terminal as given in (*a*) through (*f*) above.

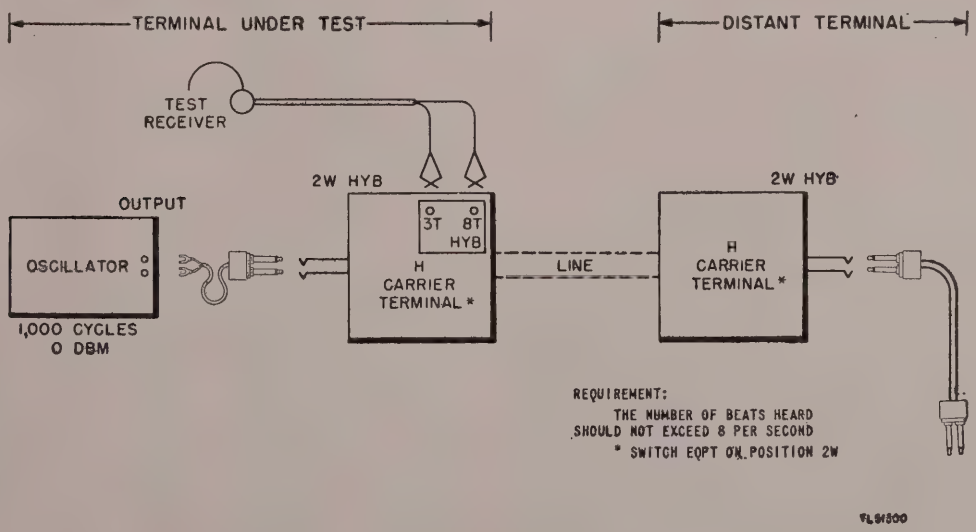
(*h*) If the requirement cannot be met by following the procedure given in (*g*) above, trouble is indicated at one or at both terminals. In this event, perform the oscillator frequency adjustment at each terminal (par. 110) and repeat the procedure given in *b*(1) and (2)(*a*) through (*f*) above.

(*i*) Remove the test receiver, oscillator, and patching cords; restore switches EQPT at both terminals to the operating positions.

c. Procedure for Radio Link Operation (fig. 57). The voice circuit or the carrier-telegraph system operating over the voice-channel of the radio link circuit should be removed from service to avoid system interruption.

(1) *Distant terminal.* (*a*) After noting the setting of switch EQPT of the channel under test, set the switch to the 2W position.

(*b*) Disconnect the voice circuit connected to terminals 5 and 6 of terminal strip A on the line panel associated with the terminal panel having switch LINE set to the RADIO TRANS position.



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Figure 56. Synchronization adjustment, wire operation.

(*c*) Connect the output of the oscillator to terminals 5 and 6 from which the wires were removed in (*b*) above.

(*d*) Patch the output of the oscillator to jacks 2W HYB of the channel under test. The output of the oscillator now is connected to both the type H carrier channel and to the voice-frequency channel.

(*e*) Adjust the oscillator to 0 dbm at 1,000 cycles.

(2) *Terminal under test.* (*a*) After noting the setting of switch EQPT of channel under test, set the switch to the 2W position.

(*b*) Disconnect the voice circuit connected to terminals 5 and 6 of terminal strip A on the line panel associated with the terminal panel having switch LINE set to RADIO REC.

(*c*) Patch jacks 2W HYB of the channel under test to terminals 5 and 6 from which the wires were removed in (*b*) above.

(*d*) Connect the test receiver to terminals 5 and 6 patched to 2W HYB in (*c*) above.

(*e*) Listen in the receiver for beats between the 1,000-cycle test tones of the type H carrier channel and the voice-frequency channel.

Requirement: The number of beats heard in the test receiver should not exceed four per second. The number of beats heard per second is equal to the difference of the carrier frequencies between the terminals.

(*f*) If the requirement is not met, unscrew the fiber tube on transformer OSC one turn. With the aid of a screwdriver, adjust the screw inside the fiber tube until the requirement is met. Only a small adjustment of the screw normally is required. Tighten the fiber tube after the adjustment is made.

(*g*) If the requirement given in (*f*) above cannot be met, follow the procedure given in *b*(2)(*g*) and (*h*) above.

(*h*) Remove the test receiver, oscillator, and patching cords; restore switches EQPT at both terminals to the operating positions, and the wires to terminals 5 and 6.

(*i*) Repeat the procedure given above in (1) and (2)(*a*) through (*h*) for the other channel.

56. Channel Net Loss-frequency Test

a. General. (1) The channel net loss-frequency test provides a means for checking the characteristics of the band filters, the adjustment of the carrier frequencies, and the effects of line irregularities upon the system in order to obtain an accurate indication of the quality of the circuit.

(2) The channel net loss-frequency test, when performed on a system operating over a radio link,

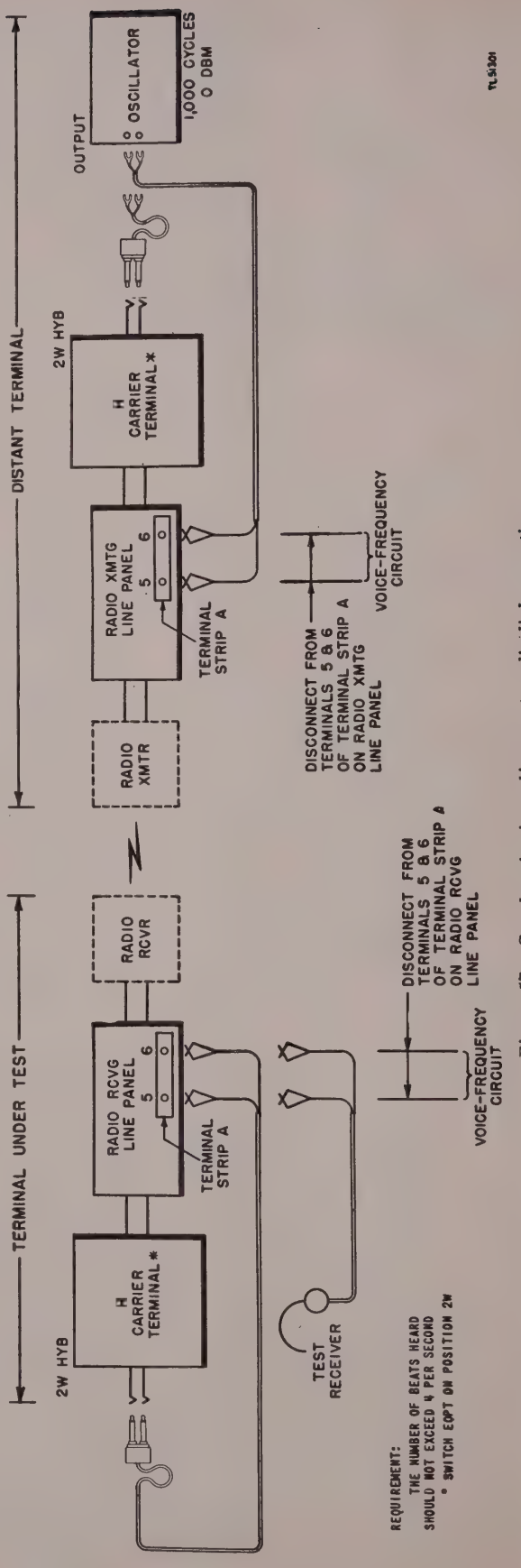


Figure 57. Synchronization adjustment, radio link operation.

provides data on the quality of the entire channel, including the radio equipment.

b. Apparatus Required:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
Patching cords.

c. Procedure (fig. 58). (1) At the transmitting terminal for a 2W position of switch EQPT, patch the output of the oscillator to jacks 2W HYB; for a 4W TEL position of switch EQPT, patch the output of the oscillator to jacks MOD IN.

(2) At the transmitting terminal for a 2W position of switch EQPT, adjust the oscillator for a frequency of 1,000 cycles at an output of 0 dbm; for a 4W TEL position of switch EQPT, adjust the oscillator for a frequency of 1,000 cycles at +4 dbm.

(3) At the receiving terminal for a 2W position of switch EQPT, patch jacks 2W HYB to the input of the transmission measuring set; for a 4W TEL position of switch EQPT, patch jacks DEM OUT to the input of the transmission measuring set. Adjust the transmission measuring set so as to obtain a reading and record the reading.

(4) Measure the channel net loss at the frequencies listed below by adjusting the oscillator at the transmitting terminal and measuring the net loss at the receiving terminal at each frequency.

Frequency in cycles	
200	1,600
300	2,000
400	2,500
500	2,800
1,000	3,200

Requirement: The lower frequency at which the output is 10 db or more below the 1,000-cycle output should not be above 400 cycles. The upper frequency at which the output is 10 db or more below the 1,000-cycle output should not be below 2,800 cycles.

(5) If the requirements are not met, see paragraph 97*d*(4).

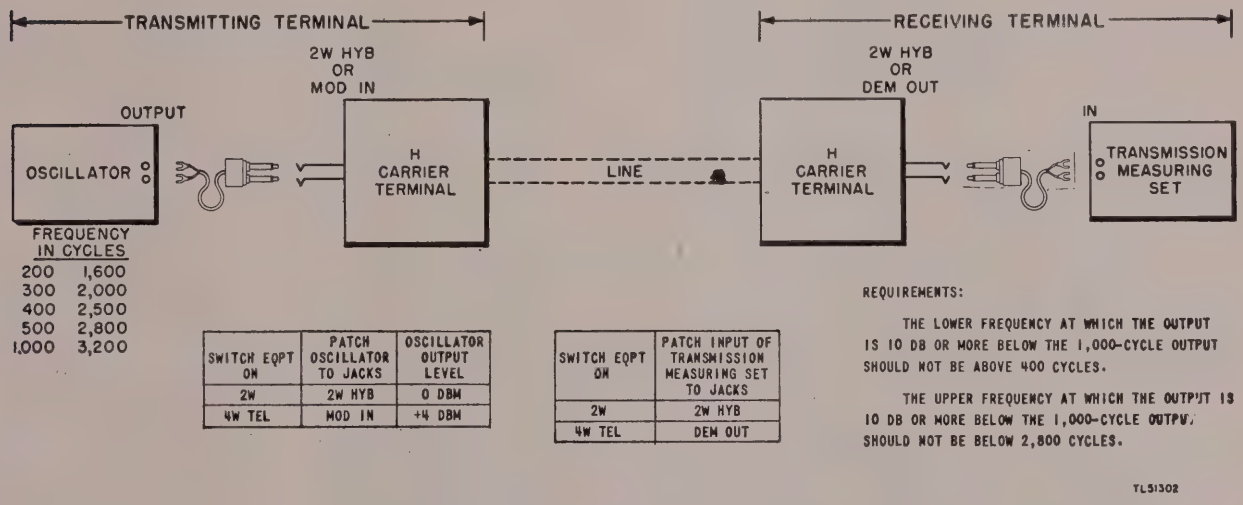


Figure 58. Channel net loss-frequency

Section VI. ROUTINE CHECKS OF PERFORMANCE

57. Records

In addition to the designation cards supplied with the equipment, records should be kept of the control settings at the terminals and repeaters and of all reported and routine troubles which develop.

a. Designation Cards. Designation cards and card holders are provided with the equipment. The cards are for recording data which will be useful in maintaining and operating the equipment. Each card shoud be filled out completely with a soft lead pencil so that erasures can be made when necessary. Figure 59 shows the designation cards used with the type H carrier equipment, properly filled out.

b. Control Setting Records. Keep records of the control settings at the terminals and repeaters on improvised forms. Suggested sample record forms are shown in figure 60. Whenever any gain control setting is changed, record the new setting together with the date of the change of setting.

TYPE H TERMINAL NO 1.5B-1
SYSTEM A-C #1
CKT A-C #1
LINE A-C
WIRES 1-2 TYPE 104CS
LINE SW. WIRE EAST
EQPT. SW. 2W
TR. GAIN SW. 45
OUTPUT +16 dbm
REC. GAIN SW. 39
OUTPUT -6 dbm
CONNECTED EQPT
LINE FILTER 1.5B-1
EQPT. RINGER 1.5A-1
OTHER

CHANNEL TERMINATING CONNECTIONS
PER TM 11-2025
FIGURE 55
CARRIER CONNECTIONS
PER TM 11-2025
FIGURE 60
RADIO LINK OPERATION
PER TM
PARAGRAPH
NOTES

A-DESIGNATION CARD FOR CARRIER TERMINAL OA-13/FC

TYPE H REPEATER NO. 1.6A-1
SYSTEM A-C #1
WEST
LINE A-C
WIRES 1-2 TYPE 104CS
W DIR FILT LINE OUTPUT +16 dbm
FILTER NO. 1W CAB 1.6A
EAST
LINE A-C
WIRES 1-2 TYPE 104CS
W DIR. FILT. LINE OUTPUT +16 dbm
FILTER NO. 1E CAB 1.6A
W-E GAIN SW. 39
E-W GAIN SW 38

CARRIER CONNECTIONS
PER TM 11-2025
FIGURE 60
NOTES

B-DESIGNATION CARD FOR CARRIER REPEATER OA-10/FC

TYPE H FILTER PANEL NO 1.7B-1E
SYSTEM A-C #1
LINE A-C
TOWARD C
WIRES 1-2 TYPE 104CS
CONNECTED EQUIPMENT FILTER
LINE LTC 1.7B-1
CARR HR 1.7B-1
VOICE VFR 1.7A
LFN VFR 1.7A
LFB
LFBN
PH LF BN

H CARRIER PAIR
LINE CONNECTIONS
PER TM 11-2025
FIGURE 60
CARRIER CONNECTIONS
PER TM 11-2025
FIGURE 60
VOICE CIRCUIT CONNECTIONS
PER TM 11-2025
FIGURE 60
NON H CARRIER SIDE CIRCUIT
PER X
TABLE
PHANTOM CIRCUIT CONNECTION
PER X
TABLE

C-DESIGNATION CARD FOR CARRIER FILTER F-36/FC

TL51318

Figure 59. Designation cards for type H carrier equipment.

Date	TERMINAL Control settings	
	TR GAIN	REC GAIN
1 Mar 45	44	22
15 Mar 45	44	23
22 Mar 45	43	23

Date	REPEATER Control Settings	
	W-E GAIN	E-W GAIN
1 Mar 45	40	38
15 Mar 45	41	39
22 Mar 45	41	38

Figure 60. Typical record of control settings.

c. TROUBLE RECORDS. Records should be kept of reported and routine troubles which develop. Such records will serve as a basis for scheduling the frequency of routine checks of performance and preventive maintenance. Forms for recording such data may be improvised and will vary with the type of office, personnel, and organization. Figure 61 is a suggested trouble-record form.

58. Equipment Performance Checks

Equipment performance checks must be made at periodic intervals, as shown in table X below, to insure optimum system performance.

Table X. Equipment Performance Check List.

Tests	Frequency of test	Paragraph reference
Terminal:		
Voltage adjustments	Every 4 months	Par. 46.
Vacuum tube test	Monthly	Par. 47.
Transmitting output adjustment	Annually	Par. 51.
Repeater:		
Voltage adjustments	Every 4 months	Par. 46.
Vacuum tube test	Monthly	Par. 47.
Over-all system:		
System line-up	Annually	Par. 53.
Loop gain measurement	Annually	Par. 54.
Channel net loss measurement	Weekly	Par. 59.
Synchronization adjustment	Annually	Par. 55.
Channel net loss-frequency test	Annually	Par. 56.

59. Channel Net Loss Measurement

After the system has been placed in service, measurements are made to check the channel net loss. The channel net loss measurement is made by sending 1,000-cycle testing power from the transmitting terminal and measuring the received testing power at the receiving terminal. The procedure then is repeated for the other direction of transmission.

a. APPARATUS REQUIRED:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
Patching cords.

b. PROCEDURE AT TRANSMITTING TERMINAL (fig. 62). (1) If switch EQPT is on the 2W position, patch the output of the oscillator to jacks 2W HYB. If switch EQPT is on the 4W TEL position, patch the output of the oscillator to jack MOD IN.

(2) Adjust the oscillator to a frequency of 1,000 cycles at an output of 0 dbm for an equipment switch setting of 2W, or +4 dbm for an equipment switch setting of 4W TEL.

c. PROCEDURE AT RECEIVING TERMINAL FOR TWO-WIRE TERMINATION (fig. 62). (1) Patch jacks 2W HYB to the input of the transmission measuring set.

(2) Read the transmission measuring set.

Requirement: The reading on the transmission measuring set should be within ±1.5 db of the specified channel net loss.

(3) If the requirement is not met, but the reading of the transmission measuring set is within ±4.0 db of the specified value, adjust control REC GAIN

TROUBLE RECORD

Date	Time	Reported by	Report	Disposition	Date	Time	Cleared by
1 May 45	1000	WWE	H carrier system 1. Can't talk.	Loose connection contact 3 of TR GAIN.	1 May 45	1015	WWE
9 May 45	1610	LH	H carrier system 2. No transmission.	Tube OSC defective.	9 May 45	1620	LH

Figure 61. Typical trouble record.

until the requirement is met. If the reading of the transmission measuring set exceeds the specified value of channel net loss by more than ±4.0 db, perform the system line-up (par. 53).

d. Procedure at Receiving Terminal for Four-wire Termination (fig. 62). (1) Patch jacks DEM OUT to the input of the transmission measuring set.

(2) Read the transmission measuring set.

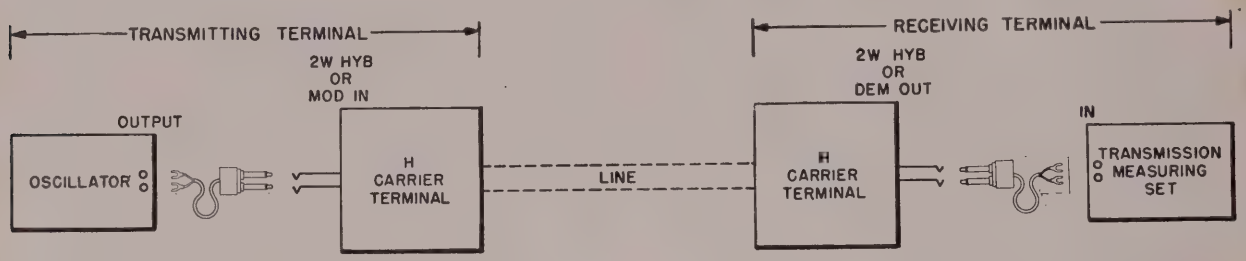
Requirement: The output should be between +2.5 and +5.5 dbm.

(3) If the requirement is not met, but the output is between 0 and +8 dbm, adjust control REC GAIN until the requirement is met. If the output is less than 0 dbm or greater than +8 dbm, perform the system line-up (par. 53).

(4) Remove the patching cords.

(5) Have the transmitting terminal remove test equipment and patching cords and restore the circuit to normal.

e. Procedure for Other Direction of Transmission. Repeat the procedure given in *b* through *d* above for the other direction of transmission.



SWITCH EQPT ON	PATCH OSCILLATOR TO JACKS	OSCILLATOR OUTPUT LEVEL	OSCILLATOR FREQUENCY
2W	2W HYB	0 DBM	1,000 CYCLES
4W TEL	MOD IN	+4 DBM	1,000 CYCLES

SWITCH EQPT ON	PATCH INPUT OF TRANSMISSION MEASURING SET TO JACKS	REQUIREMENT
2W	2W HYB	WITHIN ±1.5 DB OF SPECIFIED CIRCUIT NET LOSS
4W TEL	DEM OUT	BETWEEN +2.5 AND +5.5 DBM

TL51315

Figure 62. Channel net loss measurement.

Section VII. OPERATION UNDER UNUSUAL CONDITIONS

60. Operation under Extreme Weather Conditions

The operation of an H carrier system under extreme weather conditions, such as sleet, fog, heavy frost, dust or sand storms, and blizzards, generally results in poor transmission unless steps are taken to compensate for the effects of the weather. The effects of extreme weather conditions upon system performance together with suggested remedial measures are given below.

Weather condition	Effect on system	Remedy
Sleet Freezing rain Fog Heavy frost	Increased Loss	Increase gain at repeater and receiving gain at terminals.
Dust storms Sand storms Blizzards	Static noise	Remove telegraph circuit; ground CX or SX telegraph connections.

61. Operation over Facilities Other Than Open-Wire

The operation of an H carrier system over facilities other than open wire is not recommended except for emergency purposes. Since equalization equipment is not included, the quality of the circuit is degraded so that telegraph transmission normally cannot be used over facilities other than open wire. The use of type H carrier repeaters is not recommended for operation over facilities other than open wire. The maximum terminal-to-terminal operating distances for the more common facilities other than open wire are given below.

Line facility	Maximum terminal-to-terminal operating distance
Wire W-143	10 miles.
Cable, nonloaded, paper insulated*	7 miles.
Cable, spiral four*	30 miles.

* Because of crosstalk difficulties, only one carrier system should be operated over any one cable.

62. Operation under Emergency Conditions

In the event of a major power failure or the demolition of a repeater station, the following emergency operating methods may be used:

a. In the event that a repeater requires extensive repairs, system service can be maintained if another type H carrier repeater is available by proceeding as follows:

(1) Using a patching cord, patch jacks W DIR FILT LINE of the available repeater to jacks W LINE FILT of the inoperative repeater.

(2) Using a second patching cord, patch jacks E DIR FILT LINE of the available repeater to jacks E LINE FILT of the inoperative repeater.

(3) Set the gain controls of the available repeater to the operating settings of the inoperative repeater.

b. In the event of a major power failure at a repeater station, system service can be maintained by proceeding as follows:

(1) Using a patching cord, patch jacks W DIR FILT LINE to jacks E DIR FILT LINE.

(2) Increase the receiving gain at the terminals keeping sufficiently below the singing point.

c. In the event of the demolition of a repeater and another type H carrier repeater is not available, system service can be maintained by proceeding as follows:

(1) Connect the East line directly to the West line.

(2) Increase the receiving gain at the terminals keeping sufficiently below the singing point.

Section VIII. SUMMARY OF PROCEDURE FOR PLACING EQUIPMENT IN SERVICE

63. Summary of Procedure for Placing Equipment in Service

This summary applies to Carrier Terminal OA-13/FC, Carrier Repeater OA-10/FC, and Carrier Filter F-36/FC.

Step	*Action*	*Text reference*
1.	Mount panels in cabinet or improvised rack.....	Par. 27.
2.	Make ground connection to each panel and power connection to terminal and repeater panels....	Par. 30 through 31.
3.	Make preliminary tests and adjustments.....	Par. 32 through 36.
4.	Interconnect to associated equipment	Par. 37 through 41.
5.	Make check of system performance	Par. 42.
6.	Perform detailed tests, adjustments, and system line-up at the earliest time service conditions permit	Section V.

PART THREE

PREVENTIVE MAINTENANCE

Section IX. PREVENTIVE MAINTENANCE TECHNIQUES

64. Meaning of Preventive Maintenance

Preventive maintenance is defined as a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptions in service, and to eliminate major break-downs. To appreciate the meaning of the term *preventive maintenance,* it is necessary to distinguish between preventive maintenance and trouble shooting and repair. The primary function of preventive maintenance is to prevent break-downs and the consequent necessity for repair. The primary function of trouble shooting and repair is to locate and correct existing defects. The importance of preventive maintenance cannot be over-emphasized. The usefulness of the entire communication system depends upon the equipment being ready to operate at peak efficiency when needed. Preventive maintenance on most parts of this equipment is performed without removing it from service. Care must be taken not to interfere with operation.

Note. The operations in this section and section X, preventive maintenance check list, are second echelon (organization repairmen) maintenance. The operations in section XII, moistureproofing and fungiproofing, are higher echelon maintenance.

65. Description of Preventive Maintenance Techniques

a. GENERAL. Most of the electrical parts used in this equipment require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because maintenance technique cannot be applied indiscriminately, definite and specific instructions are needed. This section of the manual contains this type of specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations: namely, **FEEL, INSPECT, TIGHTEN, CLEAN, ADJUST, and LUBRICATE.** Throughout this manual the lettering system for the six operations will be as follows:

F—Feel*
I —Inspect
T—Tighten
C—Clean
A—Adjust*
L—Lubricate

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field requirements. For example, dust filters into the equipment no matter how much care is taken to prevent it. Rapid changes in climatic conditions (such as heavy rains followed by blistering heat) or excessive dampness, snow, and ice tend to cause deterioration of exposed surfaces and parts.

b. INSPECT (I). Inspection is the most important of all the preventive maintenance operations. If more than one man is available to do this work, choose the most observant, for careful observation is required to detect defects in the functioning of moving parts and any other abnormal conditions. To carry out the inspection operation most effectively, make every effort to become thoroughly familiar with normal operating conditions and to be able to recognize and identify abnormal conditions readily. Inspection consists of carefully observing all parts in the equipment, noticing their color, placement, cleanliness, etc. Inspect for the following conditions:

(1) *Overheating.* Overheating is indicated by discoloration, blistering, or bulging of the part or surface of the container; leakage of insulating compounds; and oxidation of metal contact surfaces.

(2) *Placement.* See that all wires and cabling are in their original positions.

(3) *Cleanliness.* Examine carefully all recesses

* The Feel, Adjust, and Lubricate operations are inapplicable to this equipment.

in the units for accumulated dust, especially between connecting terminals and contacts. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations, look for fungus growth and mildew.

(4) *Tightness.* Gently test for movement any connection or mounting which appears to be loose. Feel the lug or tetrminal screw.

c. Tighten (T). Any movement of the equipment caused by transportation, by concussion, or by vibration from moving machinery may result in loose connections and mountings which are likely to impair the operation of the equipment. The importance of firm mountings and connections cannot be overemphasized; however, never tighten screws, bolts, and nuts unless it is known definitely that they are loose. Fittings that are tightened beyond the pressure for which they are designed will be damaged or broken. When tightening, always be certain to use the correct tool of the proper size. If a screw does not turn easily, remove it and begin again.

d. Clean (C). (1) When the schedule calls for cleaning, it does not mean that every item which bears that identifying letter must be cleaned each time it is inspected. Clean parts only when inspection shows that it is necessary.

(2) Items such as vacuum tubes, capacitors, resistors, coils, etc., are cleaned by wiping with a clean, lint-free, dry cloth or by brushing. It may be necessary in some cases to use cleaning fluid to remove dirt. Apply it with a cloth or brush and wipe dry with a clean cloth. Remove corrosion by rubbing lightly with fine sandpaper.

Note. Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry Cleaning, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, may be used for cleaning purposes when dry-cleaning solvent is not at hand. Carbon tetrachloride will be used as a cleaning fluid only where specified for cleaning contact parts of electrical equipment, or as specified where inflammable solvents cannot be used because of the fire hazard. Oil, Fuel, Diesel, *will not* be used for cleaning electrical contacts.

(3) Clean switch contacts and jack spring contacts by drawing a burnishing blade between two contacts held together gently with the fingers. If excessive dirt is present, flush the contacts by dipping a toothpick in carbon tetrachloride and applying it between the contacts, or dip the burnishing blade in carbon tetrachloride and then draw it between the contacts. After the application of carbon tetrachloride, draw a piece of bond paper between the contacts. Clean the burnishing blade with a dry, lint-free cloth and burnish the contacts again.

66. Preventive Maintenance of Classes of Parts

This section of the manual does not deal with each tube, each resistor, or each capacitor of the equipment. Rather, it combines all the instructional material on the major classes of parts and devices. If abnormalities cannot be corrected by following these instructions, see the appropriate repair instructions for corrective action.

a. Vacuum Tubes and Sockets.

Caution: Preventive maintenance on these items should be performed only when the tubes are removed for periodic check.

Preventive maintenance for vacuum tubes includes inspection and cleaning. Preventive maintenance for tube sockets and mountings involves inspection, tightening, and cleaning. Each of these operations will be discussed in detail below.

Caution: Care must be taken in working on tubes. Severe burns may result from contact with the envelopes of hot tubes.

(1) *Inspect (I).* *(a)* Examine glass tube envelopes, tube caps, and tube connector clips for the accumulation of dirt and for corrosion. Watch for tube caps which have broken away from the cement that attaches them to the glass envelopes, and for tube envelopes that have broken away from the tube base. When tubes have loose grid caps or envelopes, they should be replaced if possible. If suitable replacements are not available, repair should not be attempted; but a record should be kept so that replacement will be made at the earliest opportunity.

(b) Examine the spring clips that make contact with the grid caps for corrosion and for loss of tension with resulting looseness. Check the condition of the wires soldered to the spring clips. The wires must be free of frayed insulation and broken strands. The removal of connecting clips from loose grid caps must be done with great care, particularly if signs of corrosion exist. Never turn a clip if it is on a loose cap.

(c) Determine the firmness of tubes in their sockets by inspection. Make the inspection by pressing the tubes down in the sockets and testing them in that position, and *not* by partly withdrawing the tubes and jiggling them from side to side. Movement of a tube tends to weaken the pins in the base and unnecessarily spreads the contacts in the socket; trouble will occur where it did not exist before.

(d) Be careful when removing a tube from its socket. A warm tube must never be jarred. Connections to the grid cap must always be removed. It is important to store tubes carefully after they have

been removed from the sockets. They should not be placed on elevated flat surfaces without proper precautions to prevent their rolling to the floor. They are not to be placed on the floor where they might be kicked or stepped upon.

(e) Inspect tube prongs for dirt and corrosion.

(2) *Tighten (T).* Socket mountings must be tight at all times. Otherwise, during transit they will be loosened, and the tubes in them may become irreparably damaged. When tightening bolts that hold the sockets to the panel, do not apply excessive pressure. Too much pressure will crack the insulating bushing. Tighten tube connector clips by pressing with the fingers. Do not flatten the clips, since flattened clips do not make adequate contact with the surface of the tube cap.

(3) *Clean (C).* Clean the tubes, but only if inspection shows cleaning to be necessary. These tubes do not require frequent cleaning. The cleaning of tubes calls for the removing of dust and dirt from the glass envelopes with a cloth, and the removal of dirt and corrosion from the tube prongs by rubbing lightly with a piece of fine sandpaper. Clean the grid caps by wrapping a piece of fine sandpaper around the cap, and rubbing gently along the surface. Excessive pressure is not needed; neither is it necessary to grip the cap tightly.

b. Capacitors and Filters. (1) *Inspect (I).* Inspect the terminals for corrosion. Inspect the mountings for loose mounting screws, studs, or brackets. The terminals should not be cracked or broken. The case of each capacitor must be thoroughly inspected for bulges, discoloration, and dirt.

(2) *Tighten (T).* Tighten loose terminals and mounting.

(3) *Clean (C).* Clean the case and the insulating bushings.

c. Resistors. (1) *Inspect (I).* Inspect the coating of vitreous resistors for signs of cracking and chipping, especially at the ends. Examine the bodies of all types of resistors for dirt and blistering, discoloration, and other indications of overheating. Also look for arc pits or craters. Check the security of all mountings. Do not attempt to move resistors with pigtail connections because there is danger of breaking the connections at the point where they enter the body of the resistor. Such defects cannot be repaired.

(2) *Tighten (T).* Tighten loose resistor mountings. If a resistor is allowed to remain loose, vibration may break the connection or damage the body.

(3) *Clean (C).* Remove all dirt, dust, and corrosion. Resistors with discolored bodies cannot be cleaned. Discoloration is indicative of overloading at some time prior to the inspection and is probably due to circuit trouble, which requires analysis.

d. Switches and Controls.

Caution: Do not move switches or controls since the slightest movement may impair operation and service. The gang switch contacts can be examined only when the switch panel is disassembled. If it is disassembled for repair, inspect mechanical action by turning the knobs and noting the freedom of movement, spring tension of contacts, and accumulations of dirt, dust, or corrosion on the contacts. Clean exposed parts and contacts if dirty.

(1) *Inspect (I).* Inspect for cleanliness and looseness of knobs and mounting.

(2) *Tighten (T).* Tighten all loose mounting screws.

(3) *Clean (C).* Clean the exterior surfaces with a stiff brush and wipe with a piece of cloth.

e. Jacks. Jacks require very little attention, and only at infrequent intervals. Since these jacks are inaccessible unless the switch panel is disassembled, preventive maintenance will be performed only when it is necessary to disassemble the switch panel for repairs.

(1) *Inspect (I).* Inspect for loose mounting, dirt, and corrosion. Observe the mechanical action of the jack springs by inserting and removing a cord plug.

(2) *Tighten (T).* Tighten loose mounting and spring assembly screws.

(3) *Clean (C).* Remove surface dirt with a brush and dry-cleaning fluid, and clean the contacts.

f. Transformers and Coils. (1) *Inspect (I).* Inspect for general cleanliness and tightness of connecting lugs or terminals, mounting brackets, and rivets. Dust, dirt, or moisture between the terminals of high-voltage transformers or on coils located at high-potential points in the circuit may cause flashovers.

(2) *Tighten (T).* Tighten loose mounting screws.

(3) *Clean (C).* Clean the cases of transformers and coils.

g. Wiring, Cabling, and Cords. These items are regarded as the life lines of the equipment. Their condition must be closely observed.

(1) *Inspect (I). (a)* Inspect insulation for cracking, deterioration, fraying, and cutting, especially at connecting and supporting points. Check for improper placement which causes strain, particularly at connections. Watch for kinks and improper supports.

(b) Inspect all connections for tightness. The ground connections should be observed very closely. If any one of the grounded points is open, it may in-

terfere with operation of the equipment and no protection is afforded to the operating personnel.

Caution: If any loose ground connections are observed, they should be tightened immediately. If practicable, remove the equipment from service and disconnect the power supply.

(2) *Tighten (T).* *(a)* Tighten loose cable clamps, wiring rings, and screw connections.

(b) Resolder all loose or improperly soldered connections.

(c) Cut off frayed strands of insulation. If wire is exposed, wrap it with friction tape.

(3) *Clean (C).* Clean prongs of cord plugs and connections when they are dirty or corroded. Scrub with a brush dipped in dry-cleaning fluid, and dry thoroughly with a cloth. Remove corrosion by rubbing lightly with fine sandpaper.

h. Terminal Strips and Panels. (1) *Inspect (I).* Inspect for scratches, cracks, breakage, dents, excessive dirt or dust conditions, fungus growth, and loose mountings.

(2) *Tighten (T).* Tighten loose mounting screws.

(3) *Clean (C).* Clean by brushing or wiping with a dry cloth.

67. Preventive Maintenance Tools and Materials

The tools and materials required for performing preventive maintenance are furnished in the office tool sets which must be ordered separately.

Table XI. Preventive maintenance tools and materials

Mfr's. part No.	Signal Corps stock No.	Nomenclature	Usage
KS–8740, List 2	6R24626	Soldering copper, electric, with KS-8740, List 31B, tip, 2⅜"	Repairing poor or loose connections.
P–294472	6N7531.2	Solder, rosin core, 0.070"	
R–2120	6R4748–6.5	Pliers, long-nose, 6"	
R–6433	6Q29928	Pliers, diagonal, V-notch, 5"	
KS–6854	6R40848/1	Screwdriver, 3½"	Tighten screws.
90	6R16021	Screwdriver, regular, 5"	
R–1021	6Z1550	Brush, flat, stiff, ½"	Removing dirt, dust, and corrosion.
—	—	Solvent, dry-cleaning	
	6Z7500–0000	Sandpaper, 150 grade, #0000	
KS–2423	6N1624	Cloth, lint-free	
RM–591127	6N8583	Tape, friction, ¾"	Repairing frayed insulation.
265C	6R41065C	Burnisher, relay contact	Cleaning switch contacts.
266B	6R41066C	Burnisher blade	
KS–7188	6M750	Paper, cleaning	
RM–717053	6Z8666	Toothpicks	
KS–6815	6G184	Carbon tetrachloride	
—	6R55507	Wrench, socket set, consisting of handle and 6 sockets	Tightening nuts and bolts.

Section X. PREVENTIVE MAINTENANCE CHECK LIST

68. Preventive Maintenance Check List

(These items are second echelon maintenance.

Item No.	Operations	Item	Subpar. under par. 66	Weekly	Monthly	Semi-annually
1	ITC[1]	Vacuum tubes and sockets	*a*		[1]	
2	ITC	Capacitors and filters	*b*			X
3	ITC	Resistors	*c*			X
4	ITC	Switches and controls	*d*		X	
5	ITC	Jacks	*e*		X	
6	ITC	Transformers and coils	*f*			X
7	ITC	Wiring, cabling, and cords	*g*		X	
8	ITC	Terminal strips and panels	*h*	X		

[1] These operations will be performed only when the tubes are removed for periodic check.

F	I	T	C	A	L
Feel[2]	Inspect	Tighten	Clean	Adjust[2]	Lubricate[2]

[2] The Feel, Adjust, and Lubrication operations are inapplicable to this equipment.

Section XI. LUBRICATION

69. Lubrication

Lubrication of this equipment is not required since there are no moving parts.

Section XII. MOISTUREPROOFING AND FUNGIPROOFING

70. Moistureproofing and Fungiproofing

a. General. When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are the problems met:

(1) Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

(2) Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformers windings, etc., causing eventual breakdown.

(3) Connecting wire insulation and cable insulation break-down. Fungus growth accelerates deterioration.

(4) Moisture forms electrical leakage paths on terminal strips and insulating strips, causing flashovers and crosstalk.

b. Treatment. A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture- and fungi-resistant varnish applied with a spray gun or brush. Refer to TB Sig 13 for a detailed description of the varnish-spray method of moistureproofing and fungiproofing, and the supplies and equipment required in this treatment.

Caution: Varnish spray may have poisonous effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

71. Step-by-Step Instructions for Treating Carrier Terminal OA-13/FC

a. Preparation. Make all maintenance checks, repairs, replacements, and adjustments necessary for proper operation of the equipment.

b. Disassembly. (1) Remove the control knobs by first removing the setscrew on each knob (fig. 63).

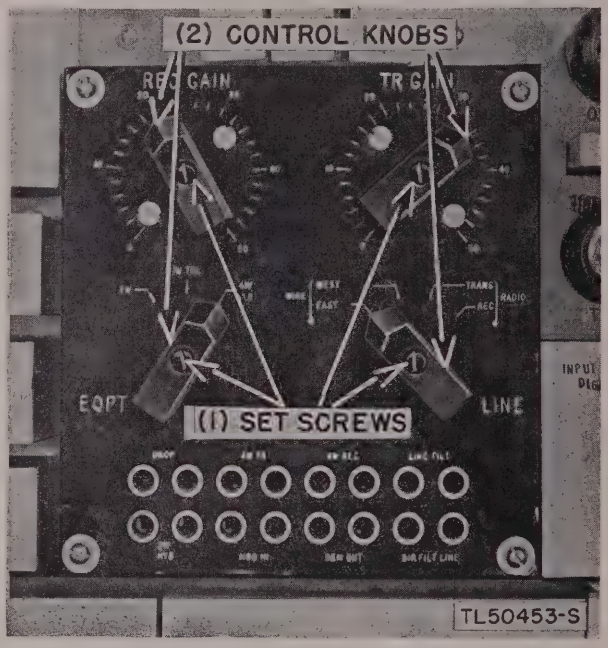


Figure 63. Removal of control knobs.

(2) Remove designation card and cover (fig. 64 ①).

(3) Remove grid leads from vacuum tubes (fig. 64 ②).

(4) Remove positioning pin from each of the control knobs (fig. 64 ③). (These pins are not to be treated.)

(5) Remove four mounting screws holding the GAIN controls (fig. 64 ④).

(6) Remove four panel screws (fig. 64 ⑤).

Caution: All screws, washers, and nuts should be replaced in their original positions after being removed. This will prevent their loss, and also the

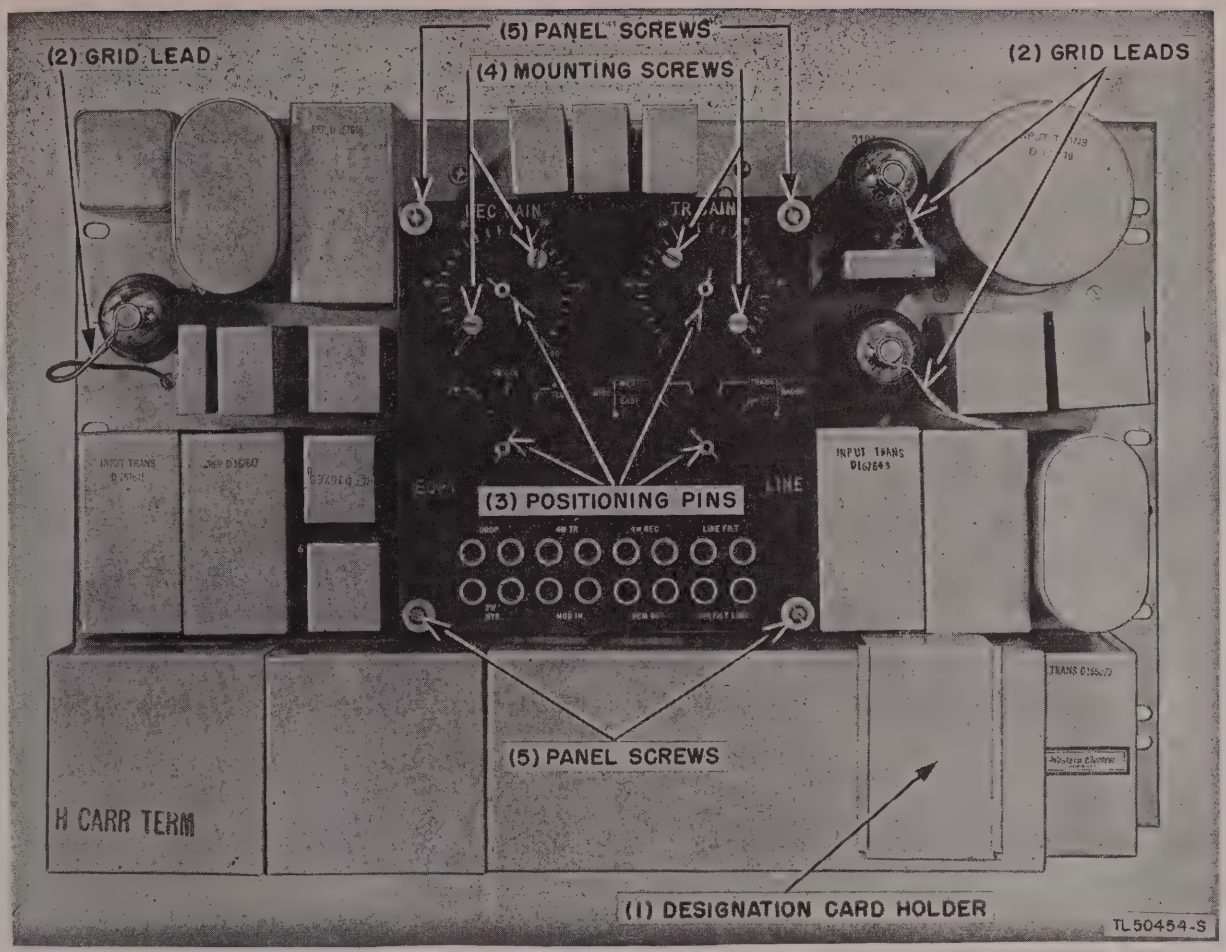


Figure 64. Disassembly of terminal subpanel.

clogging of threads, during spraying or varnishing operations. Tighten firmly any screw contacts from which it is not necessary to disconnect leads (for example, the power plug). This will prevent lacquer from getting on the contact surfaces of terminals.

(7) Carefully draw the subpanel away from the panel (fig. 65 ①). Take care not to break any of the soldered connections. Handle the subpanel only when necessary, as unnecessary motion may break the soldered connections. Resolder broken connections immediately.

(8) Remove the GAIN controls from the subpanel (fig. 65 ②).

Caution: The wires on these controls are short, and are easily broken.

(9) Remove nut and lockwasher from cover of each control (fig. 66 ①).

(10) Remove cover (fig. 66 ②).

(11) Remove four screws from cover plate of each control (fig. 66 ③).

(12) Remove cover plate (fig. 66 ④).

(13) Swing bakelite ring clear of control assembly (fig. 66 ⑤).

c. CLEANING. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

Note. Unless the cleaning is done carefully and thoroughly, the effectiveness of the moistureproofing and fungiproofing treatment will be impaired.

d. MASKING. (1) Mask jack field on subpanel (fig. 67 ①).

(2) Mask three grid clips (fig. 67 ②).

(3) Mask three grid caps (fig. 67 ③).

(4) Mask prongs of power plug (fig. 67 ④).

(5) Mask tapped holes on GAIN control cover plates (fig. 67 ⑤).

(6) Mask the rear sections, containing the switch arms and contacts, of the two GAIN controls (figs. 67 ⑥ and 68 ①).

(7) Completely mask the shaft and gear assemblies of the two controls (figs. 67⑦ and 68 ②).

(8) Completely mask the rear of the jack as-

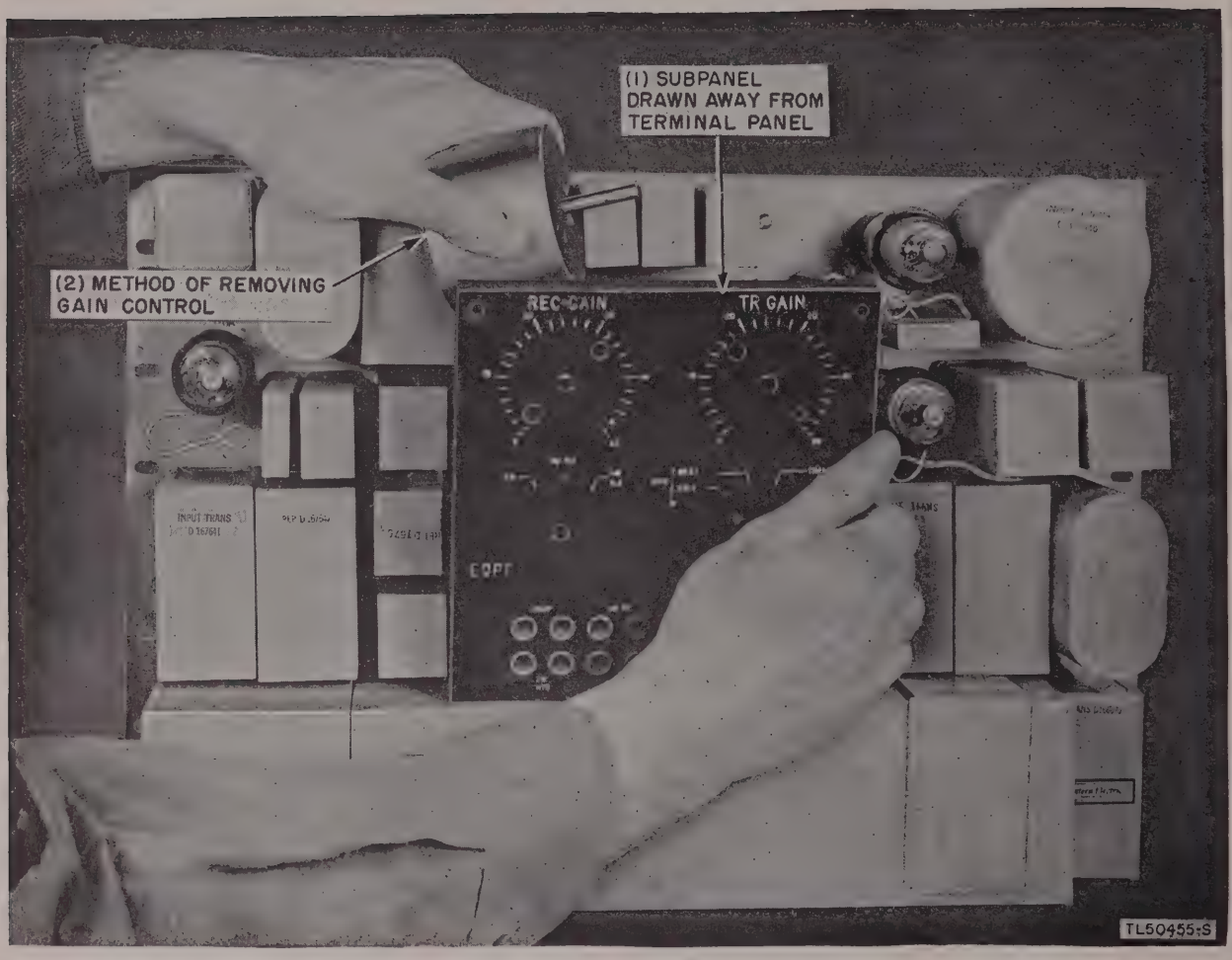


Figure 65. Disassembly of terminal panel.

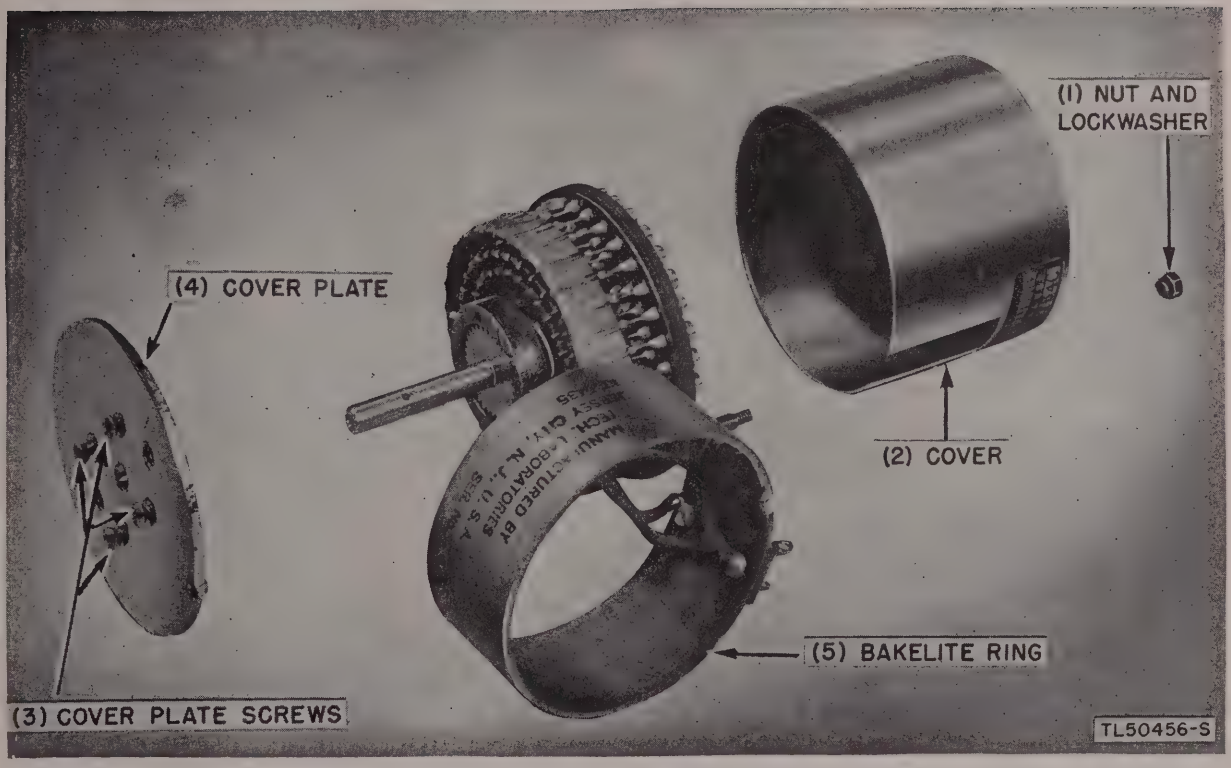


Figure 66. Disassembly of GAIN controls.

sembly (fig. 68 ③). Use masking tape and leave no openings.

(9) Completely mask LINE and EQPT switches. Stuff tissue paper between wafers and cover entire switches with masking tape (fig. 69 ① and ②).

(10) Mask bottoms of three tube sockets (fig. 69 ③).

(11) Mask fiber tube of transformer OSC (fig. 69 ④).

e. DRYING. Place equipment in oven or under heat lamps and dry for 4 to 6 hours at 140° F.

Caution: Do not exceed 140° F. If impregnating compounds begin to melt in any of the components, decrease the temperature, and increase the drying time 1 hour per each decrease of 10° F.

f. VARNISHING. (1) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71-2202 (stock No. 6G1005.3), or equal). Allow each coat to air-dry for 15 or 20 minutes before applying the next coat.

(2) Apply varnish immediately after the equipment is dried. If varnish is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(3) Spray *all* of the equipment. Use a brush to apply varnish to those portions not reached by spray. Take special care that all wiring is adequately coated with varnish.

g. REASSEMBLY. (1) Remove all masking tape, being careful not to peel varnish from near-by areas.

(2) Apply one coat of varnish with brush to all wires which are unvarnished.

(3) Reassemble the panel and test its operation.

Note. The electrical characteristics of electronic equipment are subject to change over a period of approximately 10 days after the application of varnish. For this reason it is desirable to wait until this period has elapsed before making the final check.

h. MARKING. Mark the letters MFP and the date of treatment near the designation H CARR TERM on the front of the panel.

Example: MFP—11 Mar 45.

72. Step-by-Step Instructions for Treating Carrier Repeater OA-10/FC

a. PREPARATION. Make all maintenance checks, repairs, replacements, and adjustments necessary for proper operation of the equipment.

b. DISASSEMBLY. The disassembly of the repeater panel is very similar to the disassembly of the terminal panel. Follow instructions in paragraph 71*b* but see figure 70 instead of figure 64. Before withdrawing the subpanel, remove the vacuum tube in the upper center of the repeater panel (fig. 70 ⑥).

c. CLEANING. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

Note. Unless the cleaning is done carefully and thoroughly, the effectiveness of the moistureproofing and fungiproofing treatment will be impaired.

d. MASKING. (1) Replace vacuum tube in its socket in upper center of panel (fig. 71 ①).

(2) Mask jack fields on subpanel (fig. 71 ②).

(3) Mask two grid clips (fig. 71 ③).

(4) Mask two grid caps (fig. 71 ④).

(5) Mask tapped holes on GAIN control cover plates (fig. 71 ⑤).

(6) Mask prongs of power plug (fig. 71 ⑥).

(7) Mask the rear sections, containing the switch arms and contacts, of the two GAIN controls (figs. 71 ⑦ and 72 ①).

(8) Completely mask the shaft and gear assemblies of the two controls (figs. 71 ⑧ and 72 ②).

(9) Completely mask the rear of the jack assemblies (fig. 72 ③). Use masking tape and leave no openings.

(10) Mask bottoms of two tube sockets (fig. 73 ①).

e. DRYING. Follow procedure outlined in paragraph 71*e*.

f. VARNISHING. Follow procedure outlined in paragraph 71*f*.

g. REASSEMBLY. Follow procedure outlined in paragraph 71*g*.

h. MARKING. Mark the letters MFP and the date of treatment near the designation H CARR REP on the front of the panel.

Example: MFP—11 Mar 45.

73. Step-by-Step Instructions for Treating Carrier Filter F-36/FC

a. PREPARATION. Make all repairs necessary for proper operation of the equipment.

b. DISASSEMBLY. No disassembly is required.

c. CLEANING. Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surfaces to be varnished.

Note. Unless the cleaning is done carefully and thoroughly, effectiveness of the moistureproofing and fungiproofing treatment will be impaired.

d. MASKING. No masking is required.

e. DRYING. Place equipment in oven or under heat lamps and dry for 4 to 6 hours at 140° F.

Caution: Do not exceed 140° F. If impregnating compounds begin to melt in any of the components, decrease the temperature, and increase the drying time 1 hour per each decrease of 10° F.

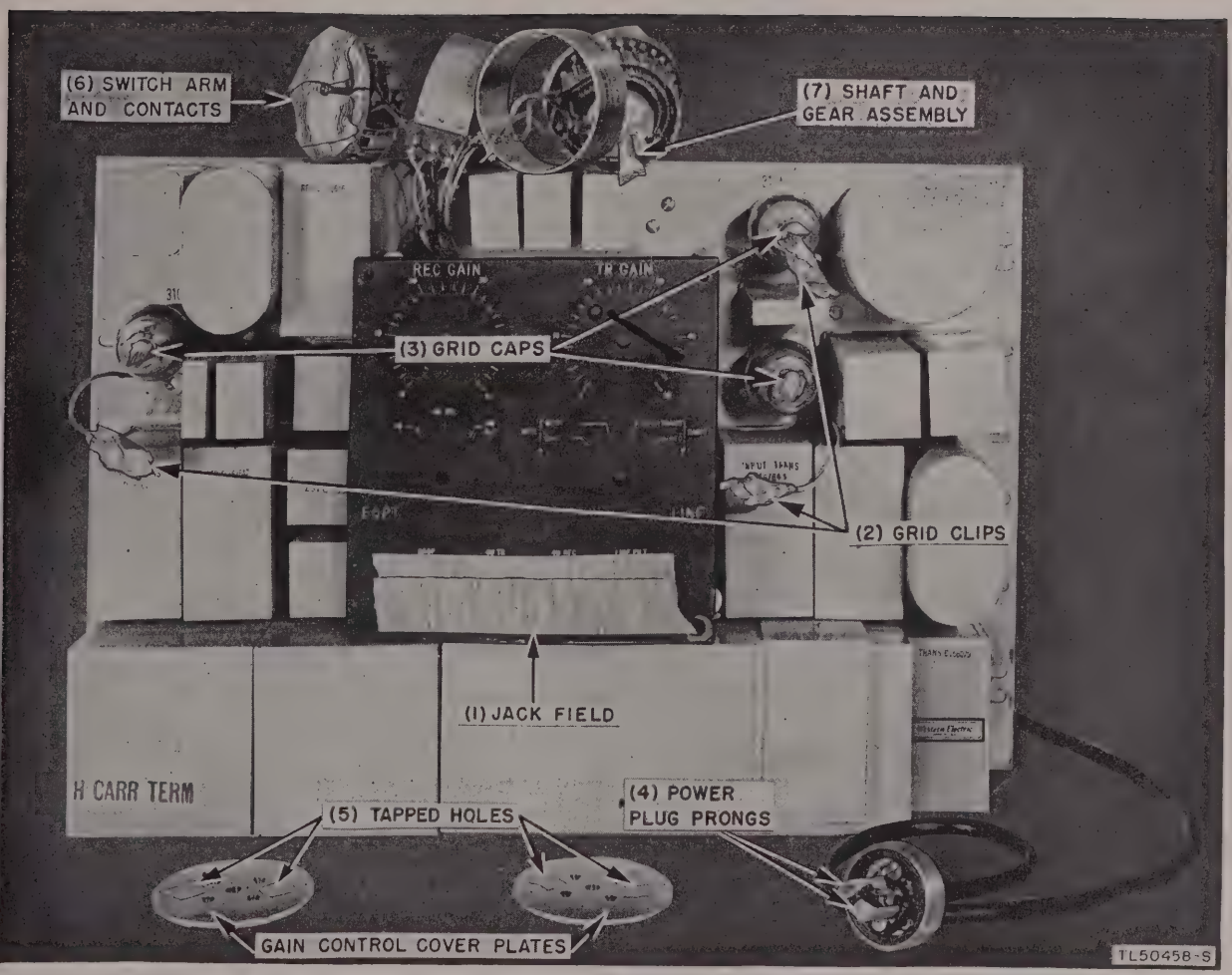


Figure 67. Masking of terminal panel, front view.

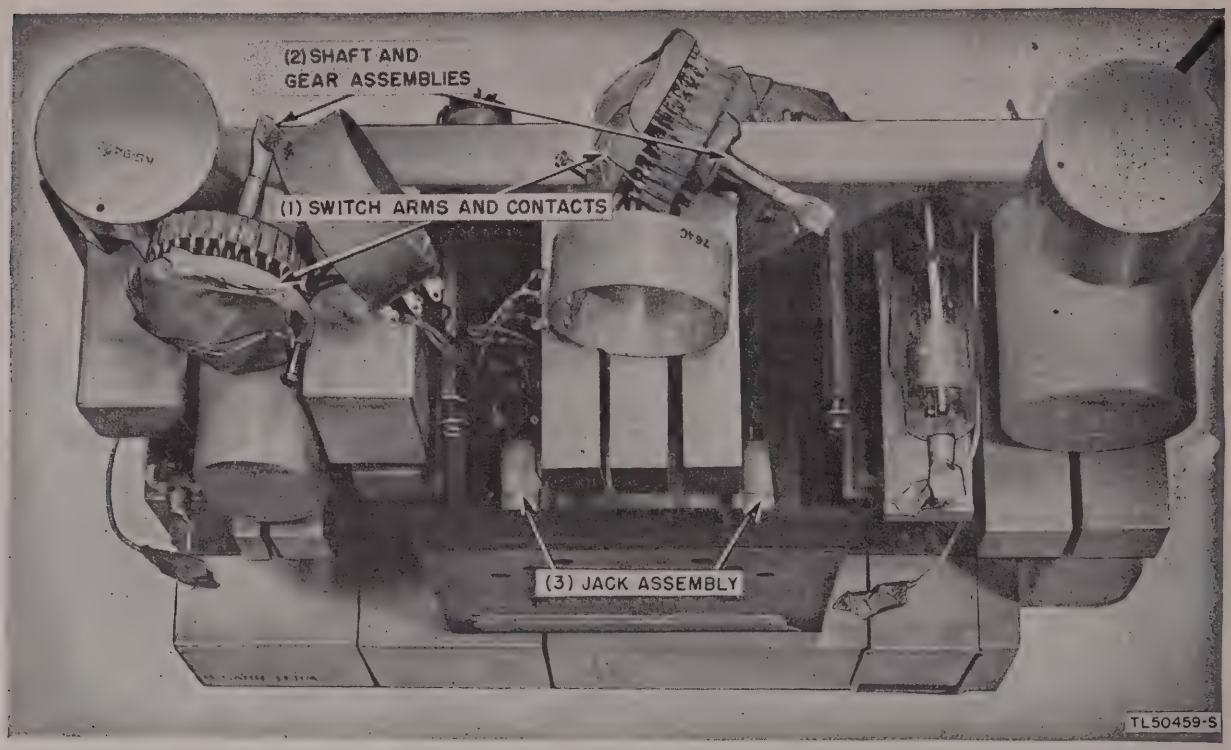


Figure 68. Masking of terminal panel, top view.

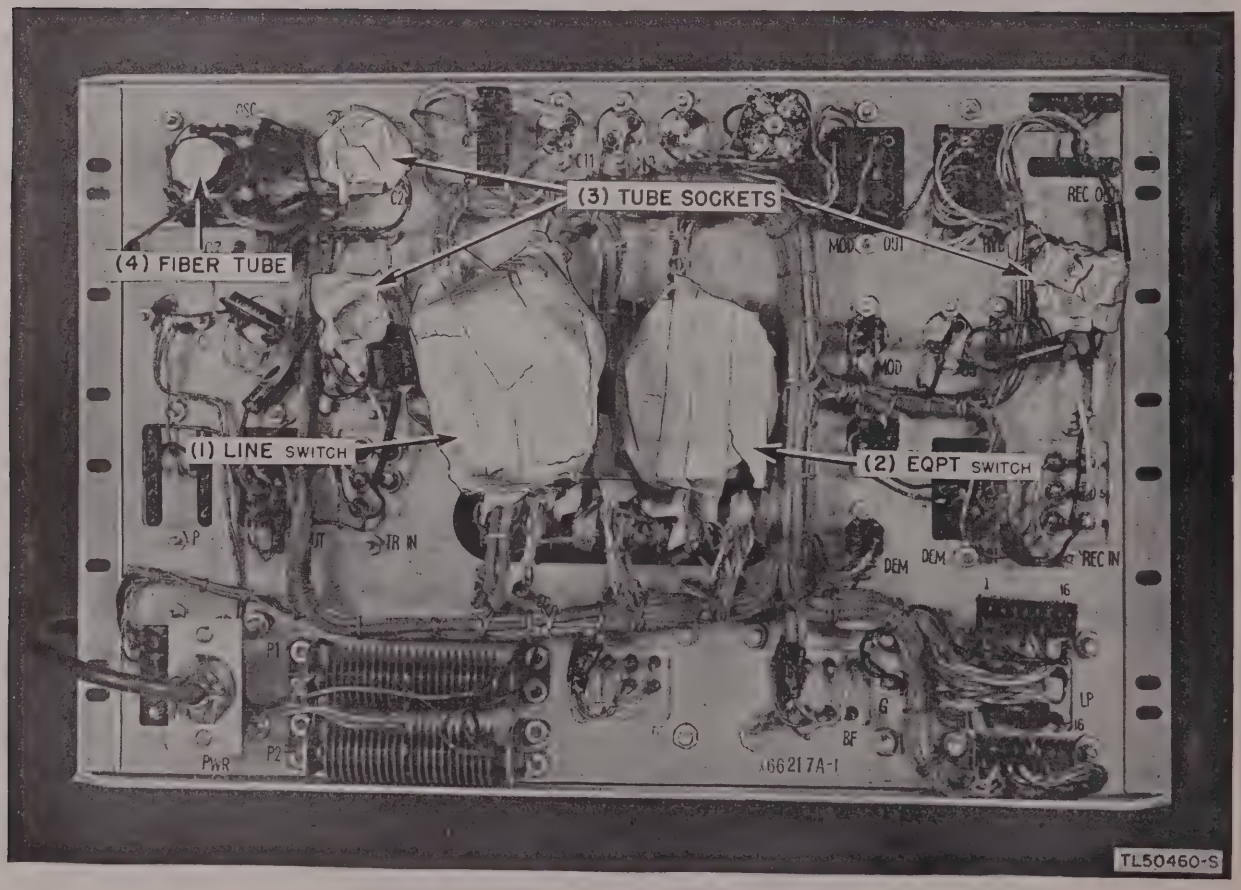


Figure 69. Masking of terminal panel, rear view.

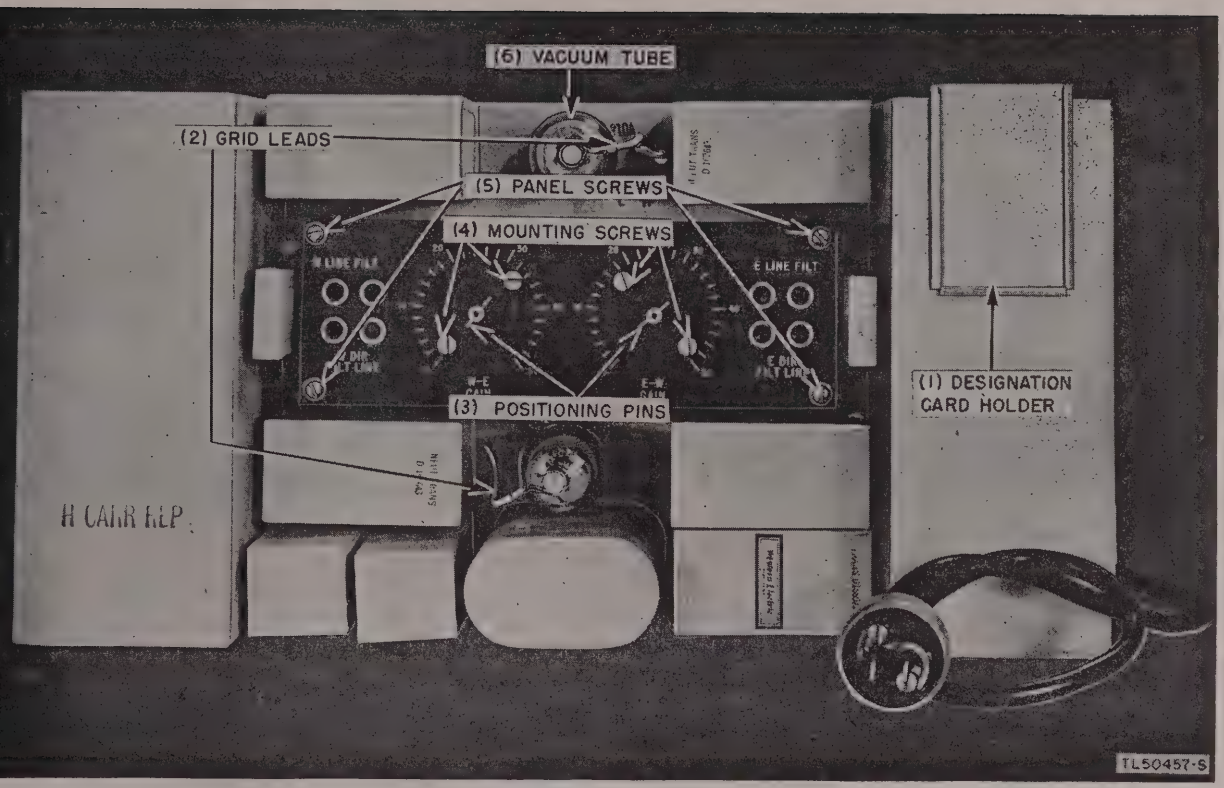


Figure 70. Disassembly of repeater panel.

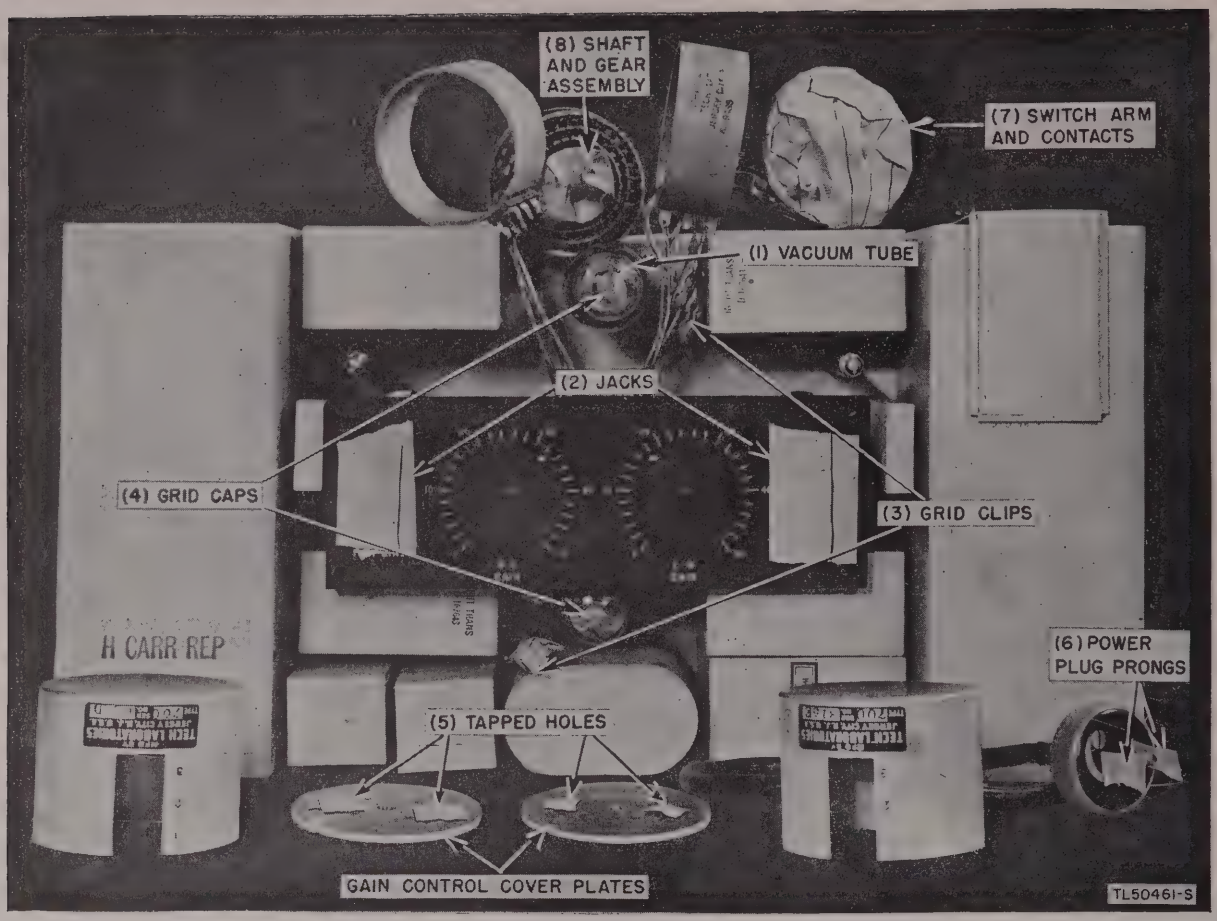


Figure 71. Masking of repeater panel, front view.

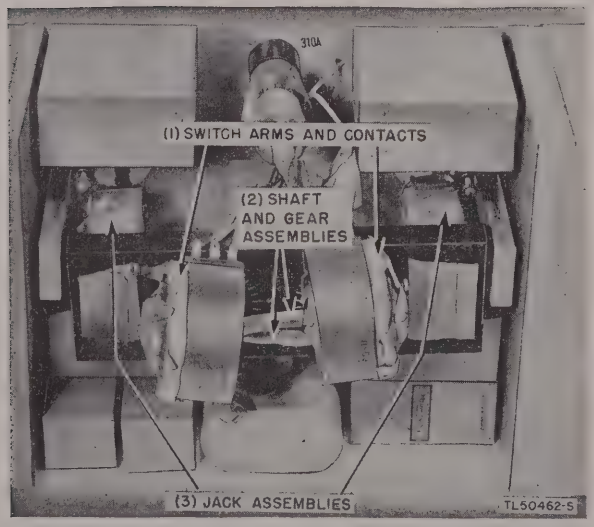


Figure 72. Masking of repeater panel, top view.

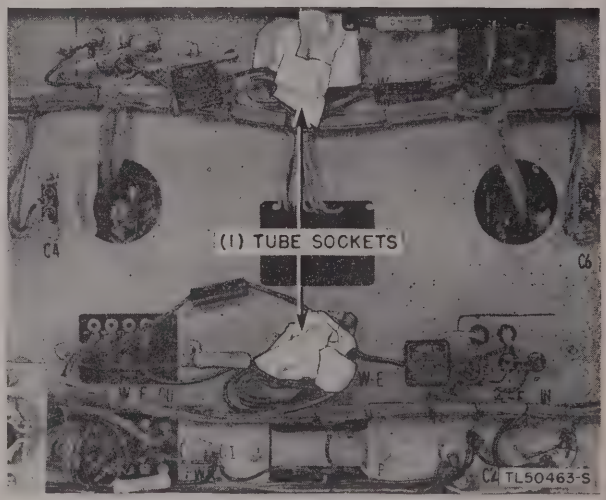


Figure 73. Masking of repeater panel, rear view.

f. VARNISHING. (1) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, spec No. 71-2202 (stock No. 6G-1005.3), or equal). Allow each coat to air-dry 15 or 20 minutes before applying the next coat.

(2) Apply varnish immediately after the equipment is dried. If varnish is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(3) Spray all of the equipment. Use a brush to apply varnish to those portions not reached by spray. Take special care that all wiring is adequately coated with varnish.

g. REASSEMBLY. (1) Apply one coat of varnish with brush to all wires which are unvarnished.

(2) No reassembly is required. Test the operation of the panel.

Note. The electrical characteristics of electronic equipment are subject to change over a period of approximately 10 days after the application of varnish. For this reason it is desirable to wait until this period has elapsed before making the final check.

h. MARKING. Mark the letters MFP and the date of treatment near the designation H CARR LINE on the front of the panel.

Example: MFP—11 Mar 45.

74. Moistureproofing and Fungiproofing after Repairs

If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

PART FOUR

AUXILIARY EQUIPMENT

(NOT USED)

REPAIR INSTRUCTIONS

Note. Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form 54 (Unsatisfactory Report). If either form is not available, prepare the data according to the sample form reproduced in figure 74.

Section XIII. GENERAL REPAIR PROCEDURE

75. Outline of Repair Technique

a. Trouble on the type H carrier system will be detected by routine testing or by a trouble report from the using or operating personnel, noting either faulty operation of the system or a complete failure. The first step in clearing this trouble is to isolate it to a terminal or repeater installation, a line section, or some external portion of the circuit. If the trouble is found to be at an installation it can be further isolated in either the transmitting or receiving branches of the equipment, or in some circuit common to both branches, such as the power supply or the hybrid coil. Voltage measurements in the power supply or amplifiers, or tone tracing in the transmitting or receiving branches, will locate the source of trouble in a particular circuit or piece of equipment. Operational and line-up tests will also aid in locating the source of trouble. Substitution of parts may be necessary when it is impossible to test all the circuits of a component part, a filter, for example.

b. When the trouble is located it may be corrected by replacement of a defective part, or by adjustment of a circuit or component. The system will be given a new over-all circuit line-up, its operation tested from end to end, and it will then be restored to service.

c. In order to perform the trouble location procedure described above, the maintenance man must have a certain amount of knowledge and skill. His knowledge must include the detailed functioning of the equipment. He must know how to read and understand wiring and schematic diagrams. He must be familiar with the testing apparatus to be used in testing the equipment, and know how to apply the information. Skill in the use of maintenance tools will not only result in more efficient operation of the system, but will also reduce the chance of the same trouble recurring. The goals to be attained are accuracy in the location of trouble, skill and efficiency in its repair, and speed in returning the system to service. If the maintenance man has the qualifications listed above, the attainment of these goals is simplified. The following repair instructions will be based on the assumption that the reader possesses the necessary qualifications.

76. Unsatisfactory Equipment Report

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment (WD AGO Form 468) should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form 54 should be filled out and forwarded through channels.

c. If either form is not available, prepare the data according to the sample form reproduced in figure 74.

WAR DEPARTMENT
UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps — MATÉRIEL		DATE: 5 Mar 45
FROM	ORGANIZATION: 579 Sig. Repair Co.		STATION: APO 10, San Francisco, Calif
TO	NEXT SUPERIOR HEADQUARTERS: Signal Officer, Tenth Army	STATION	TECHNICAL SERVICE: Signal Corps

COMPLETE MAJOR ITEM

NOMENCLATURE: Carrier Repeater OA-10/FC	TYPE: Ground, fixed, carrier		MODEL
MANUFACTURER: Western Electric Co.	U. S. A. REG. No.	SERIAL No.: 56730	DATE RECEIVED: 25 Feb 45

EQUIPMENT WITH WHICH USED (*if applicable*)

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART No.	TYPE	MANUFACTURER	DATE INSTALLED
3C1987-39A	(Ref symbol: P) Coil, retardation, 2 windings	Western Electric Co.	28 Feb 45

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (*If additional space is required, use back of form*)

Windings of coil short out due to humid operating conditions.

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
3 Mar 45	0	0	2	—	—	2	5	—	—

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN

Operation in tropics. Repeater panel has been moisture proofed and fungi proofed.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (*If additional space is required, use back of form*)
POOR	FAIR	GOOD	
		✓	Substitution of coil designed for tropical operation.

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION	SIGNATURE
J. B. WRIGHT, CAPT., SIG. C. 579 SIG. REPAIR CO.	J. B. Wright

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE: Signal Officer, Washington (25) D.C.	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3)
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL 51290

U. S. GOVERNMENT PRINTING OFFICE 16—41546-1

Figure 74. WD AGO Form 468.

Section XIV. DETAILED FUNCTIONING OF EQUIPMENT

77. Outline for Detailed Functioning of Equipment

Type H carrier equipment is furnished in three units: terminal, repeater and line panel. Each unit is first discussed generally to describe its purpose, and then the component parts and circuits are discussed individually. Transmission performance data and characteristics are given to further explain the function of items such as filters, transmitting circuits, and receiving circuits. Simplified schematic diagrams have been prepared from the over-all schematic diagrams furnished with the equipment and reproduced in the rear of this manual.

78. Functioning of Type H Carrier Terminal (fig. 75)

The complete terminal circuit may be divided into three portions: transmitting, receiving, and common. The transmitting circuit provides facilities for receiving voice frequencies, modulating them to carrier frequencies, and amplifying the carrier frequencies for transmission to the line. The receiving circuit provides facilities for receiving carrier frequencies, demodulating them to voice frequencies, and amplifying the voice frequencies for transmission to the switchboard side of the terminal. The common circuits provide facilities for combining the transmitting and receiving circuits on the switchboard side, if required, separating the carrier frequencies on the line side, and supplying the modulator and demodulator circuits with carrier-frequency supply. Although the terminal may be readily rearranged for various conditions by operating the switches and controls to various positions and by changing connections, its operation when arranged for its most usual application is first described. In this case, the switchboard side is arranged for a two-wire termination and the line side is arranged for transmission to an open-wire line. The other arrangements of the terminal will be explained immediately following this discussion.

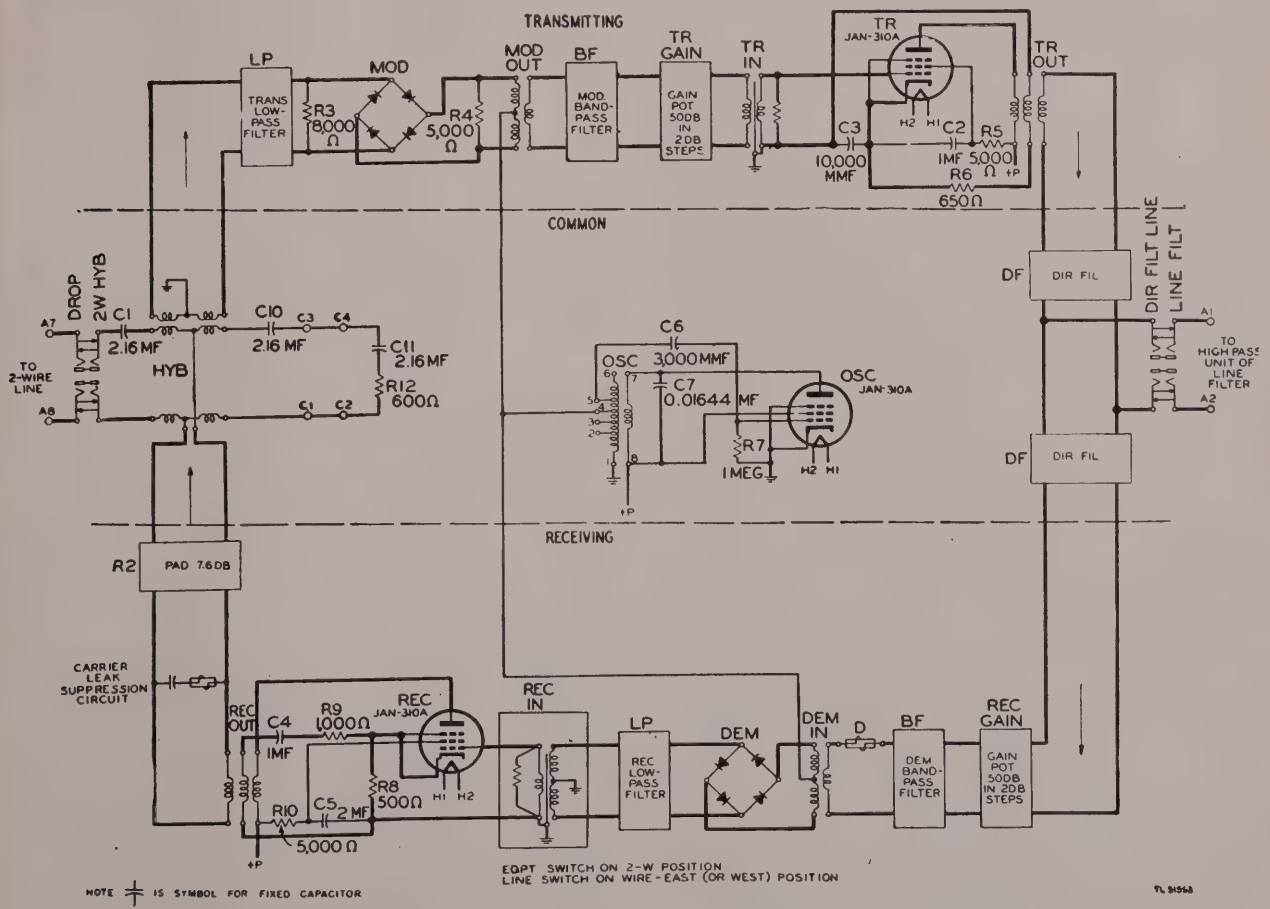


Figure 75. Type H carrier terminal circuit, simplified schematic diagram.

79. Terminal Transmitting Circuit (fig. 75, transmitting)

Voice frequencies from the switchboard side are first passed through the hybrid coil to the low-pass filter LP which suppresses undesirable speech and noise frequencies. In modulator MOD, the voice frequencies are combined with carrier frequencies and appear at transformer MOD OUT as upper and lower side bands. Band-pass filter BF suppresses the undesired side band and passes the desired side band to gain potentiometer TR GAIN. Here the signal is attenuated so that the desired power level on the line will be attained after amplification by the fixed-gain amplifier.

a. Low-pass Filter LP, Transmitting Portion. This filter suppresses frequencies above the useful voice band, thus eliminating undesirable speech harmonics and noise. However, the carrier frequency of 7,150 cycles, impressed at the midpoints of the hybrid coil and transformer MOD OUT, is passed readily. Since equal amounts of carrier current flow through each side of the filter in the same direction, the effects produced by the inductance of each side of the filter are cancelled.

b. Modulator MOD. This modulator consists of copper-oxide varistor elements arranged in a balanced circuit. Resistors R3 and R4 are shunted across the input and output, respectively, to improve the modulator impedances. Carrier power at a frequency of 7,150 cycles is supplied to the modulator by the oscillator circuit, and is impressed at the midpoints of one winding of the hybrid coil and output coil MOD OUT. When supplied with voice and carrier frequencies, the modulator produces upper and lower carrier side-band frequencies and suppresses the carrier and voice frequencies, and some extraneous products of modulation. The modulator also introduces a certain amount of volume limiting into the circuit to reduce the peaks of speech of loud talkers. Reduction of speech peaks is important when type H systems are operated over a radio link as it prevents overloading, interchannel interference, and interference on the telegraph channels.

c. Band-pass Filter BF. This filter is comprised of two sections, a 4,150- to 6,900-cycle band-pass and a 7,400- to 10,150-cycle band-pass. These portions may be switched into the receiving or transmitting circuits depending upon the arrangement of the terminal as an East or West terminal. When arranged as an East terminal, the 7,400- to 10,150-cycle section is used in the transmitting circuit, and when arranged as a West terminal, the 4,150- to 6,900-cycle section is used in the transmitting circuit. The filter is used to suppress the unwanted side band, while passing the side band to be transmitted.

d. Transmitting Gain Control TR GAIN. This control is a variable T-pad which presents a constant input and output impedance of 600 ohms for all settings. It is arranged to provide losses up to 50 db in 2-db steps. This pad is adjusted by means of a knob on the front of the panel and is used to control the transmitting gain of the terminal. Although the amplifier has a fixed gain, the transmitting gain is adjusted by attenuating the signal before amplification.

e. Transmitting Amplifier. The transmitting amplifier, consisting essentially of input transformer TR IN, vacuum tube TR, and output transformer TR OUT, provides a flat gain of approximately 33 db. The amplifier is self-biased and is arranged to provide negative feedback through two paths. One path is formed by resistor R6 between the grid and plate circuits. The other path is through the coupling between the grid and plate circuits provided by the output transformer. This negative feedback improves the stability of the amplifier and reduces distortion. Capacitor C3 provides a shunt path from the feedback circuit to ground to prevent the amplifier from singing at inaudible frequencies when the terminal is operated without any loss in the transmitting gain control. From the transmitting amplifier the transmitted frequencies then pass through part of directional filter DF (par. 81*b*) to the line.

80. Terminal Receiving Circuit (fig. 75, receiving)

Carrier frequencies from the line pass through part of directional filter DF (par. 81*b*) and are attenuated by gain potentiometer REC GAIN to provide the proper input level to the demodulator. Band-pass filter BF suppresses undesired frequencies and passes the desired frequencies to the demodulator. Here the carrier frequencies are demodulated to voice frequencies and passed to low-pass filter LP, which suppresses frequencies above the voice-frequency band. Voice frequencies passed by filter LP are amplified by receiving amplifier REC, and then fed to the termination of the type H carrier terminal.

a. Receiving Gain Control REC GAIN. This control, identical to control TR GAIN, is used to adjust the receiving gain of the terminal to provide circuits of a specified net loss and to compensate for line attenuation changes due to weather. Although the amplifier has a fixed gain, the receiving gain is adjusted by attenuating the signal before amplification.

b. Band-pass Filter BF. When the terminal is arranged as an East terminal, the 4,150- to 6,900-

cycle section of this filter is used in the receiving circuit. When arranged as a West terminal, the 7,400- to 10,150-cycle section is used in the receiving circuit.

c. Demodulator DEM. Varistor demodulator DEM is similar to modulator MOD, but demodulates the incoming carrier side band currents to voice frequencies. The oscillator circuit which supplies the modulator also supplies the demodulator. The carrier frequency is impressed at the midpoints of repeating coil DEM IN and amplifier input transformer REC IN. Retardation coil D is inserted in the circuit ahead of repeating coil DEM IN to improve the impedance looking into the demodulator.

d. Low-pass Filter LP, Receiving Section. This section of the filter serves the same purpose as the transmitting section, and suppresses undesirable frequencies not in the necessary voice-frequency range.

e. Receiving Amplifier. This amplifier, similar to the transmitting amplifier, consists essentially of input transformer REC IN, vacuum tube REC, and output transformer REC OUT. The amplifier is a negative feedback type with a flat gain of approximately 33 db. Grid bias potential is obtained from the drop across resistor R8 and the feedback voltage is derived from the voltage induced in the third winding of transformer REC OUT in addition to the drop across resistor R9 and capacitor C4. Resistor R10 reduces the voltage of the screen supply, and capacitor C5 bypasses the a-c component which appears on the screen.

f. Carrier Leak Suppression Circuit. A retardation coil and capacitor combination, tuned to a frequency of 7,150 cycles, is shunted across the output of the receiving amplifier to suppress any carrier leak from the demodulator.

g. Pad R2. This is an impedance correcting pad having a fixed loss of 7.6 db. One side has an impedance of 600 ohms to match the output of the receiving amplifier, and the other side has an impedance of 300 ohms to match the input to the hybrid coil.

81. Circuits Common to the Terminal Circuits (fig. 75)

a. Hybrid Coil HYB and Balancing Network. This combination is used only when the terminal is terminated on a two-wire basis. It serves to effectively prevent the output of the receiving amplifier from being transferred to the input of the transmitting amplifier, and thus decreases the tendency of the terminal to sing. Incoming voice currents from the switchboard side are equally divided, one-half being passed to the transmitting circuit, and the other half being passed to the receiving circuit where it is dissipated. Voice currents from the receiving amplifier are also equally divided, one-half being passed to the switchboard side, and the other half to the balancing network. The balancing network, consisting of capacitors C10 and C11 (each 2.16 mf) in series with 600-ohm resistor R12, simulates the impedance of the 2W HYB side of the hybrid coil. Capacitor C10 balances capacitor C1 (also 2.16 mf) and capacitor C11 and resistor R12 in series balance the switchboard or two-wire extension. The balance across the hybrid coil should be at least 13 db in the voice-frequency range. That is, if a compromise network, consisting of a 600-ohm resistor in series with a 2.16-mf capacitor, is connected to the drop side of the terminal, the loss measured across the hybrid coil at voice frequencies should be at least 13 db. When the type H system is extended by long voice-frequency facilities, balance considerations may make it desirable to replace capacitor C11 and resistor R12 with an external line-balancing network.

b. Directional Filter DF. This filter, like band-pass filter BF, consists of two sections, a 4,150- to 6,900-cycle band-pass and a 7,400- to 10,150-cycle band-pass. These sections may be switched into the receiving or transmitting circuits depending upon the arrangement of the terminal as an East or West terminal. When arranged as an East terminal, the 7,400- to 10,150-cycle portion is connected to the transmitting circuit, and the 4,150- to 6,900-cycle section to the receiving circuit. When arranged as a West terminal, the position of these sections is reversed. The filter serves to prevent the output of the transmitting amplifier from being fed back to the input of the receiving amplifier, and thus decreases the tendency of the terminal to sing.

c. Oscillator Circuit. The carrier frequency supplied to the modulator and demodulator is derived from a common vacuum tube oscillator circuit. The oscillator frequency of 7,150 cycles is determined by a tuned circuit which consists of the primary winding of transformer OSC, in parallel with capacitor C7. Feedback of the proper phase to sustain oscillation is obtained from the 1-5 section of the OSC secondary, and is fed to the grid of the tube through capacitor C6. The output of the oscillator is also taken from the secondary winding of OSC, between taps 1 (ground) and 4. The output level across the output terminals is about +9 dbm. The oscillator frequencies are preadjusted and should seldom require further adjustment. The frequency of the oscillator should not vary appreciably with different tubes or changes in the power supply within the limits of ± 10 volts. Although some variation will result from

aging, the oscillator frequencies at the two terminals should change more or less together. Accordingly, the carrier frequencies at the two terminals should ordinarily not be out of synchronism by more than about 10 cycles, which is not enough to affect transmission seriously. However, fine adjustments of frequency may be made by changing the position of the movable permalloy plug which forms the core of the transformer (fig. 28).

d. Jack Arrangement. Jacks are provided on both sides of the terminal for line-up and maintenance of the terminal and the type H carrier system.

82. Terminal Power Supply (fig. 76)

Voltage for the tubes of the terminal is furnished by an external a-c power source through a power transformer and associated circuits. The a-c power source is connected to the primary winding of transformer PWR. One winding of the secondary provides voltage for the heaters of the tubes. The other winding feeds voltage to varistors P1 and P2 which act as a full-wave rectifier and provides voltage for the plates of the tubes.

a. Power Source. The power supply operates from a 50- to 60-cycle, 105- to 125-volt, a-c power source.

b. PWR Transformer. (1) *Primary winding.* One lead of the power cord connects to lug 1 and the other lead is connected to lugs 3, 4, or 5 depending upon the voltage of the a-c power supply. Lug 2 is not used.

(2) *Secondary winding.* The secondary has two windings. The winding which is brought out to lugs 9 and 10 supplies 10 volts for the heaters of the three vacuum tubes. The other winding, which is brought out to lug 6 and lugs 7 or 8, connects to varistors P1 and P2 which supply between 125 and 190 volts direct current to the plates of the tubes. Normally connection is made to lugs 6 and 7. However, the varistor ages with use and after a considerable period of time will require a higher operating voltage. Connection to lug 8 provides increased voltage for the varistors at such time as the varistor output falls below the 125-volt limit.

c. Associated Circuit. Varistors P1 and P2 are connected in a bridge circuit and act as a full-wave rectifier which supplies voltage across load resistor R11. A low-pass filter, consisting of retardation coil P and capacitors C8 and C9, is connected between the varistors and the load resistor to reduce a-c hum. One side of R11 is connected to the plates of the tubes and the other side to ground.

83. Terminal Arrangement for Four-wire Termination (fig. 77)

a. Differences Between Two-wire and Four-wire Terminations. When the terminal is terminated on a four-wire basis on the switchboard side, the transmitting and receiving paths are the same as for a two-wire termination with the following exceptions:

(1) *Hybrid coil.* One winding of the hybrid coil is not used and the hybrid coil is connected as a repeating coil in the transmitting branch of the circuit.

(2) *Balancing network.* The balancing network associated with the hybrid coil is not used.

(3) *Pads.* Impedance correcting pad R2 is not connected into the receiving circuit since the output impedance of the receiving amplifier is 600 ohms and is satisfactory to match impedances of connected equipments. Pad R1, with a fixed loss of 8 db, is connected into the transmitting path in order to attenuate incoming voice-frequency signals to a level favorable to the modulator. The terminal is normally operated with this pad in the transmitting path when terminated on a four-wire basis, but it may be arranged so that the pad is omitted.

b. Transmitting and Receiving Paths. (1) *Switch at 4W TEL.* Voice currents enter the terminal through jacks 4W TR and MOD IN and pass through 8-db pad R1 to the hybrid repeating coil and modulator circuit. In the receiving path the demodu-

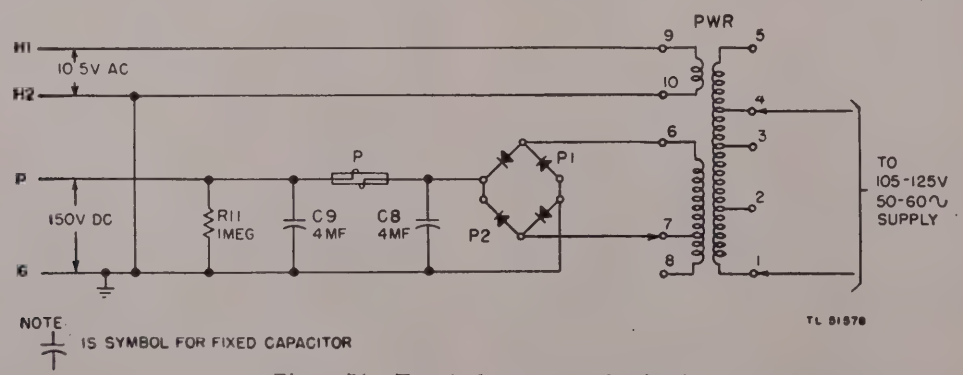


Figure 76. Terminal power supply circuit.

lated voice currents pass directly from transformer REC OUT through jacks DEM OUT and 4W REC to the four-wire line.

(2) *Switch at 4W TLG.* Voice currents enter the terminal through jacks 4W TR and MOD IN and pass directly through the hybrid repeating coil to the modulator circuit. In the receiving path the demodulated currents pass directly from transformer REC OUT through jacks DEM OUT and 4W REC to the four-wire line. In normal operation this arrangement is not used, but is provided for cases where disconnection of pad R1 in the transmitting path is desired.

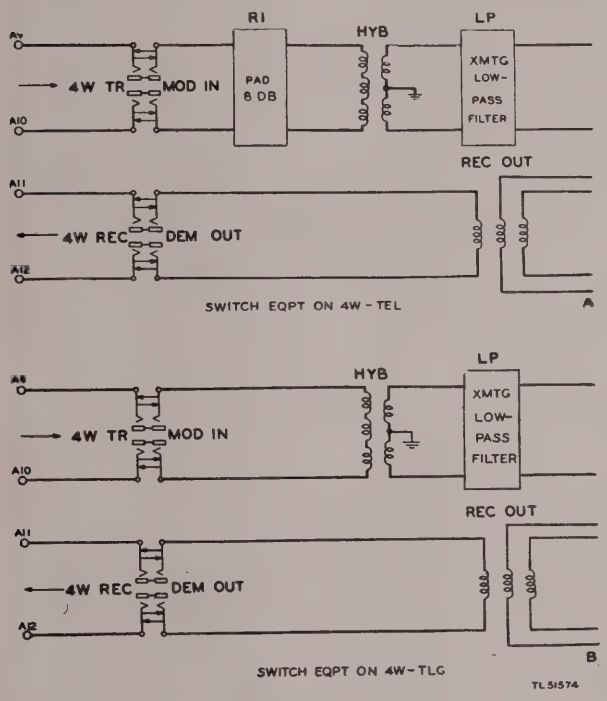


Figure 77. Four-wire termination.

84. Terminals Arranged for Radio Link Operation

When switch LINE is at either of the RADIO positions, the function of the two terminals is basically the same as that described in preceding paragraphs. Two terminals are required, and the directional filters DF, controls REC GAIN, and band-pass filters BF are so interconnected that the transmitting circuits of both terminals are connected to the directional filter of one terminal and the receiving circuits of both terminals to the directional filter of the other terminal (see figs. 8 and 9).

85. Transmission Characteristics of Terminal Filters

Three combinations of filters are used in the terminal circuits: low-pass, band-pass, and directional. Each of these filters is comprised of two units, which are sealed in a single metal container and designated as a single item (LP, BF, and DF).

a. Low-pass Filter LP (fig. 78). One portion of this filter is used in the transmitting circuit and the other in the receiving circuit. Since less suppression is required in the receiving circuit for frequencies above the voice band, the two units have different characteristics. A simplified schematic diagram of the carrier leak suppression network, housed in the same container with filter LP, is also shown in figure 78.

b. Band-pass Filter BF (fig. 79). Each of these units may be switched into either the transmitting or receiving circuit, depending upon whether an East or West terminal arrangement is used. The unit which selects the 4,150- to 6,900-cycle band is actually a low-pass filter since such a structure gives adequate suppression of the unwanted frequencies.

c. Directional Filter DF (fig. 80). These units separate the transmitting and receiving paths of the carrier frequency side bands and are arranged to provide attenuation in the high frequency singing path of the terminal with minimum distortion to the transmitted carrier frequency side bands.

86. Terminal Transmission Performance

a. Maximum Transmitting and Receiving Gains. The maximum gain available at a terminal is dependent upon the gain of the amplifiers less the losses inserted by the components of the transmitting and receiving circuits. Since these components vary with the terminating arrangement (two-wire, four-wire) the available gain varies also. The maximum available gains for the various arrangements are shown in table XII. These gains have been computed at a frequency of 1,000 cycles applied to the switchboard side of the terminal. Though there will be slight variations due to manufacturing tolerances, differences in tubes, small changes in the voltage supply, and aging of the varistor units, these gains can be obtained in most cases. The 20-db transmitting gain for the two-wire arrangement can be computed by subtracting the total loss of the components (13 db, composed of 12 db in the modulator circuit, including the hybrid coil, transmitting low-pass filter, modulator, and modulator output transformer, and 1 db in the transmitting band-pass and directional filters) from the amplifier gain (33 db). The 16-db receiving gain can be computed by subtracting the total loss of the components (17.1 db, composed of 2.0 db in the receiving directional and band-pass filters, 4.0 db in the demodulator circuit, including the demodulator input transformer, demodulator, and

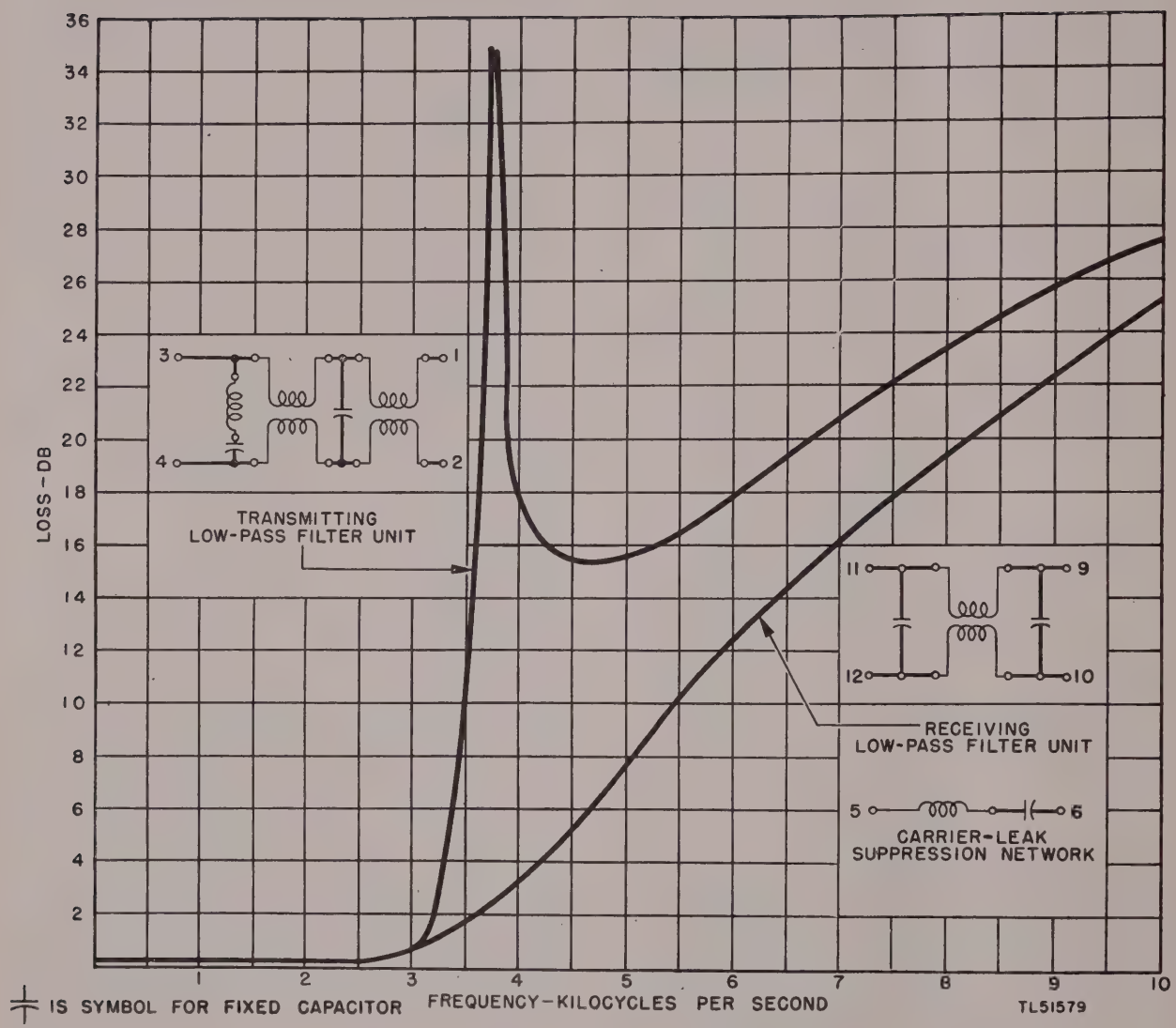


Figure 78. Transmission characteristics of low-pass filter LP.

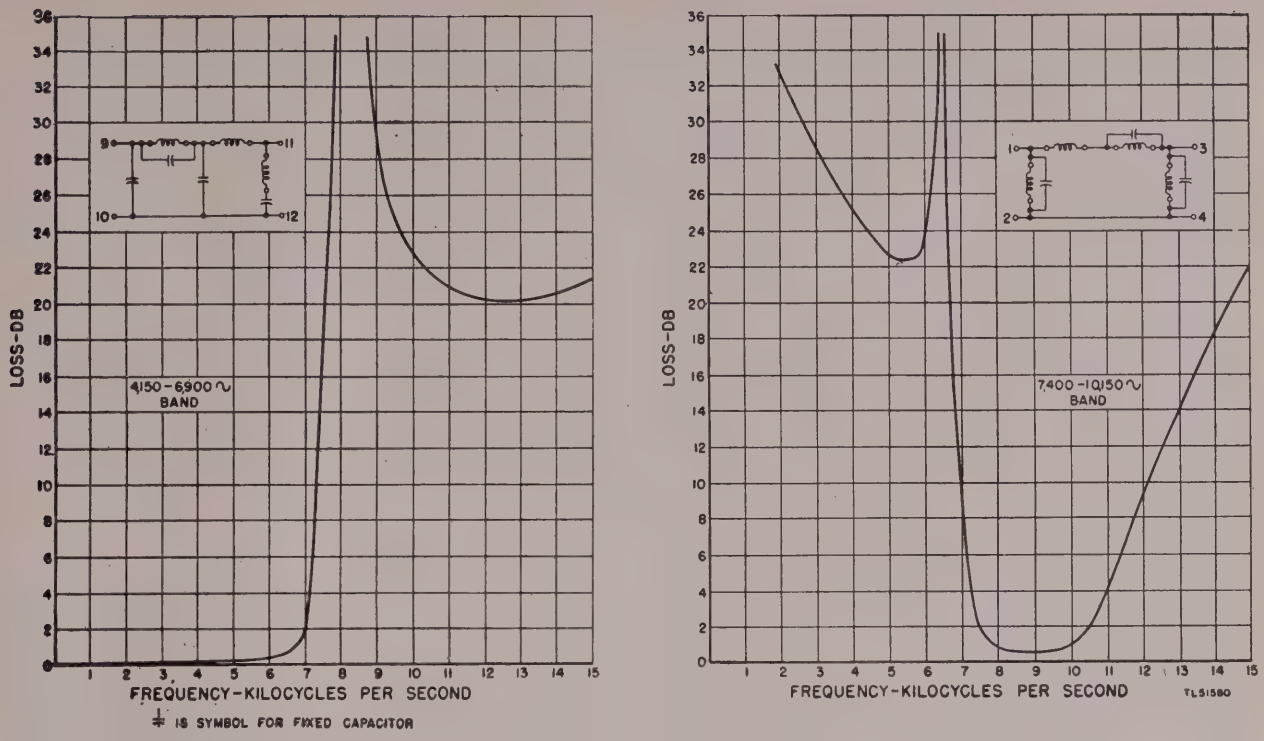


Figure 79. Transmission characteristics of band-pass filter BF.

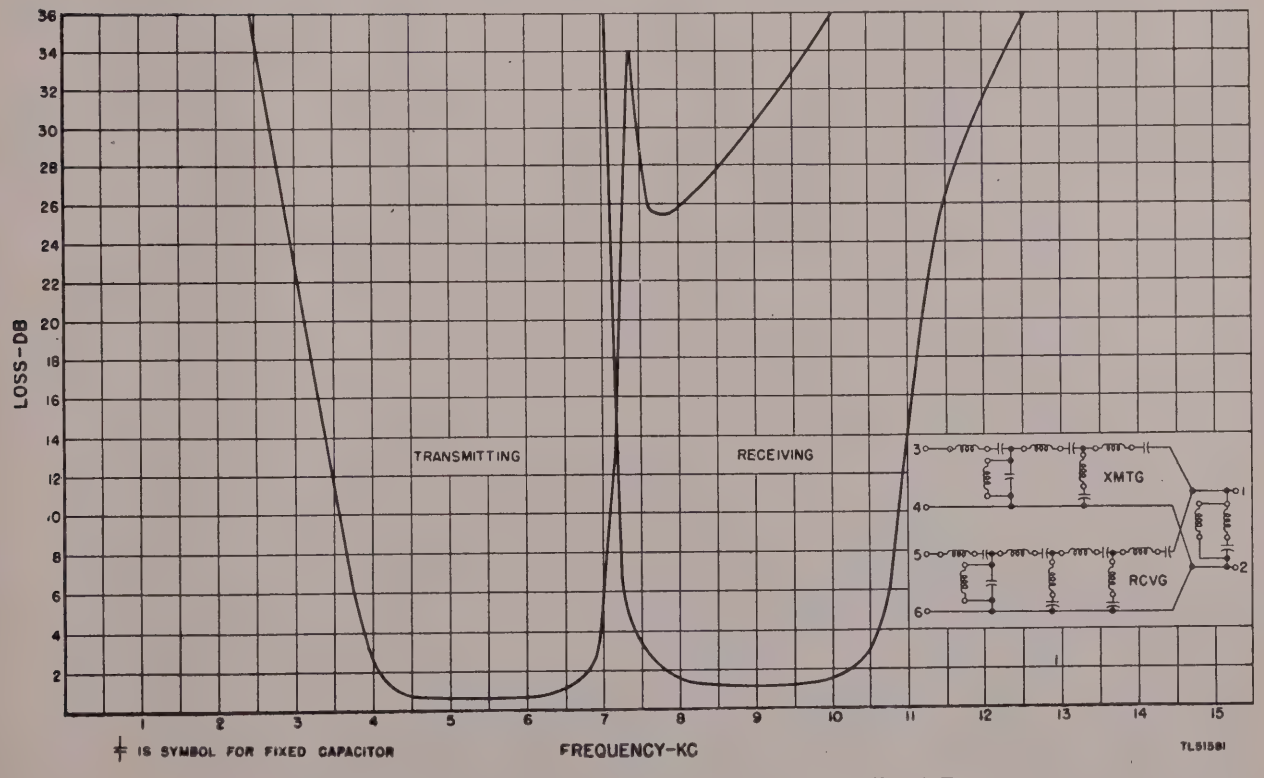


Figure 80. Transmission characteristics of directional filter DF.

receiving low-pass filter, 7.6 db in pad R2, 3.5 db in the hybrid coil) from the amplifier gain (33 db).

Table XII. Transmitting and receiving gains

EQPT switch setting	Transmitting gain (db)	Receiving gain (db)
2W	20	16
4W TEL	17	27
4W TLG	25	27

b. Limitations on Use of Maximum Transmitting and Receiving Gains. Maximum transmitting and receiving gains cannot be utilized in both directions of transmission since the use of gain is limited to the permissible loop gain, 26 db in the case of a type H carrier terminal. For example, if a gain of 20 db is used in the transmitting direction (two-wire termination) only 6 db of the approximate maximum of 16 db is available for use in the receiving direction. When the permissible loop gain is exceeded the higher gain may upset the gain-loss balance and result in the circulation of singing currents in the terminal. When necessary, however, the loop gain may be exceeded by about 2 db since a 2-db increase over the 26-db loop gain generally will not upset the gain-loss balance sufficiently to cause singing.

c. Gain-frequency Characteristics. Figures 81 and 82 show representative transmitting and receiving gain-frequency characteristics for terminal circuits with a two-wire termination, as measured between jacks 2W HYB and DIR FILT LINE. Curves plotted show the gains at various frequencies relative to the gains at 1,000 cycles and are for a terminal adjusted to a 26-db loop gain, with 16-db gain in the transmitting direction and 10-db gain in the receiving direction. Although the currents transmitted to or received from the line are in the carrier band, the graphs show frequencies in the voice band since the test transmission from jacks 2W HYB is made at voice frequencies.

d. Impedance. (1) *Two-wire operation.* The nominal input impedance looking into the switchboard at 1,000 cycles is 600 ohms.

(2) *Four-wire operation.* The nominal input impedance on the voice side looking into each of the four-wire branches is 600 ohms. On the high-frequency side looking into the directional filter the impedance is about 600 ohms, matching the impedance of the high-pass section of the line filter on the carrier line panel.

87. Terminal Switches

Two switches are used for changing connections in the terminal panel: switch EQPT and switch LINE. Switch EQPT controls the circuit arrangements on the voice-frequency side of the terminal. In the WIRE positions switch LINE switches the band-pass and directional filter units so that each selects the proper frequency for an East or West terminal In the RADIO position switch LINE provides proper circuit arrangements when the two terminals are interconnected and used with a radio link.

a. Switch EQPT. This is a two-section, three-position, rotary circuit-selector switch which is controlled by the EQPT knob on the front panel; the three positions are marked 2W, 4W TEL, and 4W TLG. Although each section has 12 terminals on the front and 12 on the rear, terminals bearing the same

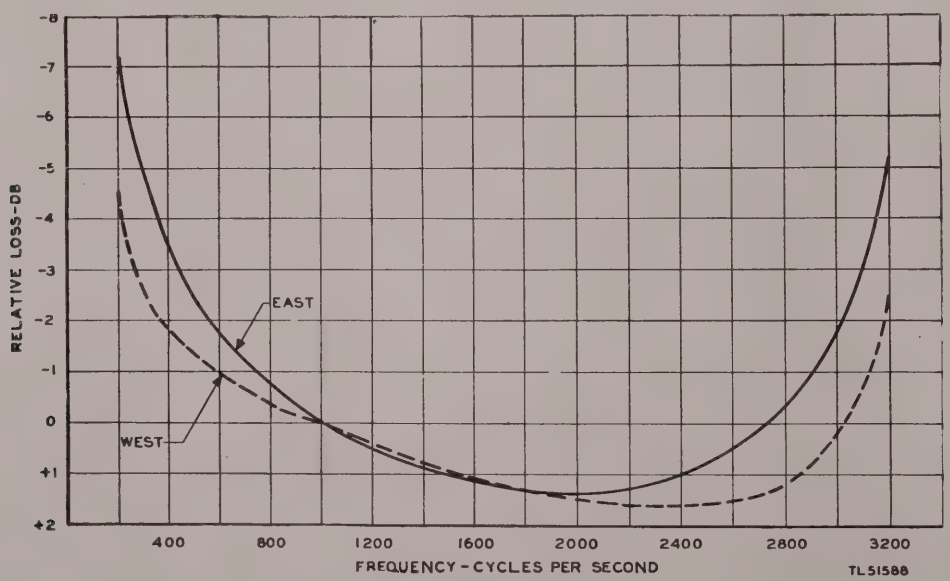


Figure 81. Transmitting gain-frequency characteristic.

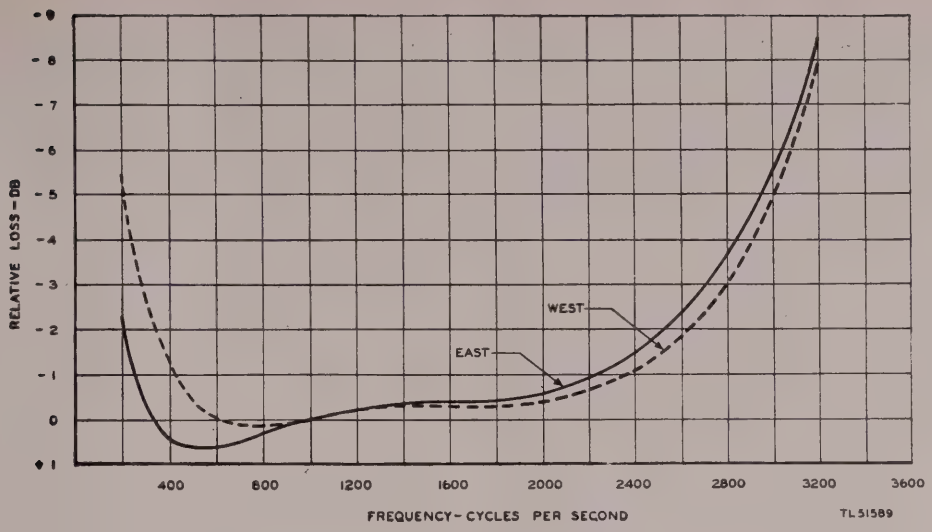


Figure 82. Receiving gain-frequency characteristic.

number are metallically connected together and are not insulated from each other (that is, terminal 1, rear, is metallically connected to terminal 1, front, etc.). Rotor blades of various shapes make contact with these terminals and set up the desired connections.

(1) *2W Position* (fig. 83). In this position the terminal is arranged for a two-wire termination. Schematically, the circuit is as shown in figure 75. Note that hybrid coil HYB is connected to the switchboard side of the terminal, the balancing network, transmitting low-pass filter LP, and pad R2.

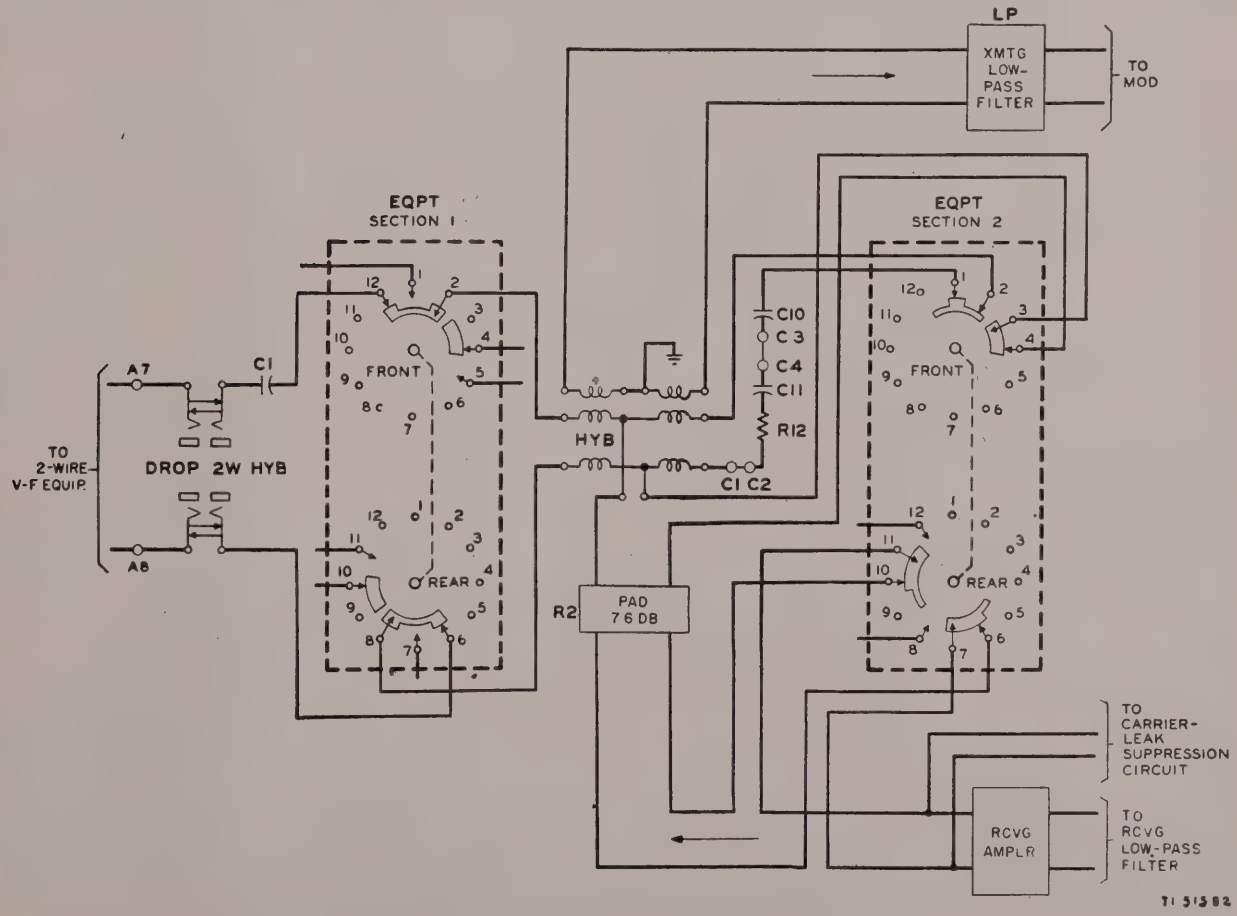


Figure 83. Switch EQPT in 2W position.

(2) *4W TEL Position* (fig. 84). In this position the terminal is arranged for a four-wire termination. Schematically, the circuit is as shown in figure 77A. Note that pad R1 is connected into the transmitting path and that coil HYB is connected as a repeating coil. Three of the coil sections are connected in series to form one side of the repeating coil and the two sections connected to filter LP are unchanged. Note also that the output of the receiving amplifier is now connected directly to the four-wire line.

(3) *4W TLG Position* (fig. 85). In this position the terminal is also arranged for a four-wire termination. Schematically, the circuit is as shown in figure 77B. The arrangement is the same as that described for the 4W TEL position except that pad R1 has been removed from the transmitting path and that coil HYB is connected directly to four-wire line.

b. Switch LINE. This is a three-section, four-position switch, similar in construction to switch EQPT. It is controlled by the LINE knob on the front panel and the four positions are marked WIRE EAST, WIRE WEST, RADIO TRANS, and RADIO REC. In addition to the three sections, there is a brass shield plate between each section and at the rear of the switch. These 3 shield plates are each equipped with 12 soldering terminals around their perimeters. The three plates are all connected to the ground and the soldering terminals provide convenient ground connections for the various equipment units. The shield plates are not shown in the three figures showing the arrangements for the four switch positions.

(1) *WIRE EAST Position* (fig. 86). In this position the terminal is arranged for operation as an East terminal. Schematically, the circuit is as shown in figure 6. Filters BF and DF are so connected that their high-frequency sections are in the transmitting path and their low-frequency sections are in the receiving path.

(2) *WIRE WEST Position* (fig. 87). In this position the terminal is arranged for operation as a West terminal. Schematically, the circuit is as shown in figure 6 if the frequency values shown in parentheses for filters BF and DF are used. Filters BF and DF are now so connected that their low-frequency sections are in the transmitting path and their high-frequency sections are in the receiving path.

(3) *RADIO TRANS and RADIO REC Positions* (fig. 88). Two terminals are shown interconnected for radio link operation. Switch LINE of the

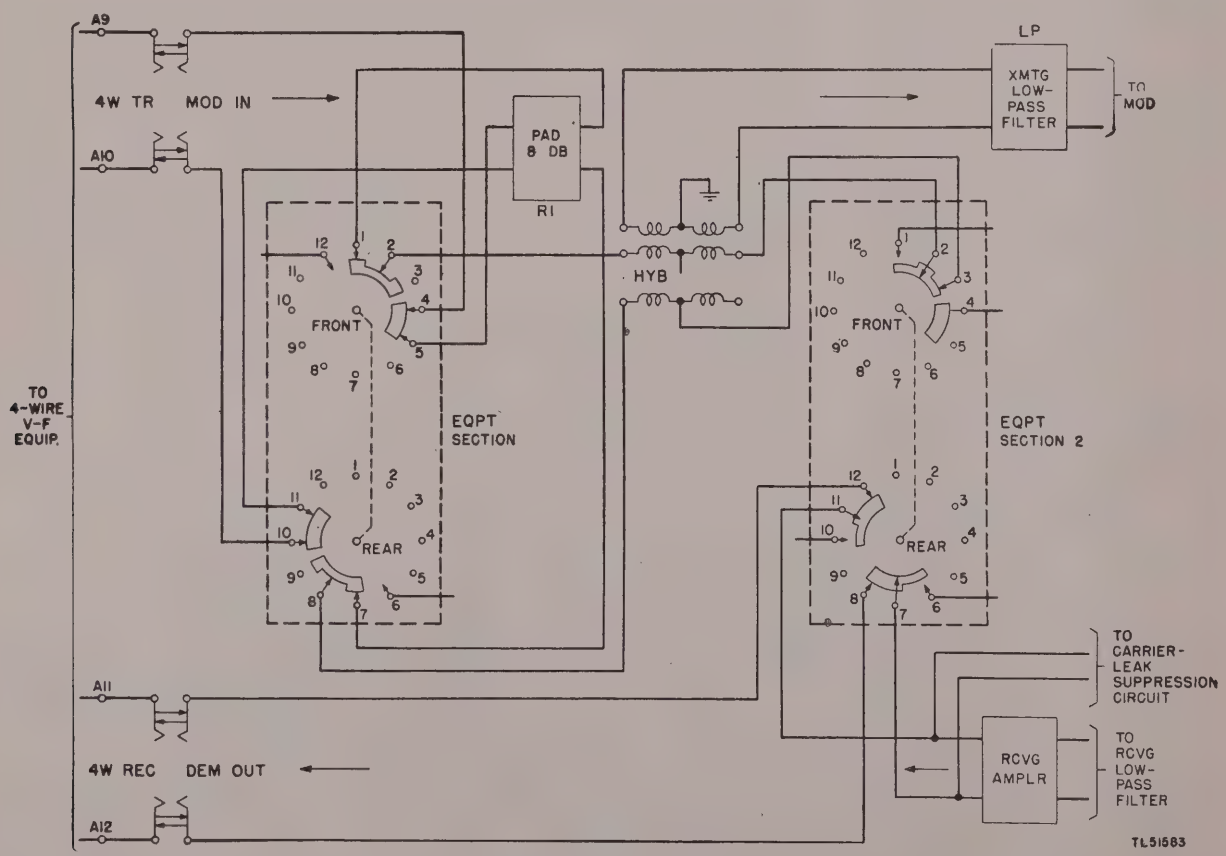


Figure 84. Switch EQPT in 4W TEL position.

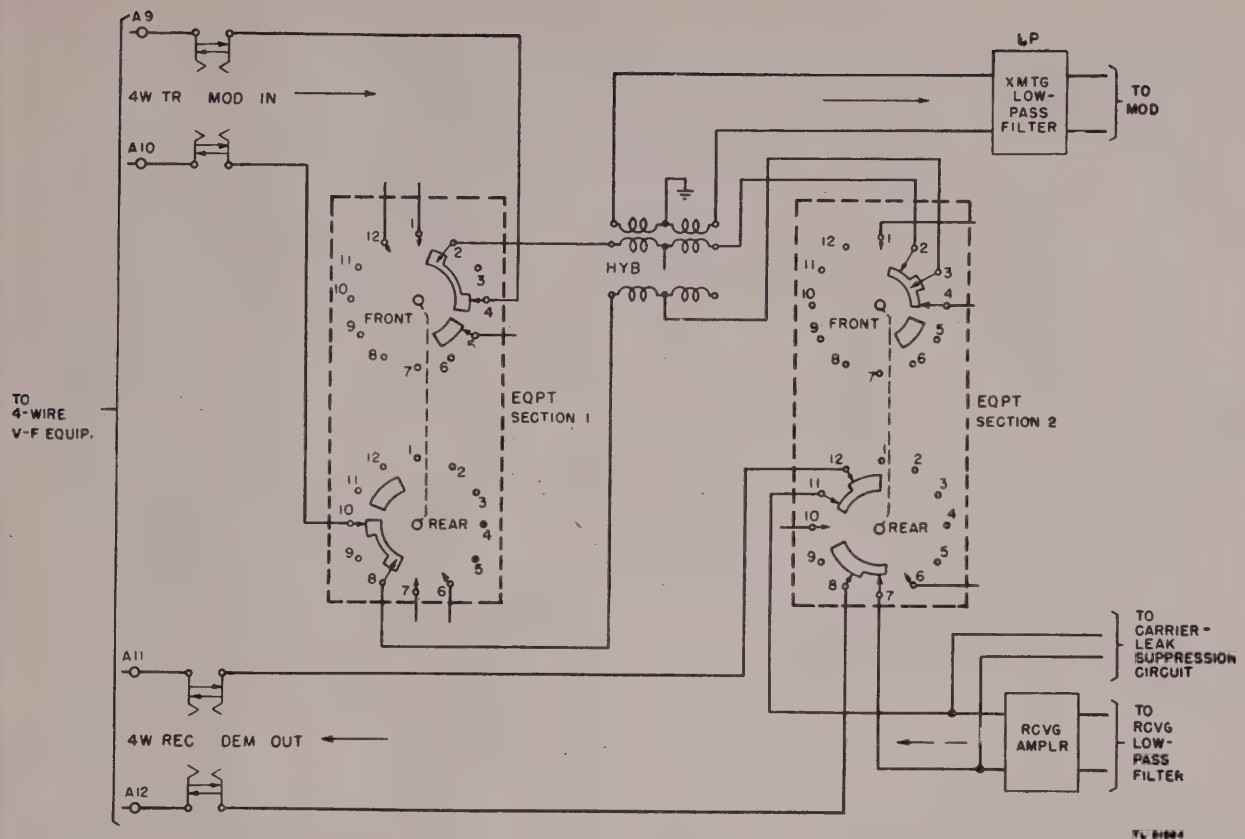


Figure 85. Switch EQPT in 4W TLG position.

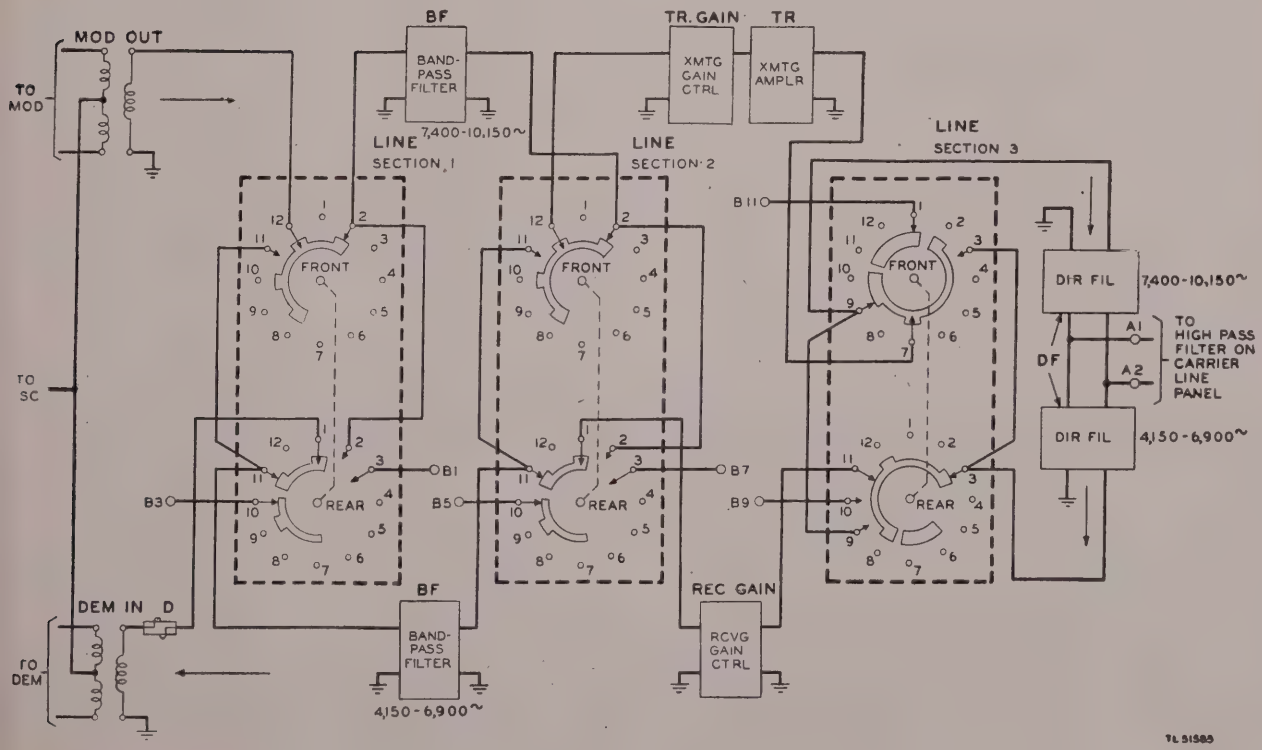


Figure 86. Switch LINE in WIRE EAST position.

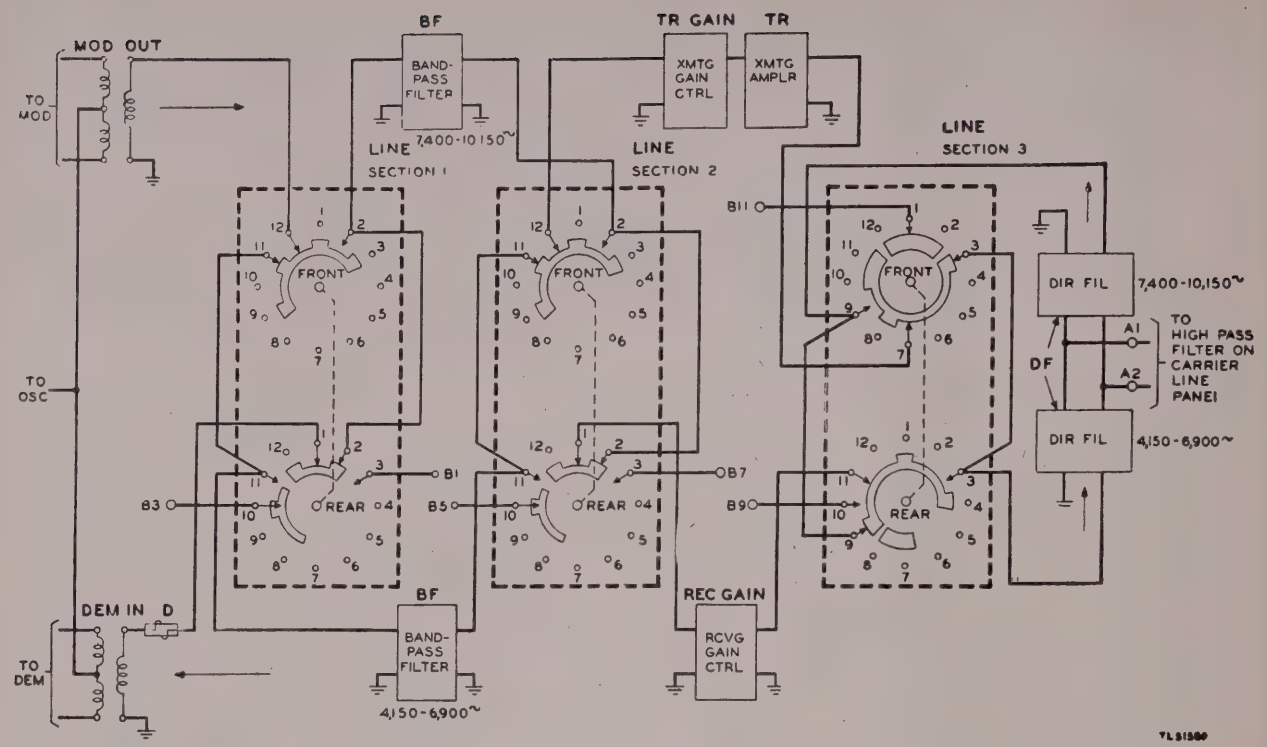


Figure 87. Switch LINE in WIRE WEST position.

upper terminal is in position RADIO TRANS and switch LINE of the lower terminal is in position RADIO REC. Schematically, the circuit is as shown in figure 8. Note that the transmitting paths of both terminals are connected to filter DF of terminal 1 and that the receiving paths are connected to filter DF of terminal 2. Note also that controls TR GAIN and REC GAIN and the sections of filter BF have been rearranged.

88. Functioning of Type H Carrier Repeater (fig. 89)

West-to-East transmission, using the 4,150- to 6,900-cycle side band, enters the repeater through the W LINE FILT and W DIR FILT LINE jacks and passes through the 4,150- to 6,900-cycle unit of directional filter W DF. From the filter the side-band frequencies pass through control W-E GAIN, to and through the W-E amplifying circuit, and through the 4,150- to 6,900-cycle unit of directional filter E DF. From filter E DF the side band passes through jacks E DIR FILT LINE and E LINE FILT to the high-pass unit of the carrier line filter and out to the East line. East-to-West transmission, using the 7,400- to 10,150-cycle side band, follows a similar path through the repeater, the transmitted side band being selected by the 7,400- to 10,150-cycle units of directional filters E DF and W DF and passing through control E-W GAIN and the E-W amplifying circuit to the West line.

a. Directional Filters. The two filter units in each direction of transmission are arranged to provide maximum attenuation to circulating singing currents with minimum distortion to the desired transmitted side bands. The two filter units associated with each directional filter are inclosed in metal containers designated E DF and W DF respectively. The directional filter for the East side is the same as the directional filter used in the terminal panel; figure 80 shows simplified schematic diagrams and transmission characteristics for the E DF filter units. Figure 90 shows simplified schematic diagrams and transmission characteristics for units of the slightly different directional filter used on the West side of the repeater.

b. Gain Controls. Controls W-E GAIN and E-W GAIN are the same as the TR GAIN and REC GAIN controls described in paragraphs 79 and 80. The repeater gain controls are adjusted by knobs on the front panel designated W-E GAIN and E-W GAIN.

c. Amplifiers. E-W and W-E amplifier circuits are the same as the transmitting amplifier circuit used in the terminal. The circuit is described in paragraph 79*e*.

d. Power Supply (fig. 91). The circuit which supplies power to the tubes is the same as that used in the carrier terminal (par. 82), with the following exceptions:

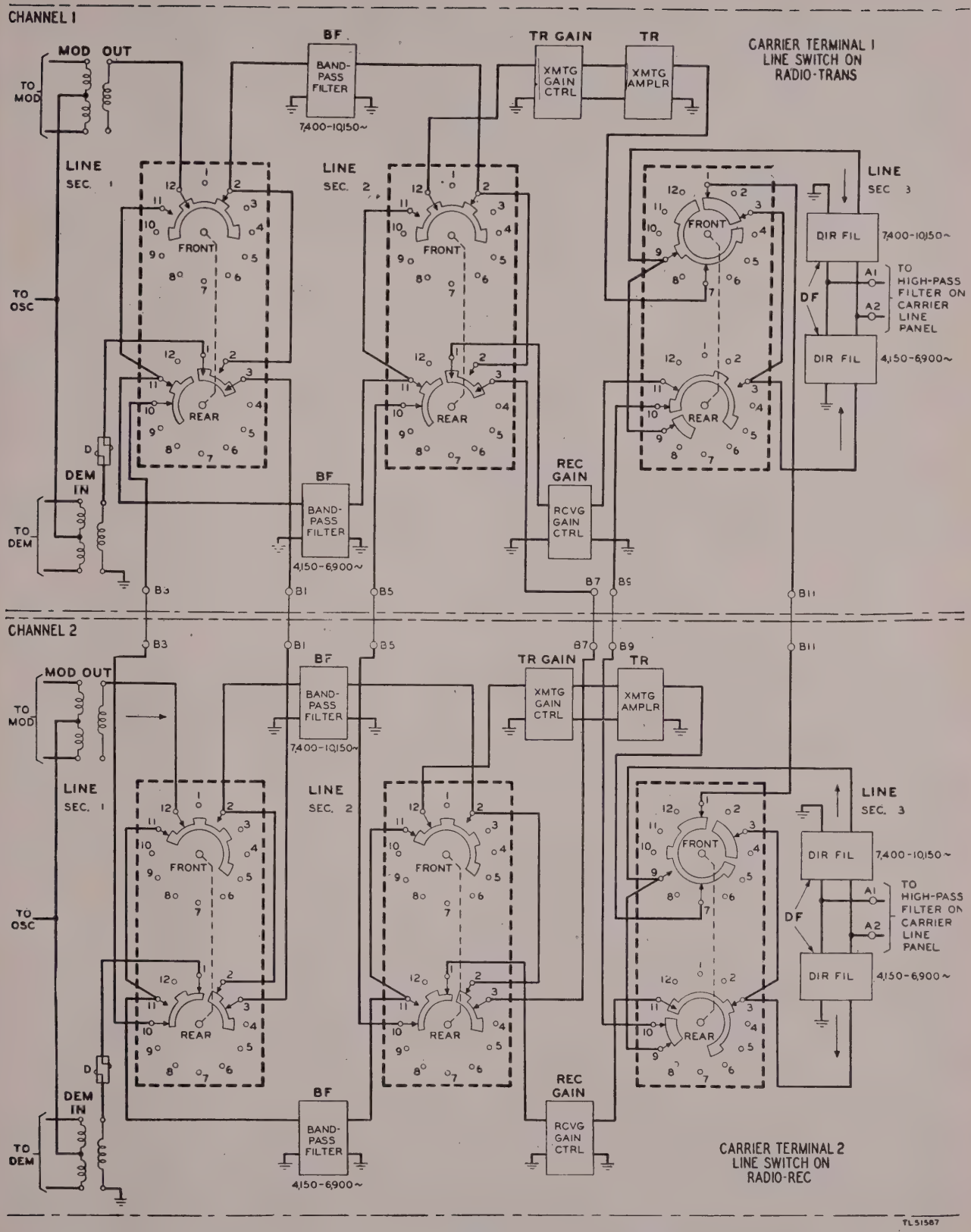


Figure 88. Switches LINE in RADIO TRANS and RADIO REC positions.

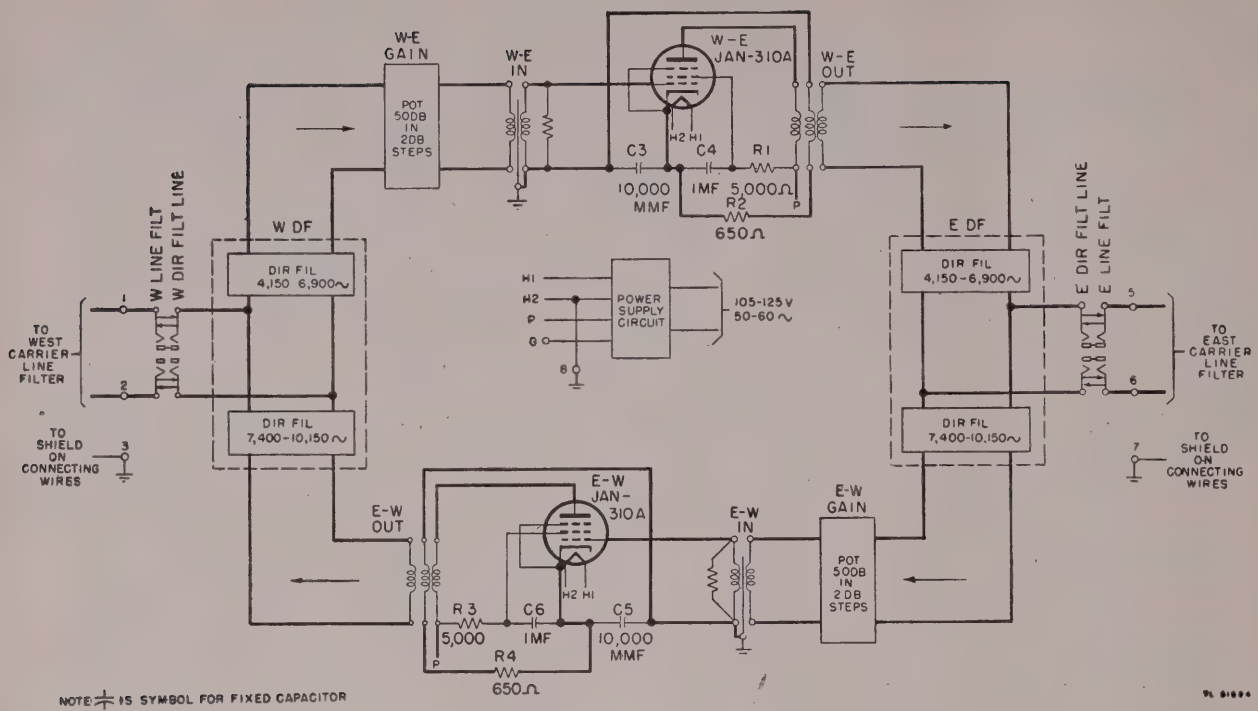


Figure 89. Type H carrier repeater circuit, simplified schematic diagram.

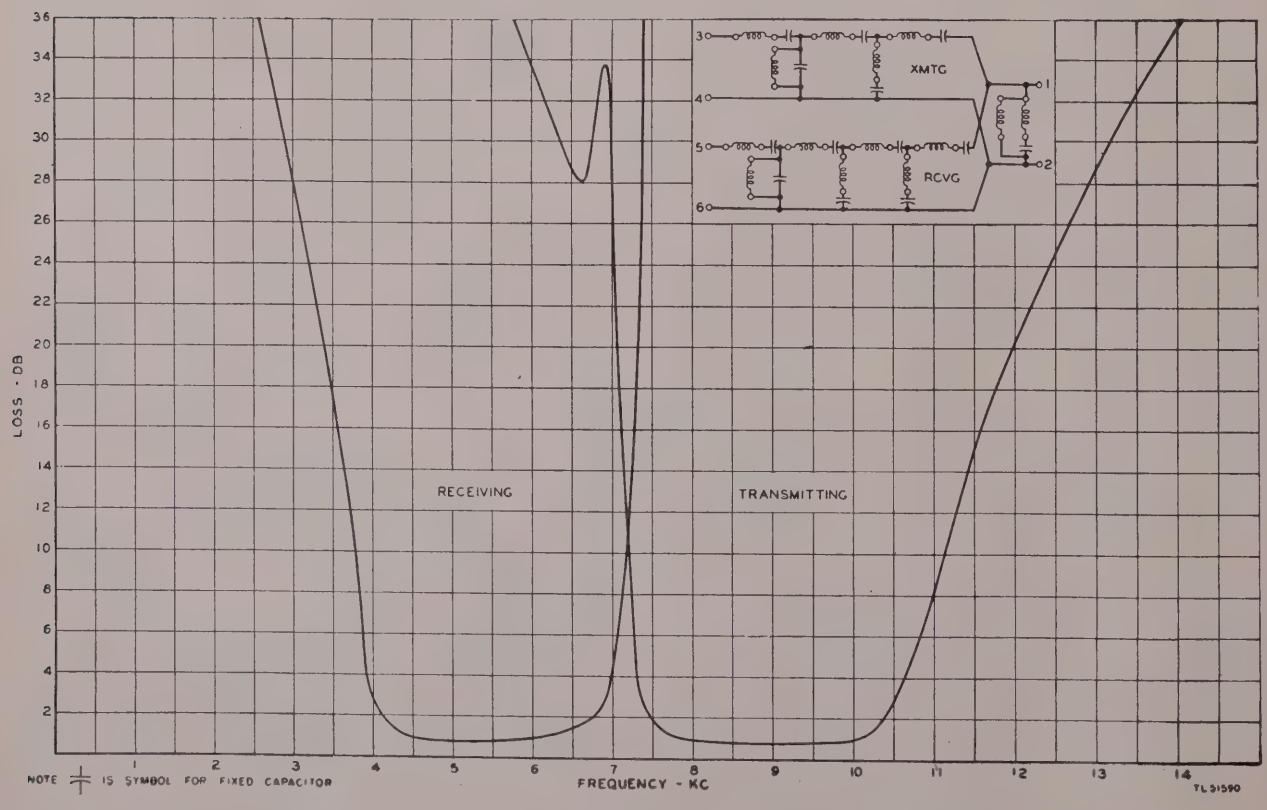


Figure 90. Transmission characteristics of directional filter W DF.

(1) Resistor R6 is connected in series with the winding of the secondary which supplies power to the heaters of the tubes. In the terminal the heaters of three tubes are supplied by this winding of the secondary, whereas in the repeater only two heaters are connected to this winding. Resistor R6 is included in the heater power circuit to compensate for the reduced load.

(2) The resistor coded R11 in the terminal is coded R5 in the repeater; capacitors coded C9 and C8 for the terminal are coded C1 and C2, respectively, for the repeater.

89. Repeater Transmission Performance

a. GAINS. (1) *Maximum gain.* The repeater will provide a maximum gain of approximately 29 db in either direction of transmission for carrier sideband frequencies equivalent to the 1,000-cycle point in the voice-frequency band. This 29-db gain results from an amplifier gain of approximately 32 db less about 3-db loss across the directional filters.

(2) *Usable gain.* The loop gain for a repeater is limited to 45 db and thus the maximum repeater gain of approximately 29 db cannot be utilized in both directions of transmission at the same time. The sum of the gains in the two directions must be held to 45 db to meet singing margin requirements.

(3) *Gain-frequency characteristics.* Figure 92 shows representative gain-frequency characteristics for both directions of transmission. These gains are for a repeater adjusted to a loop gain of 30 db, with 15-db gain in each direction of transmission. As the loop gain is increased the transmission-frequency characteristics may be expected to become somewhat less uniform.

b. IMPEDANCES. The carrier-frequency impedances looking into the repeater from either direction are approximately 600 ohms, matching the high-pass unit of the carrier line filter.

90. Functioning of Type H Carrier Line Panel Equipment

The low- and high-pass filters and voice-frequency repeater and phantom balancing equipment required for use with the carrier terminal and repeater panels are contained on the carrier line panel. One carrier

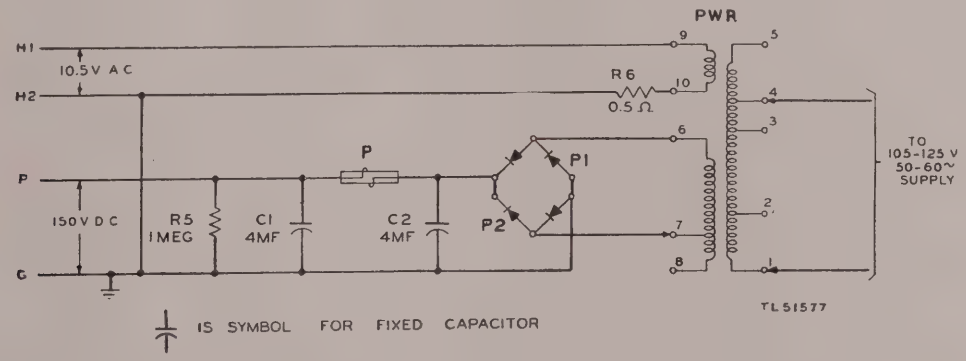


Figure 91. Repeater power supply circuit.

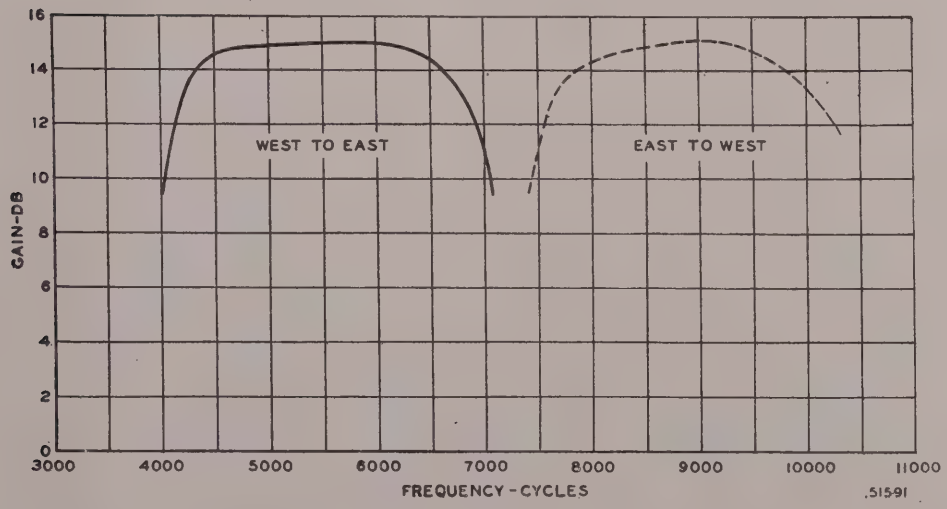
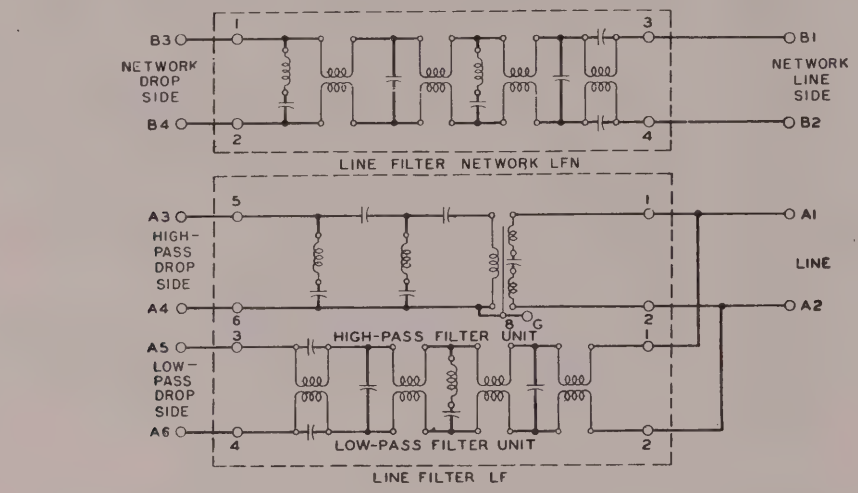


Figure 92. Repeater gain-frequency characteristics.

line panel is required with a terminal panel and two with a repeater panel. Two panels are required to form a carrier transfer or bypass set.

a. Carrier Line Filter. The carrier line filter consists of three units: a low-pass filter, a high-pass filter, and a line filter network. Each of these units is inclosed in a separate metal container and all three are assembled on a common base.

(1) *Low- and high-pass filters* (fig. 93). The low- and high-pass filter units, which together form the line filter and are designated LF, provide frequency separation between the voice-frequency circuit and the carrier-frequency circuit operating over the same pair. The high-pass filter unit is balanced on the line side but unbalanced on the drop side. The low-pass filter unit is balanced in both directions. As viewed from the line side, the low- and high-pass filter units in parallel have a nominal impedance of



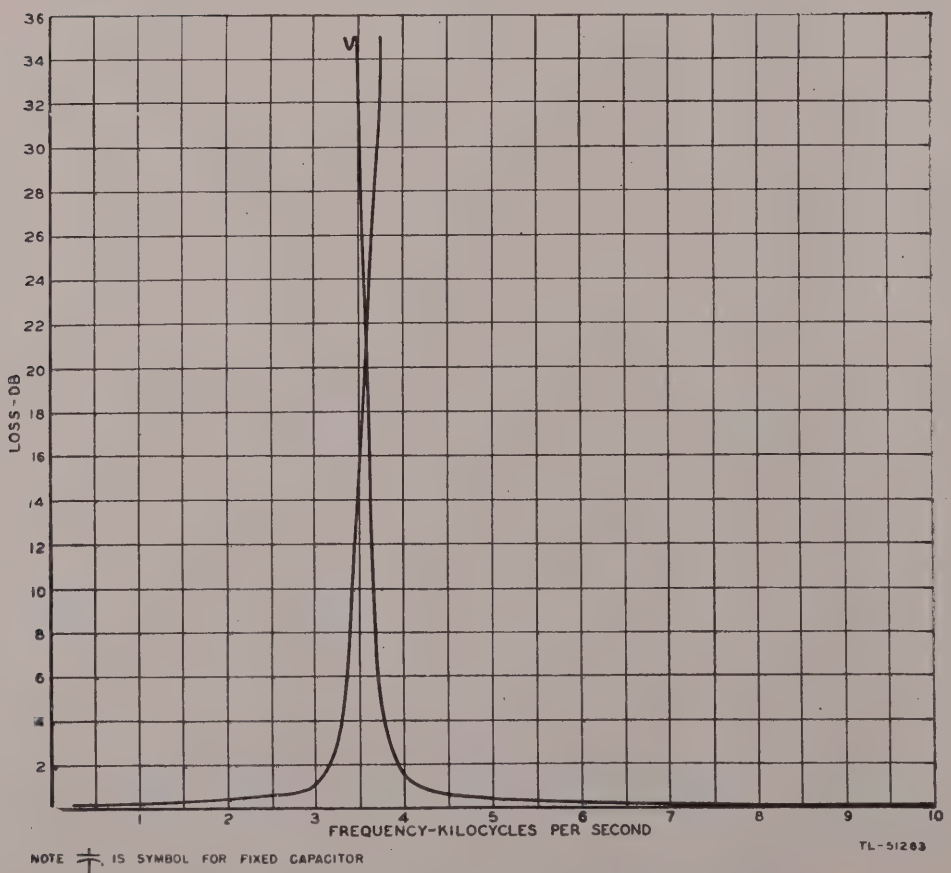


Figure 93. Transmission characteristics of line filter LF.

690 ohms at voice frequencies and 600 ohms at type H carrier frequencies. The nominal impedance looking into the drop side of the low-pass filter unit is about 690 ohms and looking into the drop side of the high-pass filter unit about 600 ohms. In the following subparagraphs the balance between the nominal impedance and the actual impedance for a specific frequency range is expressed as a loss across a hybrid coil.

(a) With the high-pass drop side terminated in 600 ohms and the low-pass drop side terminated in 690 ohms, the balance between the nominal impedance of 690 ohms and the actual impedance looking into the line side of the line filter at frequencies between 300 and 2,500 cycles should be not less than 10 db.

(b) With the line side terminated in 690 ohms and the high-pass drop side terminated in 600 ohms, the balance between the nominal impedance of 690 ohms and the actual impedance looking into the low-pass drop terminals of the low-pass unit of the filter at frequencies between 300 and 2,500 cycles should be not less than 18 db.

(c) Looking toward the terminal from the open-wire line the impedance at carrier frequencies is about 600 ohms when control REC GAIN is set for 0-db loss. This impedance is fairly uniform over the two transmission bands.

(2) *Line filter network.* Line filter network LFN balances the low- and high-pass filter units and is connected in the balancing network circuit of a voice-frequency repeater when the repeater is used on an open-wire pair with a type H carrier system. With the LFN network, which is connected on the network side of the repeater hybrid, terminated in 690 ohms on the drop side, and the line filter terminated in 690 ohms on the line side (fig. 94), the balance between the line filter and the line filter net-

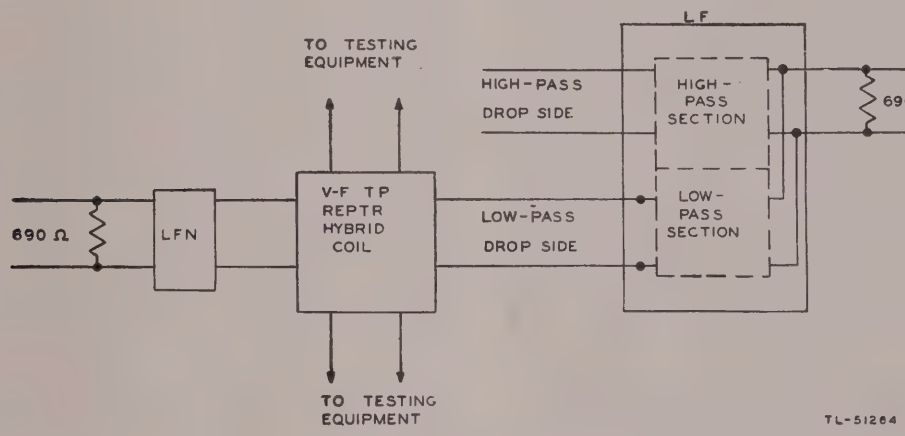


Figure 94. Measurement of balance between LF and LFN.

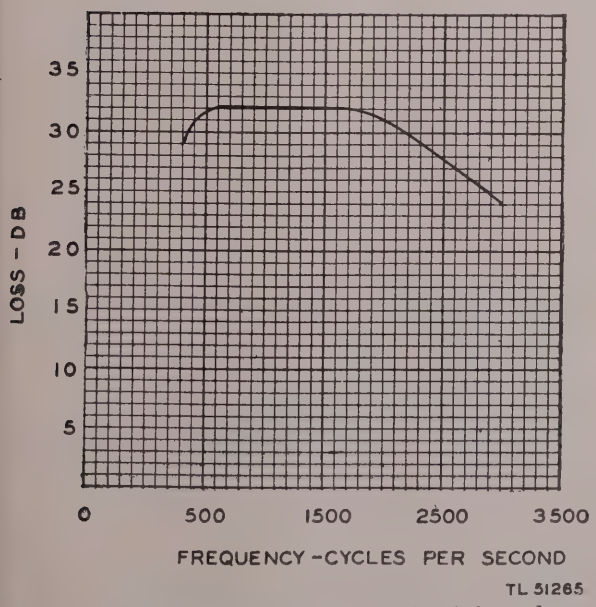


Figure 95. Loss-frequency curve showing balance between LF and LFN when connected to hybrid coil.

work, expressed in terms of loss across the hybrid, should be as follows:

(a) At frequencies between 500 and 1,700 cycles the loss across the hybrid should be at least 32 db.

(b) At 300 cycles the loss should be at least 29 db.

(c) At 3,000 cycles the loss should be at least 24 db.

(d) Figure 95 is a graph showing the loss across the hybrid coil in figure 94 as a function of frequency.

(3) *Frequency characteristics.* The carrier line filter and the line filter network are shown schematically in figure 93, which also shows representative loss-frequency characteristics of the low- and high-pass filter units. The low-pass unit passes voice frequencies up to about 3,000 cycles and suppresses the carrier frequencies. The high-pass unit passes frequencies above about 3,800 cycles and suppresses voice frequencies. There will be some attenuation variation between line filter units, but the variation

usually will be at the frequencies adjacent to the cut-off frequencies rather than in the bands passed. Slight changes in attenuation also may appear with temperature changes.

(4) *Losses.* The low-pass filter unit introduces a slight loss into the voice-frequency circuit, generally about 0.2 db at 1,000 cycles. The loss to the phantom circuit from the low-pass filter unit will be about 0.15 db.

(5) *Lightning protection.* The line filter is designed to withstand momentary peak voltages of 1,000 volts. However, to provide additional protection against lightning surges both to the line filter and to the directional filters contained on the terminal and repeater panels, a varistor is connected across the drop side of the high-pass filter unit. This varistor consists of a thyrite disk so proportioned as to present a high shunt resistance to tolerable voltages and a low shunt resistance to excessive voltages. It is assembled on a small metal bracket which is mounted on one of the filter mounting studs. This unit does not take the place of the conventional office protector, but merely adds to the lightning protection.

b. Balancing Equipment Used for Phantom Operation. The line panel contains three balancing units for use in phantom operation: a line filter balance unit designated LFB, a line filter balancing network designated LF BN, and a line filter balancing network designated PH LF BN for use on the phantom circuit. An application of these units to a phantom circuit is shown in figure 14.

(1) *Line filter balancing unit LFB. (a) Description.* The insertion of a line filter in one side circuit of a phantom group requires that similar impedance be added to the other side circuit of the group to keep the phantom telephone circuit balanced. Line filter balancing unit LFB is used for this purpose. The balance between low- and high-pass filter units and the line filter balancing unit is such that existing noise on the phantom circuit will not be increased appreciably by the insertion of these units on opposite sides of a phantom group. The line filter balancing unit consists of a retardation coil and two resistors, and the unit is housed in a metal container mounted separately on the panel.

Note. If both side circuits of a phantom group were equipped with type H carrier line filters the line filter balancing unit would not be used. However, the LFB unit must be used if different types of carrier systems are used on the two side circuits of a phantom group.

(b) Losses. At 1,000 cycles the line filter balancing unit introduces a loss of about 0.2 db into the voice-frequency circuit and a loss of about 0.15 db into the phantom circuit.

(2) *Line filter balancing network LF BN.* When a voice-frequency repeater is used on a physical circuit equipped with line filter balancing unit LFB, a resistor, designated LF BN, is required in the network of the repeater to balance line filter balancing unit LFB. The balance between LFB and LF BN is at least as good as that provided between the low- and high-pass filters and their balancing network LFN. Resistor LF BN is mounted separately on the carrier line panel.

(3) *Phantom line filter balancing network PH LF BN.* The resistor designated PH LF BN is connected in the network of the voice-frequency repeater on the phantom circuit to balance line filter LF and line filter balancing unit LFB in the side circuits of the phantom group. The balance between PH LF BN and the LF and LFB units which it balances is at least as good as that provided between the low- and high-pass filters and their balancing network LFN. Resistor PH LF BN is mounted separately on the carrier line panel.

Section XV. TROUBLE LOCATION

91. Technique of Trouble Location

a. Scope. This section of the manual covers trouble localization on an H carrier system terminated on a two- or four-wire basis, operated over either wire or radio link. For wire operation, an H system consisting of two terminals and a repeater is assumed. If the H carrier system is used in tandem with other carrier or voice-frequency systems, reference should be made to TM 11-2022 for procedures to localize the trouble in a particular system.

b. Organization. Table XIII lists the trouble tests which are covered in this manual.

(1) *Preliminary procedures.* These procedures outline the course of action on the receipt of a trouble report. All available data are first assembled and an analysis is made. The extension circuits are next checked. This procedure is designed to localize the trouble either in the H carrier system or in some external circuit.

(2) *Systems trouble tests.* These tests cover a check of the extensions of the H carrier system, fol-

lowed by a check of the system line-up or of the system condition, depending upon the type of trouble reported.

(3) *Panel trouble tests.* These tests cover trouble localization procedures on the terminal, repeater, and line panel. A quick method is given for checking the gain in each direction of transmission, followed by a suggested procedure for isolating the trouble in a particular circuit or part.

(4) *Apparatus trouble tests.* These tests cover trouble location procedures on the individual parts of the type H carrier panels. Detailed testing procedures are given wherever possible, and suggested procedures are included where detailed tests are not practicable.

Table XIII. Trouble tests

	Wire	Radio
	Paragraphs	*Paragraphs*
1. Preliminary.		
a. General procedure	94*a*	94*a*
b. Two-wire extensions and terminations	94*b*	94*b*
c. Four-wire extensions and terminations	94*c*	94*c*
2. System.		
a. Failure	95	96
b. Poor transmission	97*a*	97*b*
c. Singing tests	98	98*a*
3. Panels.		
a. Terminal	99	100
b. Repeater	101	—
c. Line	102	102
4. Components.		
a. Power supply	103	103
b. Amplifier	104	104
c. Oscillator	105	105
d. Filters	106	106
e. Potentiometers, switches, and jacks	107	107

c. Trouble Reports. Trouble on the H carrier system will be reported by either using or operating personnel during normal system operation, or by maintenance personnel in the performance of initial or periodic tests.

(1) *Troubles reported by using or operating personnel.* Trouble reports from this source sometimes may be vague or incomplete. While receiving the report the repairman should secure sufficient information to indicate a trouble such as one of the following:

Failure to ring distant end.
Failure to hear distant end after receiving ring.
Inability to talk to distant end although distant end can be heard.
Line is distant, although talking is possible.
Line is noisy.
Excessive crosstalk on circuit.
Quality of transmission is poor.
Circuit is singing.

Upon receipt of a trouble report, the repairman will verify the report by talking, listening, and ringing on the circuit. Note any further symptoms which will indicate trouble in a particular piece of equipment, such as the ringer, etc.

(2) *Troubles detected by performance of periodic tests.* In many cases performance of periodic tests and adjustments will correct minor troubles on the H carrier system such as an incorrect circuit net loss, poor synchronization, etc. If trouble is indicated by any test, the corrective procedures given in this section will be followed.

d. Trouble Analysis. Analysis of the trouble report and all other symptoms which may be noted will indicate the trouble as one of three types: system failures or abnormal speech levels; noise and crosstalk, which includes power hum, static, unintelligible interference, etc., and poor speech quality or singing, which also includes echo, hollowness and distortion.

e. Trouble Location. Wherever possible, detailed tests are given to aid in trouble location. However, in some cases detailed tests would be too involved to be of any value and in these cases general tests have been prescribed. The skill of the repairman will be a controlling factor in the length of time necessary to locate and clear a trouble. If the repairman is not familiar with methods of testing the equipment, trouble may have to be cleared by substituting parts known to be good. This procedure requires much time and numerous replacement parts must be available. The repairman who is familiar with the equipment may develop short-cut methods involving tone tracing and continuity testing which will immediately isolate the trouble in one piece of apparatus.

92. Test Equipment

A variety of testing equipment is necessary for the installation, operation, maintenance, and repair of the carrier panels. This equipment is usually available at a voice-frequency telephone repeater or C carrier installation. All of the testing equipment required for trouble location work is listed in table XIV. Equipments equivalent to those listed may be used.

Table XIV. Test equipment

Nomenclature	Signal Corps stock No.	Mfr's No.	Description	Usage
Audio Oscillator TS-379/U.	3F3570-1	WECo 19C (SPL).	Oscillator.	Supply testing power.
Multimeter TS-380/U.	3F7127	WECo D-166852.	Volt-ohm-milliammeter.	Electrical measurements.
Decibel Meter TS-399/U.	3F4270-2	WECo 13A (SPL).	Transmission measuring set	Measure test power.
Tube Tester I-171.	3F5681	Hickok Model 560 (SPL).	Tube tester.	Test vacuum tubes.
Attenuator TS-402/U.	3F1775	WECo 5A (SPL).	Attenuator.	Insert loss.
Test Set TS-190/U.	3F4316.1	WECo 67B (SPL).	Test receiver.	Continuity tests.
			Magneto telephone or handset.	Listening and talking.
	4C7317D.1	WECo 217D.	600-ohm terminating plug.	Terminating.
			Patching cords.	Making interconnections.

93. Use of Diagrams and Charts

a. Drawings. The drawings furnished with the H carrier panels are helpful in shooting trouble, in tracing wiring, and in rewiring apparatus which has been replaced. Two copies of each schematic and wiring diagram listed below are furnished with the equipment and are reproduced in the rear of this manual. If this equipment is installed in an apparatus cabinet, reference may be made to the power service circuit schematic and wiring diagrams furnished with the cabinet.

Table XV. Drawings furnished with equipment

Equipment	Schematic	Wiring
Carrier terminal panel	B-400044-1	B-400044-2
Carrier repeater panel	B-400045-1	B-400045-2
Carrier line panel	B-400046-1	B-400046-2

b. Schematic Diagrams. (1) Schematic diagrams generally may be classified as circuit schematics and application schematics. Use the circuit schematics generally when locating trouble in the equipment, as they show each circuit completely and include the designations and pertinent characteristics of each piece of apparatus. An application schematic drawing shows the arrangement of the circuits which form a complete unit. Assignments of terminal strip terminals on panels, together with the external wiring connections, are shown.

(2) All of the type H carrier drawings are in the B letter series. These drawings have six digit serial numbers. The schematic drawings are identified by –1 after the serial number. When more than one sheet is required to show a circuit, this is indicated on each sheet as 2 sheets, sheet 1; or 2 sheets, sheet 2.

c. Wiring Drawings. (1) Wiring drawings are generally associated with schematic drawings. They show, in a semipictorial manner, the wiring arrangements as viewed from the wiring side (rear) of the panel. The wiring symbols used are explained in notes on the drawing. The size of wire, color codes, cabling, and the connections between the terminals of each piece of apparatus forming a circuit are shown. Use wiring drawings primarily for trouble location work when it is necessary to check the wiring. For the type H equipment the wiring drawings are also assigned in the B letter series. Each drawing bears a serial number corresponding to the associated schematic drawing. The first sheet of a wiring drawing is suffixed -2, the second -3, etc.

(2) Wiring drawings covering the H equipment use the so-called "airline" system of showing connections. In the airline system, each individual piece of apparatus, or each group in some cases, is

numbered, and the lines representing the individual wires from each piece of apparatus are carried a short distance and terminated in a base line. These individual lines between the apparatus and base line are called feed lines. Each feed line is numbered to correspond with the identification number of the piece of apparatus at which the other end terminates. It is not necessary to follow a connection through the base line and no provision is made for doing so. By observing the color and identification number included with the feed line it is possible to trace directly between pieces of apparatus.

94. Preliminary Procedures

After a circuit utilizing an H carrier system has been reported in trouble, immediate performance of the preliminary procedures in this paragraph will serve two purposes: localization of trouble will be speeded by analysis of symptoms and conditions; the extensions will either be eliminated or indicated as the source of trouble. If the extensions are found to be free of trouble, turn to the proper paragraph following for directions on localizing the trouble within the H system.

a. General Steps. (1) Gather all possible information from the person reporting the trouble and also from circuit records, trouble records, etc. Data on how the trouble appeared, whether or not it appears intermittently, its presence in one or both directions of transmission, the condition of power and associated equipment, condition of other circuits on the same line, weather conditions, recent performance of the circuit, maintenance checks or repairs on the circuit, and other data, will all be of use to the repairman charged with locating and clearing the trouble.

(2) If the voice-frequency circuit on the same line has not been reported in trouble, check its performance by ringing, talking, and listening on it. The appearance of a trouble similar to that reported on the carrier circuit will locate the trouble in a line section or in some piece of equipment common to both circuits. Notify the operators or other using personnel to take the voice-frequency circuit out of service, and clear its trouble first. This may also clear the trouble on the H carrier system. It is advisable at this time to check other circuits on the same line or radio link system. External troubles, such as induction from a power line, or atmospheric disturbances, will eliminate the H carrier system as the primary source of trouble. If no trouble is found on any of the other systems, trouble probably exists in the H carrier system or its extensions and terminations.

(3) Analyze the assembled information concerning the trouble symptoms. If they indicate a trouble peculiar to one part of the system, many of the recommended tests may be eliminated. This analysis, if done properly, will save much time and labor. If the analysis shows that a line section, or equipment common to both the H and voice-frequency circuits, or equipment common to one direction of transmission, is in trouble, proceed to the proper paragraph following for localization tests. If the extensions of the H system are not eliminated by analysis, check their condition first.

Note. Check of the extensions, either two-wire or four-wire, should be made at both ends of the system at the same time.

b. Check of Two-wire Extensions and Terminations. (1) Insert 600-ohm plug in jacks 2W HYB. (This will isolate the extension from the rest of the system.)

(2) Establish contact with the switchboard or telephone at the end of the extension by connecting a magneto telephone to jacks DROP at the terminal.

(3) Check the extension for ringing from the switchboard, talk with the switchboard, and listen for the presence of noise and crosstalk.

(4) If no trouble is encountered proceed with the localization tests.

(5) If trouble is found in the extension, notify other installations and clear the trouble.

(6) When the trouble has been cleared, turn to paragraph 111 for instructions on returning the system to service.

c. Check of Four-wire Extensions. The check of a four-wire extension, used either for telephone or telegraph, can be made in several ways. Follow the general suggestions given below.

(1) Check one pair at a time, by first blocking off equipment connected at both ends of the extension. Insert 600-ohm plugs in the jacks of the equipments both ways from the extension under test.

(2) Test the pair by talking or by making transmission measurements between the output jacks of the connected equipments. Listen on the pair for noise or crosstalk.

(3) Repeat the tests on the other pair.

(4) If no trouble is encountered proceed with the localization tests.

(5) If trouble is localized in extension, notify other installations. Clear the trouble in any practicable manner.

(6) When the trouble has been cleared, turn to paragraph 111 for instructions on returning the system to service.

95. Procedure for Localization of System Failure, Wire Operation

This test covers the localization of trouble in a type H system, where no communication is possible in one or both directions between the two H terminals of the circuit, or where the voice levels are excessively high or low. The test is actually a check of system line-up, and the following test equipment is required at each terminal and repeater installation:

1 Audio Oscillator TS-379/U (not required at repeater).
1 Attenuator TS-402/U.
1 Decibel Meter TS-399/U.

The test will be performed after the extensions at each end of the system have been checked and found to be free of trouble. It will consist of checking input and output levels at each installation. Minor deviations from specified levels will be tolerated at intermediate points, as long as total deviation at the distant terminal is not greater than 4 db. Sharp deviations from specified levels will indicate trouble. Information on proper levels should be shown on the circuit record cards.

Note. All testing will be done under the direct supervision of the control terminal. If trouble is suspected in the receiving direction, viewing the system from the control terminal, make the test in this direction first.

a. Control Terminal Tests (fig. 96). (1) Patch the test oscillator to the 2W HYB or to MOD IN jacks depending upon the position of switch EQPT. Adjust the oscillator for 1,000 cycles at the output listed below:

Setting of switch EQPT	Patch to jacks	Output of oscillator
2W	2W HYB	0 dbm
4W TEL	MOD IN	+4 dbm

(2) Connect the OUT terminals of the attenuator to the input of the transmission measuring set. Set the attenuator for a loss equal to the level of the terminal output. (If specified output is +16, set attenuator to 16 db.) Patch the input of the attenuator to jacks DIR FILT LINE.

Requirement: Measuring set indicates 0 dbm.

(3) If the requirement is met, remove patch to jacks DIR FILT LINE, and instruct the repeater to proceed with the tests outlined in *b* above.

(4) If the requirement is not met, notify other installations that trouble has been localized, then proceed with terminal tests.

b. Repeater Tests (fig. 97). (1) Connect the output of the attenuator to the input of the transmission meauring set. Set the attenuator for a loss equal to the output level of the repeater in the direction of testing. When notified by the control terminal, patch the input of the attenuator to jacks DIR FILT LINE on the side away from the terminal sending the testing power.

Requirement: Measuring set indicates 0 dbm.

(2) If requirement is met, remove patch from jacks DIR FILT LINE and notify control terminal that no trouble has been found at repeater.

(3) If requirement is not met, remove the patch from the jacks DIR FILT LINE and patch the transmission measuring set directly to jacks LINE FILT on the side of the repeater toward the terminal sending the testing power.

(4) If an abnormally low power level is measured, trouble exists in connected equipment at the repeater or terminal installation (protectors, composite set, carrier line panel, etc.) or in the preceding line section. Remove the patch to jacks LINE FILT and notify the control terminal that trouble exists between the repeater panel and the terminal sending testing power.

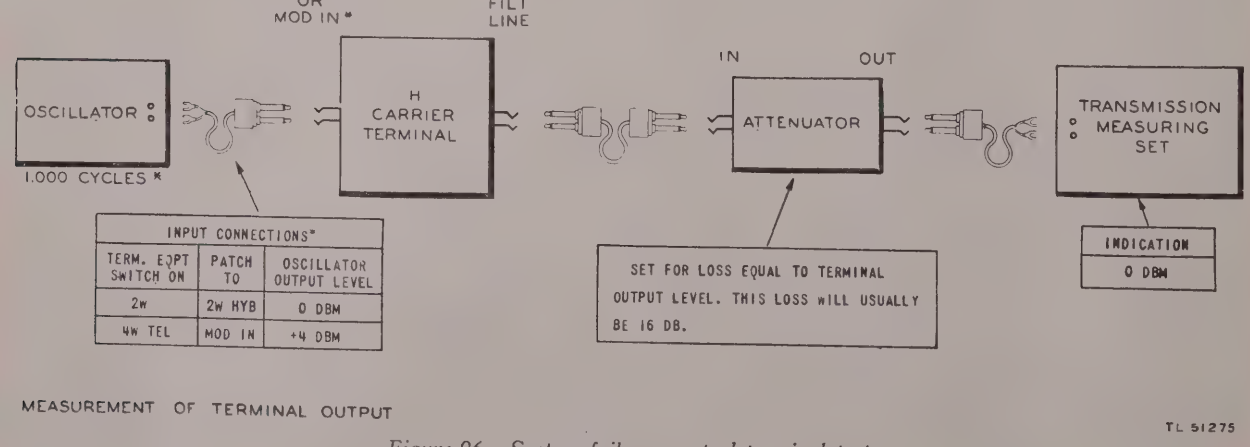


Figure 96. System failure, control terminal test.

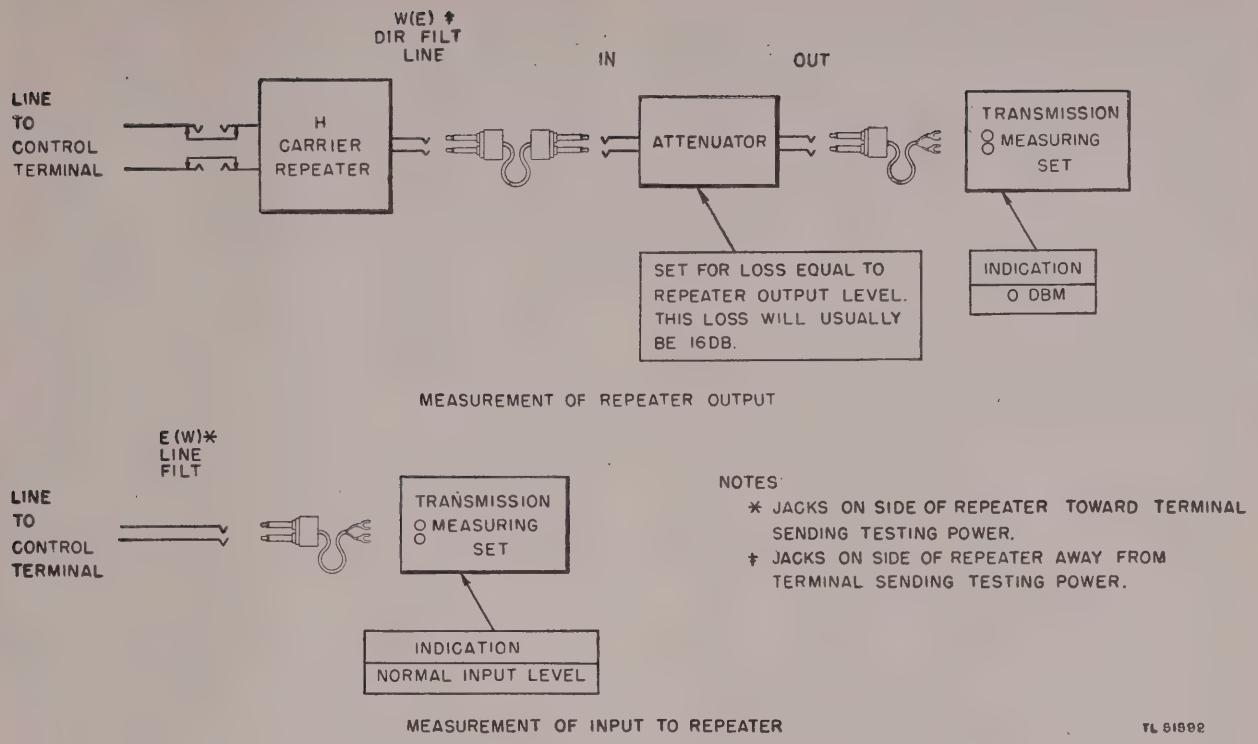


Figure 97. System failure, repeater tests.

(5) If a normal power level is measured, trouble exists in the H carrier repeater panel. Remove the patch to jacks LINE FILT and notify the control terminal that trouble exists in the repeater. Proceed with repeater tests.

c. Distant Terminal Tests (fig. 98). (1) When notified by the control terminal, patch the transmission measuring set to jacks 2W HYB or DEM OUT, depending upon the setting of switch EQPT. The output level should be as follows:

Setting of switch EQPT	Patch to jacks	Indication of transmission measuring set
2W 4W TEL	2W HYB DEM OUT	Specified ckt net loss +4 dbm

(2) If requirement is met, remove the patch and notify the control terminal that the test has been completed. The above tests are then made in the opposite direction.

(3) If requirement is not met, remove the patch from the terminal, and patch the transmission measuring set to jacks LINE FILT.

(4) If an abnormally low power level is measured, trouble exists in connected equipment at the receiving terminal or at the previous repeater installation (protectors, composite set, carrier line panel, etc.) or in the preceding line section. Remove the patch to jacks LINE FILT and notify the control terminal that trouble exists between the previous repeater panel and the receiving terminal panel.

(5) If a normal power level is measured, trouble exists in the receiving terminal panel. Remove the patch to jacks LINE FILT, and notify the control terminal that trouble exists in the receiving terminal panel. Proceed with terminal tests.

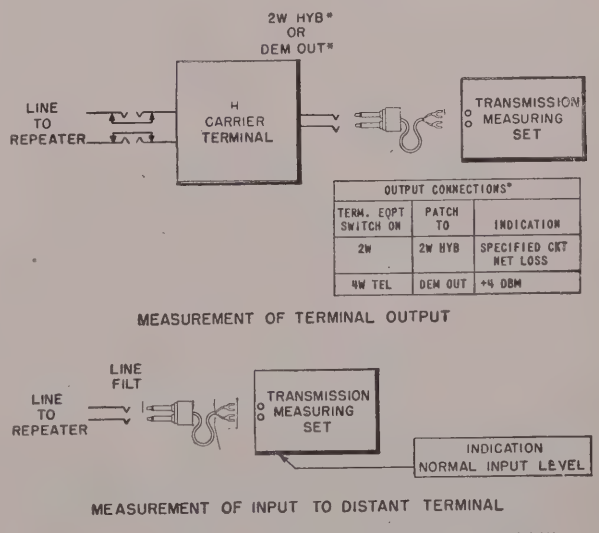


Figure 98. System failure, distant terminal tests.

d. Test of System in Opposite Direction of Transmission. (1) If the preceding tests are completed and the trouble is not located, the opposite direction of transmission must be tested in the same manner. In this case the distant terminal takes over the functions of the control terminal and sends testing power to the line.

(2) If this test is completed and trouble is not located, the trouble may be intermittent or may have cleared itself. Check the circuit again by listening, ringing, and talking, and if performance is satisfactory, return the circuit to service. However, keep a close check on the circuit for a few days to detect recurrence of the same trouble.

96. Procedure for Localization of System Failure, Radio Link Operation

If communication should fail on a circuit operating over a radio link section, failure of the two other circuits would indicate trouble in the radio link equipment or power supply. Before making any other tests on the H carrier system be certain that the radio apparatus is operating satisfactorily in both directions. If trouble appears to be in the H carrier equipment, a localization test similar to that described in the previous paragraph should be performed. Proper testing levels for radio link operation should be substituted for those listed. These levels will be found on the circuit record cards. If the trouble is localized in either terminal, turn to paragraph 100 for directions on locating and clearing the trouble. Line troubles, if found, should be cleared according to directions in the applicable technical manual.

97. Procedure for Localization of Transmission Troubles

This paragraph covers the localization of noise, crosstalk, poor quality, singing, and other troubles on the H carrier system. Localization will be attempted first by successively terminating line sections and installations as described below. If this procedure is not successful in indicating the trouble, further tests are provided for troubles which may be caused by singing, near-singing, or poor synchronization.

a. Sectionalization Tests, Wire Operation. This test is performed under the direction of the control terminal. It is used to locate the source of crosstalk, noise, power hum, singing, and other troubles which appear on the circuit.

(1) *Control terminal tests. (a)* Set switch EQPT on 2W.

(b) Connect from jacks 2W HYB to Test Set TS-190/U or a magneto telephone.

(c) Insert 600-ohm plug in jacks DIR FILT LINE. Note any change in circuit condition. Remove plug.

(d) If trouble was heard with plug in jacks, source of trouble is the terminal. (See *c*(1) below.) If trouble disappears, notify repeater to begin repeater test.

(2) *Repeater test. (a)* While monitoring the circuit, the control terminal should direct the repeater to terminate the adjacent line section with 600 ohms in jacks LINE FILT toward the control terminal. Note any change in circuit condition. Instruct repeater to remove plug.

(b) If trouble was heard at control terminal with plug in jacks, its source is the connected equipment at the repeater or terminal installation (protectors, composite sets, line panels, etc.) or the line section. (See *c*(2) below.) If trouble disappears, continue with repeater test.

(c) While monitoring the circuit, the control terminal should direct the repeater to terminate the output to the distant terminal at jacks DIR FILT LINE with 600 ohms. Note any change in circuit condition. Instruct repeater to remove plug.

(d) If trouble was heard at control terminal with plug in jacks, its source is the repeater. (See *c*(1) below.) If trouble disappears, notify the distant terminal to begin distant terminal tests.

(3) *Distant terminal test. (a)* While monitoring the circuit, the control terminal should direct the distant terminal to terminate the line section with 600 ohms in jacks LINE FILT. Note any change in circuit condition. Instruct the distant terminal to remove plug.

(b) If trouble was heard with plug in jacks, its source is the connected equipment at the repeater or distant terminal installation (protectors, composite sets, line panels, etc.), or in the line section. (See *c*(2) below.) If trouble disappeared, its source is the distant terminal, since the distant extension has already been checked. (See *c*(1) below.)

b. Sectionalization Test—Radio Link Operation. If excessive noise or crosstalk exists on H channels operated over a radio link, it is advisable to check the radio link section of the system first. A majority of troubles encountered will be caused by lack of synchronization between the radio link terminals, or by atmospheric conditions. Once the radio link section of the system is eliminated as a source of trouble, the wire sections may be checked by a procedure similar to that given in subparagraph *a* above. It should be rembered that coordination between the channels of H carrier and voice-frequency carrier telegraph, if used, is extremely critical, and

much crosstalk and noise may exist between these channels.

c. Analysis of Possible Troubles. (1) *Terminal and repeater. (a) Noise and power hum.* These conditions may be caused by a defective vacuum tube or rectifier. If replacement of the vacuum tubes does not improve the particular condition, check the power supply (par. 103). Noise or power hum originating in the power supply will usually be cleared by replacement of a leaky capacitor or varistor. If trouble still persists after performance of the above checks, the trouble may originate in the amplifier. Check the wiring and circuit components of the amplifier (par. 104).

(b) Singing. If the terminal or repeater is singing, check to see that the gain controls are on their normal operating settings. If these settings are correct, singing may be caused by a defective feedback circuit in an amplifier, or a defective directional filter. Check these circuits according to directions in paragraphs 104 and 106. If all equipment is in satisfactory condition, see paragraph 98 to determine operating point which will eliminate singing.

(2) *Line section, line equipment, and line filter. (a) Noise and crosstalk:* These troubles may be caused by lack of coordination between various carrier systems on the same line. Check that the East-to-West direction of transmission of the system in trouble corresponds to the East-to-West direction of transmission of the other systems on the line. Coordinate the outputs of the various systems so that the power at any point on the line will be approximately the same for all systems. If ringing crosstalk or cross rings are detected, trouble may lie in the incorrect range setting of a voice-frequency ringer. When operating on radio link, if interference is detected between the H carrier channels and the voice-frequency channel, the trouble may be due to poor coordination of outputs on the three channels.

(b) Power noise, static, and other noise. Static caused by atmospheric or weather conditions will be observed on all lines of the telephone system at the same time. It is impossible to clear this type of trouble completely, but its effect may be reduced by keeping the output of each terminal and repeater as high as possible. Other types of static caused by faulty outside plant construction can be cleared by proper policing and maintenance of the line. Power hum may be caused by power exposures within an installation, but a more common source will be an outside power line running parallel to the carrier line. Its effect may be minimized in the same manner as that described for static. Single frequency tones of objectionable magnitude may be caused by singing in an adjacent circuit, by crosstalk paths into an adjacent circuit, or by voice-frequency telegraph or pilot currents in an adjacent circuit. Clearing these troubles is a matter of adjusting levels and remedying troubles which exist in the adjacent circuit. When operating an H system on radio link, some static and noise will be picked up on the radio channels.

d. Procedure for Clearing Poor Quality. (1) Poor quality of transmission over the system will usually indicate a lack of synchronization between the carrier oscillators at the two terminals. Perform the oscillator synchronization test and adjustment (par. 55) to check whether or not poor synchronization is the cause of poor quality. If it is not, perform the oscillator-frequency adjustment test (par. 110).

(2) Poor quality may result from a repeater which is singing. The singing frequency may be outside the audible range. Perform the singing point test of the repeater (par. 98) to determine its singing point. If the requirement of this test is met, and the operating loop gain of the repeater does not exceed 45 db, it is probable that this repeater is not the cause of the trouble.

(3) Poor quality may result if the system is not operated at a sufficiently high net loss. First check to see that the circuit is operating at its specified net loss. If the circuit net loss is correct, poor quality may be the result of a faulty directional filter, or poor balance between the compromise network and the two-wire extension. If the filter has been tested (par. 106) and found to be good, and the best possible balance has been obtained between the balancing network and the two-wire extension, perform the terminal singing margin test (par. 98) to determine the highest circuit net loss at which the system may be operated.

(4) Poor quality may indicate that the loss-frequency characteristic of the system does not meet the requirements specified in paragraph 56. This condition may be caused by a faulty line section, amplifier, or filter. The attenuation of the open-wire line should be measured for each line section, using frequencies between 3,000 and 11,000 cycles. If the line attenuation is correct at the testing frequencies, it can be plotted to form a curve which rises as the frequency is increased. Excessive humps or peaks in the curve of any line section will indicate that section to be the probable cause of trouble. If the attenuation requirements of the line are met in all line sections, check the amplifiers and filters at each

terminal and repeater as described in paragraphs 104 and 106.

98. Singing Tests

a. Terminal Singing Margin Test. An 8-db singing margin should be observed at the terminal to insure good quality of transmission, and also to prevent the system from singing if the circuit net loss should change appreciably with changes in weather conditions. If the terminal sings, it usually will do so at some frequency in the audible range. For this reason the singing margin test of the terminal may be performed with a telephone instead of a measuring set. The procedure for making the test is as follows:

(1) Terminate both ends of the circuit in telephone sets with the receivers off the hooks. In switchboard-terminated circuits connect the H carrier circuit to a local extension and remove the telephone receiver from its hook.

(2) Test first one terminal, then the other. Note the settings of the TR GAIN and REC GAIN controls in their normal operating conditions. Advance the REC GAIN control four steps (8 db). If no singing is heard, there is a sufficient singing margin. Return the REC GAIN control to its normal setting, and then test the other terminal in the same manner. If the circuit net loss is increased at one terminal to maintain an adequate singing margin, increase it by the same amount at the other terminal in order to keep the same circuit net loss in both directions.

(3) Note the reading of the control where singing appears, if singing is heard as the REC GAIN setting is advanced. Back the control off four steps (8 db) from this setting. The new setting will give the highest possible circuit net loss at which the system can be operated without reducing the singing margin. If a lower circuit net loss is desired with an 8 db singing margin still maintained, it can be achieved by improving the balance between the balancing network, and the two-wire extension. Do this by replacing it with a network which is designed to balance the type of extension used. If it is absolutely necessary to obtain a lower circuit net loss than is possible with the balance obtained, the singing margin may be slightly decreased. If this sacrifice is made, the quality of the circuit will be impaired, and it is liable to be unusable at times because of variations in line attenuation.

b. Repeater Singing-point Test. Singing will occur unless the losses in the repeater loop equal or exceed the gain of its amplifiers. The repeater singing point is found by advancing the settings of the repeater gain controls until singing takes place or maximum gain is reached. If singing takes place at too low a point, there is insufficient loss indicated across one or both of the directional filters.

(1) *Method.* The test is made by watching for an indication on a transmission measuring set of any singing currents which may appear in the repeater when the gain is increased by setting both gain controls near the maximum step. If the repeater does not sing, no appreciable reading should be obtained on the measuring set since no power is fed into the repeater. A slight reading may be ignored for the purposes of this test since such a reading may be due to noise in the repeater or measuring set. A singing condition is not always audible since the singing may occur above the voice-frequency range and, therefore, a measuring set is useful to detect the condition. A singing condition is indicated when an appreciable reading is obtained on the measuring set.

Caution: At the singing point, the increase in gain may be great enough to damage the measuring set unless an attenuator is used and the measuring set is adjusted to indicate maximum input.

(2) *Apparatus required:*

1 600-ohm plug.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
Patching cords.

(3) *Procedure. (a)* Insert a 600-ohm plug in jacks W DIR FILT LINE.

(b) Patch from jacks E DIR FILT LINE to the input jacks of the attenuator. Set the attenuator for 20 db loss.

(c) Connect from the output jacks of the attenuator to the input jacks of the measuring set. Adjust the measuring set to indicate maximum input.

(d) Note the setting of controls E-W and W-E GAIN, so that they may be returned to their working settings when the test is completed. Then set both gain controls on 40.

(e) Advance control E-W GAIN one step. Then, while watching the meter of the measuring set, increase the sensitivity of the measuring set one step at a time until an appreciable reading is obtained, or until maximum sensitivity is reached. If no reading is obtained, readjust the measuring set to indicate maximum input. Then advance control E-W GAIN another step, and repeat the measuring set procedure. Continue the above procedure until a reading is obtained, or step 50 is reached on control E-W GAIN. If no reading is obtained after completing the above procedure, leave the E-W GAIN control on step 50, and advance the W-E GAIN control one step at a time by following the same pro-

cedure until an appreciable reading is obtained. Add gain control settings at which singing began.

Caution: Always adjust the measuring set to indicate maximum input before advancing the repeater gain control another step.

(f) Interchange the 600-ohm plug and the measuring set. Repeat the test. Add the gain control settings at which singing began. Compare this sum with the sum previously obtained, and use the lower of the two as the sum of the gain control settings at which the repeater will sing.

Requirement: The sum of the gain control settings should equal at least 84 before the repeater begins to sing.

Note. If the requirements are not met, trouble exists in the amplifiers or directional filters. Check these components according to directions in paragraphs 104 and 106.

(g) Reset controls E-W GAIN and W-E GAIN on operating settings; remove patching cords and plugs and restore the circuit to normal.

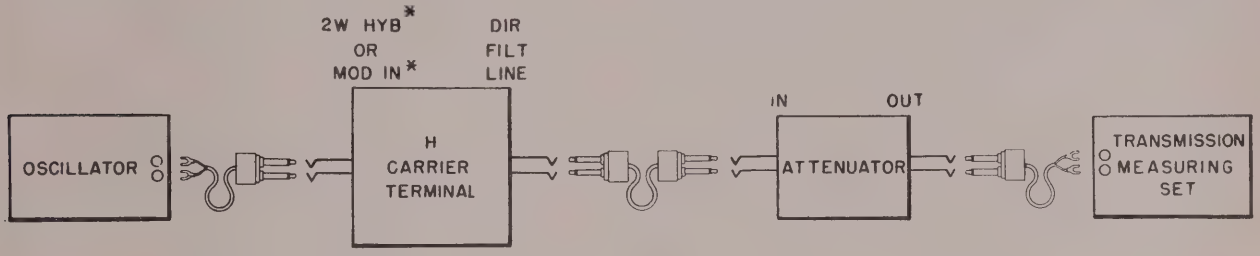
99. Trouble Test on Terminal Panel: Wire Operation

The following test equipment is required for localizing trouble on the terminal panel:

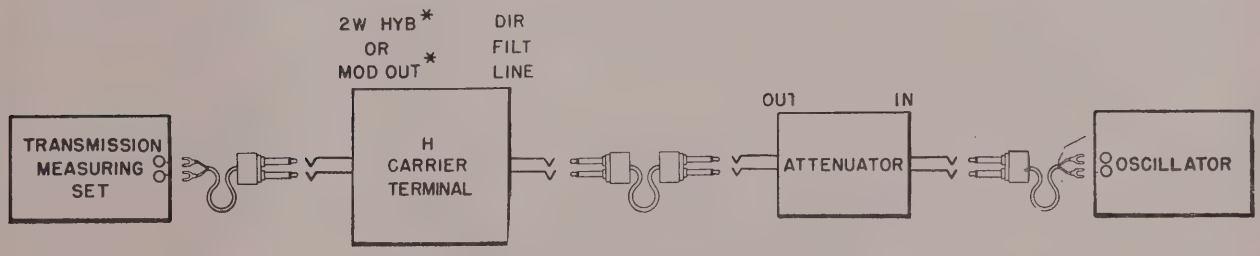
1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
1 Multimeter TS-380/U.
Patching cords.

a. Check of Transmitting and Receiving Circuits. When trouble is known to exist in either the transmitting or receiving circuit, make a test of the other direction of transmission to determine the condition of equipment common to both circuits. See figure 99 for arrangement of testing equipment. If this test definitely locates the trouble in only one circuit, proceed to *c* or *d* below.

(1) Note the settings of both gain controls, then set the control of the circuit being tested on 50, and the other control on 0.



TRANSMITTING CIRCUIT						
INPUT				OUTPUT		
					GAIN-DB	
EQPT SWITCH	JACKS*	POWER (DBM)	FREQ (CYCLES)	JACKS	EAST TERM.	WEST TERM.
2W	2W HYB	0	1,000	DIR FILT LINE	21.0	21 3
4W TEL	MOD IN	+4	1,000		16 0	16.3



RECEIVING CIRCUIT						
INPUT			OUTPUT			
					GAIN-DB	
DIR FILT LINE JACKS	POWER (DBM)	FREQ (CYCLES)	EQPT SWITCH	JACKS*	EAST TERM.	WEST TERM.
EAST TERM.	-20	6,000	2W	2W HYB	17.0	16.6
WEST TERM.	-20	8,000	4W TEL	DEM OUT	27.9	27.5

TL-50501-6

Figure 99. Terminal gain test.

(2) Adjust the frequency and input level of the oscillator as specified under INPUT. Patch this testing power to the proper jacks.

(3) Measure the output of the terminal at the jacks specified under OUTPUT.

Requirement: The measured gain will be within ±3.5 db of the specified gain.

(4) Remove the patching cords and restore the gain controls to their normal settings.

(5) If the requirements are not met for both directions of transmission, trouble is indicated in equipment common to both circuits. Proceed to *b* below.

(6) If the requirements are met in one direction of transmission and not in the other, proceed to *c* or *d* below for tests of the circuit which is in trouble.

b. Trouble in Both Transmitting and Receiving Circuits. (1) Check power supply voltages (fig. 100). If output voltages do not meet requirements, see paragraph 103. If voltages meet requirements, proceed with (2).

(2) Check the oscillator output (par. 48). If requirements are not met, see paragraph 105. If requirements are met, proceed with (3).

(3) Check the wiring, connections, and the remaining common equipment, consisting of jacks, switches, directional filter, and hybrid coil.

(4) If these tests do not disclose the trouble, perform tests described in *c* and *d* below. Tests should be performed both for the transmitting and receiving circuits since there may be trouble in both circuits.

c. Trouble in Transmitting Circuit. (1) Replace vacuum tube TR and check circuit.

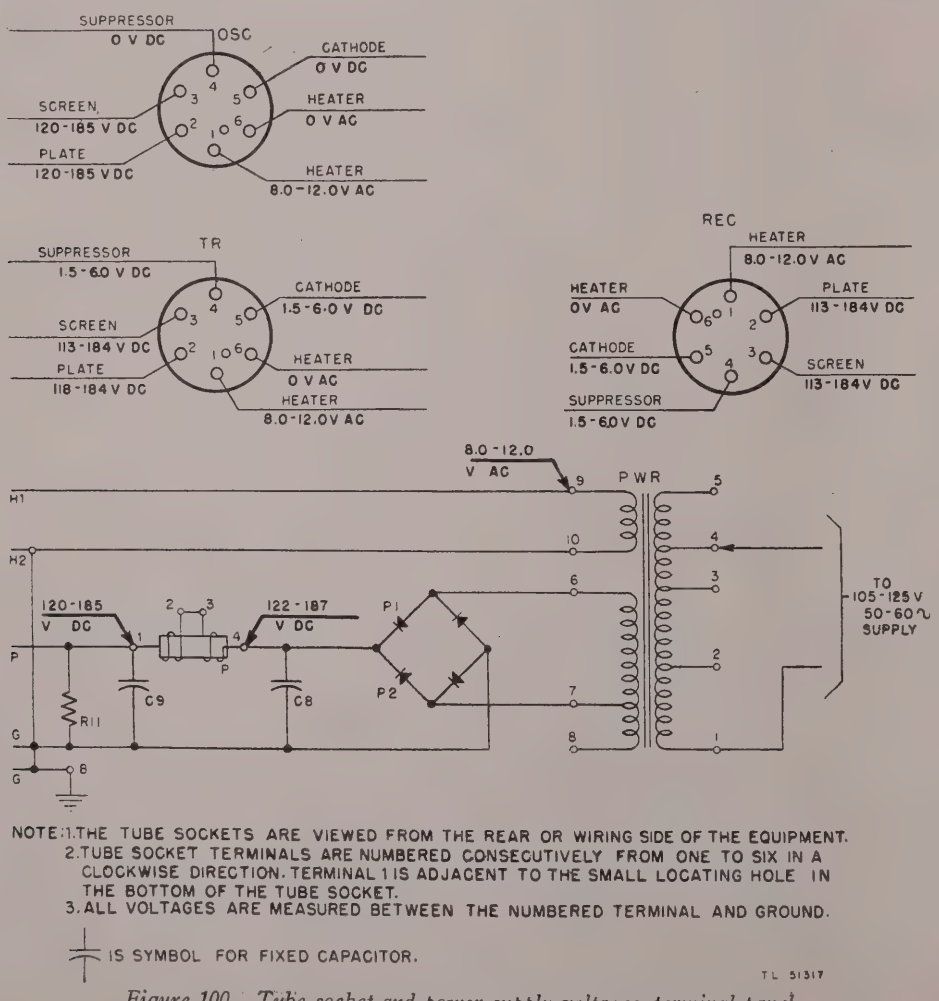
(2) Check TR tube socket voltages (fig. 100).

(3) Check the transmitting amplifier (par. 104).

(4) Check the oscillator output as described in paragraph 48 but note that the output measurement is made between the center tap of transformer MOD OUT and ground.

(5) Check wiring, connections, and all equipment not previously checked.

d. Trouble in Receiving Circuit. (1) Replace vacuum tube REC and recheck circuit.



NOTE: 1. THE TUBE SOCKETS ARE VIEWED FROM THE REAR OR WIRING SIDE OF THE EQUIPMENT.
2. TUBE SOCKET TERMINALS ARE NUMBERED CONSECUTIVELY FROM ONE TO SIX IN A CLOCKWISE DIRECTION. TERMINAL 1 IS ADJACENT TO THE SMALL LOCATING HOLE IN THE BOTTOM OF THE TUBE SOCKET.
3. ALL VOLTAGES ARE MEASURED BETWEEN THE NUMBERED TERMINAL AND GROUND.

IS SYMBOL FOR FIXED CAPACITOR.

TL 51317

Figure 100. Tube socket and power supply voltages, terminal panel.

(2) Check REC tube socket voltages (fig. 100).

(3) Check the receiving amplifier (par. 104).

(4) Check the oscillator output as described in paragraph 48 but note that the output measurement is made between the center tap of transformer DEM IN and ground.

(5) Check wiring, connections, and all equipment not previously checked.

100. Trouble Tests on Terminal Panel: Radio Link Operation

Trouble localization on two terminals connected for radio link should be preceded by an analysis of trouble symptoms. If one terminal only is in trouble, set its LINE switch on one of the WIRE positions, and perform the terminal tests described in paragraph 99. If both circuits of the terminal meet test requirements, trouble lies in the switches, interpanel connections, or in the BF or DF filters of the other terminal panel. Perform the terminal tests on the other terminal. If the other terminal also meets test requirements, the trouble lies in the interpanel connections or in the RADIO setting of the LINE switch on the terminal in trouble. If both terminals are reported in trouble at the same time, the common equipment which may be suspected includes the directional filters, jacks, LINE switches, line connections, and the external source of power.

101. Trouble Tests on Repeater Panel

The following test equipment is required for localizing trouble on the repeater panel:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Attenuator TS-402/U.
1 Multimeter TS-380/U.
Patching cords.

a. Check of Circuits in Both Directions of Transmission. When trouble is known to exist in either the East-to-West or the West-to-East circuit, make a test of the other direction of transmission to determine the condition of equipment common to both circuits. See figure 101 for arrangement of testing apparatus. If this test definitely locates the trouble in only one circuit, proceed to *c* below.

(1) Note the settings of both gain controls, then set the control of the circuit being tested on 50, and the other control on 0.

(2) Adjust the frequency and input level of the oscillator as specified under INPUT. Patch this testing power to the proper jacks.

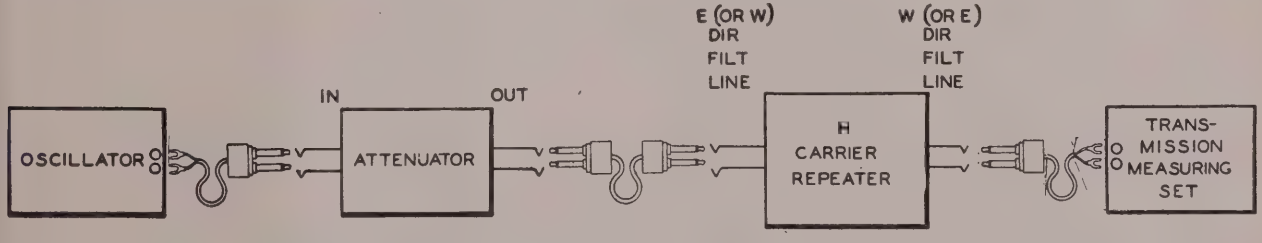
(3) Measure the output of the repeater at the jacks specified under OUTPUT.

Requirement: The measured gain will be within ±2.5 db of the specified gain.

(4) Remove the patching cords and restore the gain controls to their normal settings.

(5) If the requirements are not met for both directions of transmission, trouble is indicated in equipment common to both circuits. Proceed to *b* below.

(6) If the requirements are met in one direction of transmission and not in the other, proceed to *c* below for tests of the circuit which is in trouble.



DIRECTION	INPUT			OUTPUT	
	JACKS	POWER (DBM)	FREQ (CYCLES)	JACKS	GAIN (DB)
E-W	E DIR FILT LINE	-25	8,000	W DIR FILT LINE	31
W-E	W DIR FILT LINE	-25	6,000	E DIR FILT LINE	32

TL 50502-1

Figure 101. Repeater gain test.

b. TROUBLE IN BOTH DIRECTIONS. (1) Check the power supply voltages (fig. 102). If output voltages do not meet requirements, see paragraph 103. If voltages meet the requirements, proceed with (2).

(2) Check the wiring, connections, and the remaining common equipment, consisting of the jacks and directional filters.

(3) If these tests do not disclose the trouble, follow the directions in *c* below for testing each direction of tranmission individually.

c. TROUBLE IN ONE DIRECTION ONLY. (1) Replace the vacuum tube and recheck the circuit.

(2) Check the tube socket voltages (fig. 102).

(3) Check the amplifier (par. 104).

(4) Check wiring, connections, and all equipment not previously checked.

102. Trouble Tests on Line Panel

a. Check wiring and connections.

b. Check characteristics of line filter LF (par. 106).

c. The balancing networks and varistor may be checked by substitution of parts known to be good.

103. Trouble in Power Supply

The information in this paragraph is applicable to the power supply at either the terminal or repeater.

a. Check the output voltages (fig. 100 or 102).

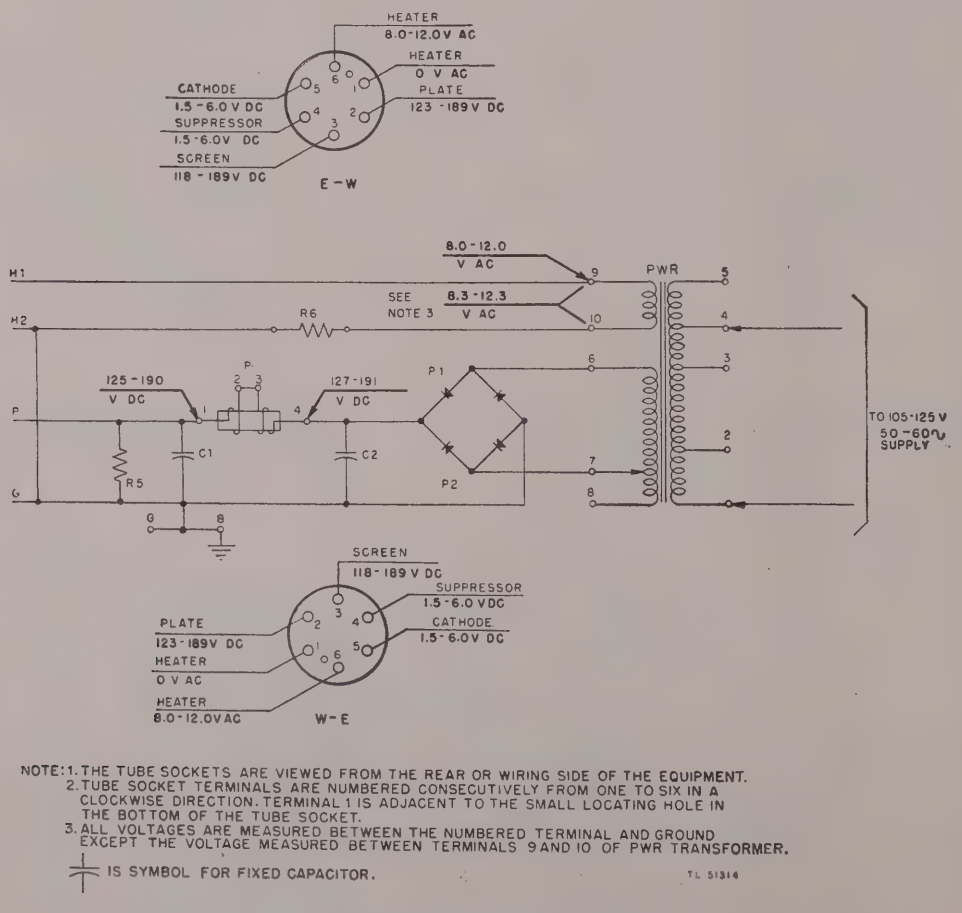
b. If requirements are met, check wiring between measuring point and tube sockets.

c. Perform power supply adjustment if voltages measured do not meet requirements (par. 46).

d. If no output is measured from the filament winding and the d-c supply, trouble is indicated on the primary side of the PWR transformer. Check or replace the power cord and the transformer.

e. If no output is measured from the filament winding, the winding may be defective, or may be open at the repeater resistor R6. Replace the defective part.

f. If the d-c output is low or no output is measured between terminal 4 of coil P and ground, check the capacitors and replace if necessary. If one varistor is found to be defective both varistors should be replaced in order to preserve the electrical characteristics of the varistor bridge.



NOTE: 1. THE TUBE SOCKETS ARE VIEWED FROM THE REAR OR WIRING SIDE OF THE EQUIPMENT.
2. TUBE SOCKET TERMINALS ARE NUMBERED CONSECUTIVELY FROM ONE TO SIX IN A CLOCKWISE DIRECTION. TERMINAL 1 IS ADJACENT TO THE SMALL LOCATING HOLE IN THE BOTTOM OF THE TUBE SOCKET.
3. ALL VOLTAGES ARE MEASURED BETWEEN THE NUMBERED TERMINAL AND GROUND EXCEPT THE VOLTAGE MEASURED BETWEEN TERMINALS 9 AND 10 OF PWR TRANSFORMER.

⊣⊢ IS SYMBOL FOR FIXED CAPACITOR.

TL 51314

Figure 102. Tube socket and power supply voltages, repeater panel.

104. Trouble in Amplifiers

This paragraph covers trouble location procedures for a defective amplifier at a terminal or repeater, and also includes a test of the amplifier gain.

Note. When making tests of the amplifier other than voltage measurements or the amplifier gain test, be sure to disconnect the wires running to the external source of power.

a. Trouble Location. (1) Check the condition of the amplifier tube.

(2) Recheck all socket voltages.

(a) Incorrect filament voltage may be caused by wiring defects.

(b) Incorrect plate or screen voltages may be caused by defective resistors or capacitors in the amplifier, defective wiring, or by a defect in the windings of the OUT transformer. Examine all wiring and connections carefully, and check or replace all components of the amplifier.

b. Amplifier Gain Test (fig. 103). This test is used to check the amplifier gain after a defective part has been replaced, or it may be used as a further trouble location test after the socket voltages have been checked and found to be within limits.

(1) The test is made by first removing existing connections from the primary of transformer IN and secondary of transformer OUT. Testing power at the proper level is then connected to the primary of transformer IN and the amplifier gain is measured by connecting a measuring set to the secondary of transformer OUT. Oscillator output level and frequency, and attenuator setting are specified on figure 103.

(2) The following test equipment is required:

1 Audio Oscillator TS-379/U.
1 Attenuator TS-402/U.
1 Decibel Meter TS-399/U.
Patching cords.

(3) Make the test in the following manner:

(a) Set the attenuator for the specified loss.

(b) Connect the test equipment to the amplifier.

(c) Adjust the oscillator as specified.

(d) Determine the gain of the amplifier.

Requirement: The measured gain will be within ±2.0 db of the specified gain.

(4) If the gain is too high and the power supply is adjusted properly, it is probable that there is trouble in the feedback circuit. If the gain is too low and the power supply is adjusted properly, loose connections or defective coupling transformers may be the cause of the trouble.

105. Trouble in Oscillator

This paragraph covers trouble location in the oscillator when no output is measured or when the output is outside limits specified previously.

a. Trouble Procedure. (1) Be sure that a good tube has been placed in the socket.

(2) Check the tube socket voltages (fig. 100).

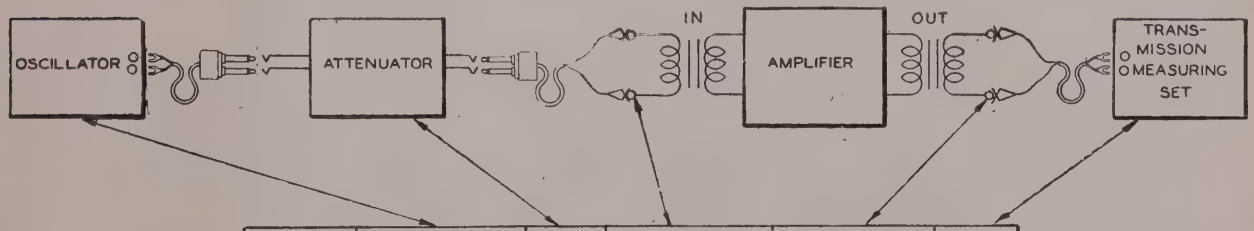
(a) Incorrect filament voltage may be caused by wiring defects.

(b) Incorrect plate or screen voltages may be caused by defective resistors or capacitors in the oscillator circuit, defective wiring, or by a defect in the windings of the OSC transformer. Examine all wiring and connections carefully, and check or replace all circuit components.

(3) Adjust the oscillator frequency (par. 110) when the trouble has been remedied.

106. Trouble in Filters

If any of the localization tests indicate that a filter may be in trouble, its condition may be checked by



AMPLIFIER	OSCILLATOR		ATTEN-UATOR SETTING	AMPLR INPUT		AMPLR OUTPUT		GAIN REQUIRE-MENT (DB)
	OUTPUT (DBM)	FREQ (CYCLES)		EQUIP	TERMS	EQUIP	TERMS	
TERM. XMTG	0	8,000	25	TR IN	1 & 2	TR OUT	3 & 4	33 0±2
TERM RCVG	0	1,000	25	REC IN	1 & 3	REC OUT	1 & 2	32 0±2
REPTR E-W	0	8,000	25	E-W IN	1 & 2	E-W OUT	3 & 4	33 0±2
REPTR W-E	0	6,000	25	W-E IN	1 & 2	W-E OUT	3 & 4	33 0±2

FL 81291

Figure 103. Amplifier gain test.

the tests listed in this paragraph. The following test equipment is necessary:

1 Audio Oscillator TS-379/U.
1 Decibel Meter TS-399/U.
1 Multimeter TS-380/U.
Patching cords.

a. Disconnect all wiring to the terminals of the filter under test (table XVI).

b. Using the lowest ohms scale of the multimeter, measure between each of the terminals mentioned in table XVI and ground.

(1) On any filter except the carrier section of line filter LF continuity between any terminal and ground indicates that the filter should be replaced. A ground will seriously affect the characteristics of the filter.

(2) The carrier or high-pass section of line filter LF is unbalanced to ground. The grounded side is brought out to terminal 4 of terminal strip A.

c. Check the frequency characteristic of the filter in the following manner:

(1) Connect the oscillator and measuring set to the terminals indicated in table XVI as shown in figure 104.

(2) Measure the loss of the filter for each of the frequencies specified.

Note. The calibrations of both the oscillator and the measuring set must be accurate at all times during the test. Check them frequently.

(3) If the filter does not meet any one of the minimum requirements in the table, it is defective. Replace it.

(4) Turn to paragraph 111 for directions on returning the system to service after a filter is replaced.

107. Troubles in Potentiometers, Switches, and Jacks

All tests specified in this paragraph may be made with Multimeter TS-380/U.

a. Potentiometers. The potentiometers at the terminal and repeater are identical. They are constant impedance, adjustable T-type pads, with the bottom of the T grounded. The condition of any potentiometer may be checked by performing the applicable gain measurement test described in section V. The measurement should change approximately 2-db per step as the potentiometer is rotated. If this requirement is not met, first check the external wiring of the potentiometer, and if no trouble is found, remove the potentiometer from the subpanel and repair or replace it.

b. Switches. If a switch is suspected of causing trouble, determine its condition by repeating the gain checks of the terminal transmitting and receiving circuits with the two switches on the following settings:

EQPT.	*LINE*
2W	WIRE EAST
2W	WIRE WEST
4W TEL	WIRE EAST

If the terminal is set for radio link operation, the switches are tested in the prescribed wire positions. If the gain requirement for any switch setting is not met, check the setting for continuity. If the requirement is not met, check the switch for dirty or open contacts or mechanical failure. If the requirement is met, wiring connections to the switch may be defective.

c. Jacks. To check the condition of the jack perform a continuity test between the two connected jack terminals located at the rear of the panel. Continuity through the jacks should be broken and made by inserting and removing a plug.

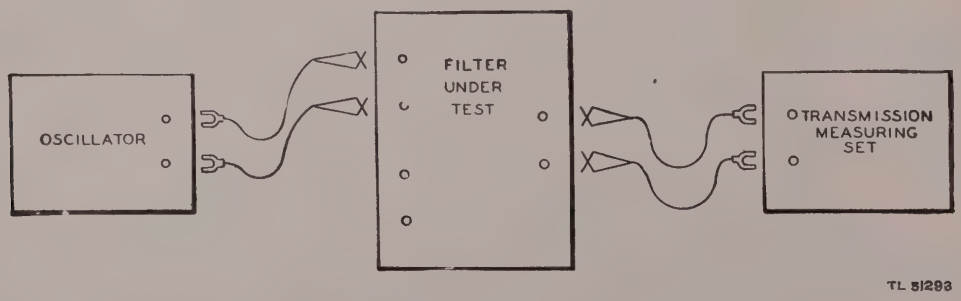


Figure 104. Filter test.

Table XVI. Filter characteristics

Filter test	Test connections: Oscillator to — Equip.	Test connections: Oscillator to — Term.	Test connections: Measuring set to — Equip.	Test connections: Measuring set to — Term.	Input frequency (kc)	Loss requirement (db)
Terminal panel						
LP:						
(Xmtg side)	LP	3 and 4	LP	1 and 2 [1]	1.0	4.0 or less
					3.0	3.0 or less
					4.0	12.0 or more
					10.0	30.0 or more
(Rcvg side)	LP	9 and 10	LP	11 and 12	1.0	2.0 or less
					15.0	24.0 or more
BF:						
(High-pass) (section)	BF	1 and 2	BF	3 and 4	6.5	18.0 or more
					8.0	2.0 or less
					10.0	2.0 or less
					15.0	18.5 or more
(Low-pass) (section)	BF	9 and 10	BF	11 and 12	6.0	1.5 or less
					8.0	25.0 or more
					12.0	18.0 or more
DF (E DF) [2]						
(High-pass) (section)	DF (E DF)	5 and 6	DF (E DF)	1 and 2	6.5	45.0 or more
					7.0	7.0 or more
					9.0	2.5 or less
					13.0	45.0 or more
(Low-pass) (section)	DF (E DF)	3 and 4	DF (E DF)	1 and 2	3.0	15.0 or more
					5.0	2.0 or less
					6.5	3.0 or less
					7.5	20.0 or more
					12.5	45.0 or more
Repeater panel						
E DF [2] (See test on DF of terminal panel):						
W DF						
(High-pass)	W DF	3 and 4	W DF	1 and 2	6.5	24.0 or more
					7.0	6.0 or more
					9.0	2.0 or less
					15.0	35.0 or more
	W DF	5 and 6	W DF	1 and 2	3.6	9.0 or more
					5.0	2.0 or less
					7.5	12.0 or more
					9.0	38.0 or more
Line panel						
LF:						
(Carrier section)	Term. Strip A	3 and 4	Term. Strip A	1 and 2	3.4	18.0 or more
					4.0	4.5 or less
					5.0	1.5 or less
(Voice section)	Term. Strip A	5 and 6	Term. Strip A	1 and 2	1.0	1.0 or less
					3.0	4.5 or less
					4.0	40.0 or more

[1] Remove resistor between these terminals before making test.
[2] Directional filter E DF at the repeater is identical to directional filter DF provided at the terminal.

Section XVI. REPAIRS

108. Replacement of Parts

With the exception of jacks, gain controls, and switches, no particular difficulty should be encountered in the removal and replacement of parts contained in H carrier equipment. The replacement of jacks, gain controls, and switches involves the removal of the bakelite subpanel, described in section XII.

109. Use of Tools and Repair Equipment

a. GENERAL. Important items in the clearing of

trouble are maintaining cleanliness in the equipment. care in the use of tools, accuracy when making adjustments, and care in handling equipment.

b. CLEANLINESS. (1) Keep the apparatus clean. Contact trouble is caused mainly by dust and lint lodging between the contact surfaces of the multiple contact switches and jacks.

(2) Take care not to break the wires connected to the multiple contact switches when working on the terminal and repeater panels. These are the GAIN potentiometers at the repeater and terminal and also the LINE and EQPT switches at the terminal. Since these switches are in the transmission path, a loose connection or a collection of dirt and lint on any of them will cause noise in the circuit or may cause an open in the transmission circuit.

(3) The multiple contact switches and jacks are not provided with covers. Take care not to allow dust and lint to fall on the spring contacts of the jacks nor on the contacts of the switches when working on equipment.

(4) Keep the doors on the front and rear of the equipment cabinets closed except when working on the equipment, in order to reduce as much as possible the chance for trouble from dirt and lint.

c. SOLDERING. Use care in making wiring changes, or in the clearing of troubles such as wiring crosses or opens, and when removing or replacing a piece of apparatus, in order to avoid introducing potential wiring troubles. Properly soldered connections are important. A properly soldered joint should be sound with not too much solder. Adequate clearance should be provided between adjacent terminals so that vibration will not cause crosses. Take extreme care to see that no loose bits of wire or solder are left between the wiring terminals, among the wires, or in the apparatus housings after soldering operations. Protect the apparatus immediately below from solder particles or bits of wire during the above operations. Use a piece of cotton duck or similar material for protection. Always use a soldering iron holder to avoid a possible fire hazard.

d. REPAIR EQUIPMENT. No special repair equipment is required to aid in the replacement of any of the H carrier equipment. If the tools supplied with the office tool set are used properly and carefully it will be possible to perform all repairs necessary.

110. Oscillator Frequency Adjustment (fig. 105)

This adjustment is used to set the oscillator frequency after a defective oscillator component has been replaced, or after performance of the synchronization test has indicated that the terminal oscillators are out of adjustment. Make the test by unbalancing transformer MOD OUT to increase the carrier leak, then measure this leak on the receiving side of the terminal at the low-pass output side of band filter BF. The following test equipment is required:

1 decibel meter TS-399/U.
600-ohm plug.
Patching cords.

a. Note the setting of switch LINE and set it on RADIO TRANS.

b. Note the setting of controls TR GAIN and REC GAIN. Set TR GAIN on 50 and REC GAIN on 44.

c. Strap between terminals 5 and 6 of transformer MOD OUT at the back of the panel. This transformer is located at the top right of the panel.

d. Connect terminal 5 to 7 and 9 to 11 on terminal strip B.

e. Terminate jacks DIR FILT LINE with a 600-ohm plug.

f. Connect the terminals of the measuring set to terminals 3 and 4 of terminal strip B.

g. Adjust the measuring set to obtain an indication.

h. Loosen the fiber tube on the back of the OSC transformer, located on the rear of the panel in the upper left corner. Using a screwdriver, adjust the screw inside the fiber tube until the highest possible output reading is obtained on the measuring set. The oscillator is generating the correct carrier frequency when the screw is set for maximum output. If no peak reading can be obtained, some part of the oscillator circuit is in trouble; follow the procedure given in paragraph 105.

i. After the oscillator frequency has been adjusted properly, tighten the fiber tube, and disconnect the measuring set. Remove straps on terminal strip B and on MOD OUT transformer. Restore the LINE switch and the GAIN controls to normal operating positions.

j. Perform synchronization test (par. 55).

111. Procedure for Returning System to Service

a. After repairs, replacement of parts, or adjustments have been made on H carrier equipment which may affect the over-all system line-up, check the entire system before it is returned to service.

b. Ascertain that all switches and controls are on their proper operating settings.

c. Perform the power supply adjustment if the output voltages of the power supply have been affected (par. 46).

d. Check the voltages at all tube sockets (figs. 100 and 102).

e. If any tubes have been replaced that satisfac-

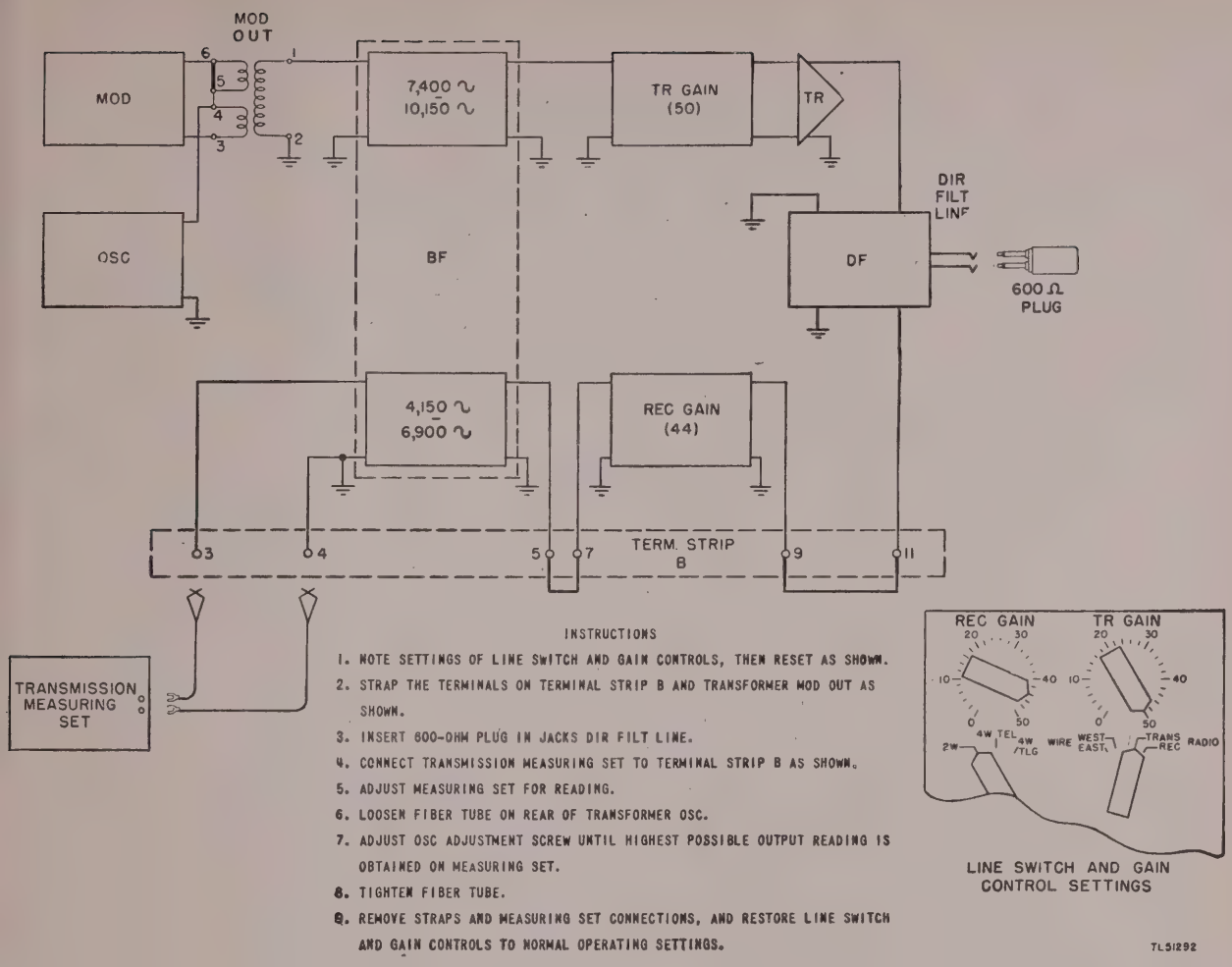


Figure 105. Oscillator frequency adjustment.

torily passed test requirements, retain these tubes as spares.

f. Perform the oscillator synchronization test if the output of the oscillators has been affected (par. 55).

g. Make a circuit net loss measurement in each direction.

h. Perform a detailed system line-up if the above measurement indicates that the system is lined up incorrectly.

i. Perform the channel frequency net loss test if any filters have been replaced.

j. Ring, talk, and listen on the system from its terminations.

k. If system performance is satisfactory return it to service.

LIST OF COMPONENT PARTS

Note. This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

1. Component Parts of Carrier Terminal OA-13/FC

Quantity	Component part
1	Carrier Terminal OA-13/FC (Western Electric Co X-66217A).
4	Designation cards.
6	Vacuum Tube JAN-310A (spares).
1	TM 11-2025.
2 sets	Drawings:
	B-400044-1, sheet 1, carrier terminal panel schematic diagram.
	B-400044-1, sheet 2, carrier terminal panel schematic diagram.
	B-400044-2, carrier terminal panel wiring diagram.

2. Component Parts of Carrier Repeater OA-10/FC

Quantity	Component part
1	Carrier Repeater OA-10/FC (Western Electric Co X-66217B).
4	Designation cards.
6	Vacuum tube JAN-310A (spares).
2 sets	Drawings:
	B-400045-1, repeater panel schematic diagram.
	B-400045-2, repeater panel wiring diagram.

3. Component Parts of Carrier Filter F-36/FC

Quantity	Component part
1	Carrier Filter F-36/FC (Western Electric Co X-66217C).
200 ft	20-ga wire, black and black-red.
5 ft	22-ga wire, shielded slate and slate-red.
4	Designation cards.
1	TM 11-2025.
2 sets	Drawings:
	B-400046-1, line filter and balance network panel schematic diagram.
	B-400046-2, line filter and balance network panel wiring diagram.

MAINTENANCE PARTS

1. Maintenance Parts for Carrier Terminal OA-13/FC

The following information was compiled on 30 March 1945. The appropriate section of the ASF Signal Supply Catalog for Carrier Terminal OA-13/FC is:

Fixed Plant Maintenance List: SIG 10-840.38, Carrier Terminal OA-13/FC.

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

Note. The following list covers station stock maintenance parts.

Ref. symbol	Signal Corps stock No.	Name
C1, C10, C11	3DB2-958	CAPACITOR
C2, C4	3DB1.962-1	CAPACITOR
C3	3DA10-158	CAPACITOR
C6	3DA3-34	CAPACITOR
C8, C9	3DB5-12.1	CAPACITOR
P1, P2	3H4956-54	RECTIFIER
R3	3Z6580-26	RESISTOR
R4, R5, R10	3Z6500-87	RESISTOR
R6	3Z6065-4	RESISTOR
R7, R11	3Z6801-80	RESISTOR
R8	3Z6050-133	RESISTOR
R9	3Z6100-162	RESISTOR
R12	3Z6060-36	RESISTOR
OSC, REC, TR	2J310A	TUBE, vacuum
DEM, MOD	4Z9715	VARISTOR

2. Maintenance Parts for Carrier Repeater OA-10/FC

The following information was compiled on 30 March 1945. The appropriate section of the ASF Signal Supply Catalog for Carrier Repeater OA-10/FC is:

Fixed Plant Maintenance List: SIG 10-840.39, Carrier Repeater OA-10/FC.

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

Note. The following list covers station stock maintenance parts.

Ref. symbol	Signal Corps stock No.	Name
C1, C2	3DB5-12.1	CAPACITOR
C3, C5	3DA10-158	CAPACITOR
C4, C6	3DB1.962-1	CAPACITOR
P1, P2	3H4956-54	RECTIFIER
R1, R3	3Z6500-87	RESISTOR
R2, R4	3Z6065-4	RESISTOR
R5	3Z6801-80	RESISTOR
R6	3Z5985-4	RESISTOR
E-W, W-E	2J310A	TUBE, vacuum

3. Maintenance Parts for Carrier Filter F-36/FC

The following information was compiled on 30 March 1945. The appropriate section of the ASF Signal Supply Catalog for Carrier Filter F-36/FC is:

Fixed Plant Maintenance List: SIG 10-840.40, Carrier Filter F-36/FC.

For the latest index of available catalog sections, see ASF Signal Supply Catalog SIG 2.

APPENDIX III

REFERENCES

1. Parts List

SIG 1, Introduction to ASF Signal Supply Catalog.
SIG 2, Complete Index to ASF Signal Supply Catalog.
SIG 3, List of Items for Troop Issue.
SIG 4-1, Allowances of Expendable Supplies.
SIG 5, Stock List of All Items.
SIG 10, Fixed Plant Maintenance List.
SB 11-10, Signal Corps Kit and Materials for Moisture- and Fungi-resistant Treatment.

2. Technical Manuals on Associated Equipment and Test Equipment

TM 11-2021, Ringers TA-38/FC and TA-39/FC (Voice-frequency Ringer Packaged Equipment).
TM 11-2026, Type C Carrier Telephone Packaged Equipment, Moisture-resistant (Carrier Terminals OA-11/FC and OA-12/FC, Carrier Repeater OA-9/FC, and Carrier Filter F-37/FC).
TM 11-2028, Voice-Frequency Telephone Repeater Packaged Equipment, Moisture-resistant (Telephone Repeaters OA-7/FC and OA-8/FC).
TM 11-2029, Voice-frequency Carrier Telegraph Packaged Equipment (Carrier Terminals OA-4/FC and OA-5/FC).
TM 11-2039, 19C (SPL) Oscillator (Audio Oscillator TS-379/U).
TM 11-2042, Volt-ohm-milliammeter per D-166852 (Multimeter TS-390/U).
TM 11-2044, 5A (SPL) Attenuator (Attenuator TS-402/U).
TM 11-2045, 13A (SPL) Transmission Measuring Set (Decibel Meter TS-399/U).
TM 11-2046, 67B and 68B (SPL) Test Sets (Test Set TS-190/U).
TM 11-2047, Hickok Model 560 (SPL) Tube Tester (Tube Tester I-171).

3. Shipping Instructions

U. S. Army spec No. 100-14A Army-Navy General Specification for Packaging and Packing for Overseas Shipment.

4. Decontamination

TM 3-220, Decontamination.

5. Demolition

FM 5-25, Explosives and Demolitions.

6. Other Publications

FM 21-6, List of Publications for Training.
FM 21-7, List of War Department Films, Film Strips, and Recognition Film Slides.
FM 21-8, Military Training Aids.
FM 21-40, Defense Against Chemical Attack.
TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment.
TM 1-455, Electrical Fundamentals.
TM 11-473, Central Office Maintenance.
TM 11-475, Principles of Long Distance Telephone and Telegraph Transmission.
TM 11-486, Electrical Communication Systems Engineering.
TM 11-487, Electrical Communication Systems Equipment.
TM 11-755, Grounds and Grounding for Wire Equipment.
TM 11-2022, Application of Fixed Plant Packaged Equipment to Open-Wire Lines.
TM 11-2037, Installation, Operation, and Maintenance of Open-Wire Offices Packaged Equipment.
TM 37-250, Basic Maintenance Manual.

7. Forms

WD AGO Form 468, Unsatisfactory Equipment Report.
Army Air Forces Form 54, Unsatisfactory Report.

8. Abbreviations

ac .....alternating current (noun)
a-c .....alternating-current (adjective)
amp .....ampere(s)
amplr .....amplifier

approx .....approximately
AWG .....American Wire Gauge

bal .....balancing

cap .....capacitor
carr .....carrier
chan .....channel(s)
ckt .....circuit
ctrl .....control
cx ..... composite telegraph circuit or set

db .....decibel(s)
dbm .....power in decibels referred to 1 milliwatt
dc .....direct current (noun)
d-c .....direct-current (adjective)
dem .....demodulator
dir ..... directional
dwg .....drawing

E .....East
equip .....equipment

fig .....figure
fil .....filter
freq .....frequency

ga .....gauge
gnd .....ground

hyb .....hybrid

kc .....kilocycle(s)

M .....thousand
meg .....megohm(s)
mf .....microfarad(s)
mi .....mile(s)
mod .....modulator
mtg .....mounting

net .....network
No .....number

osc .....oscillator

ph .....phantom
pot ..... potentiometer
prot .....protector(s)
pwr .....power

rcvg .....receiving
rcvr .....receiver
reptr .....repeater
reqd .....required
res .....resistor
rptg .....repeating

sb .....switchboard
sec .....section
sig .....signal
so .....socket
sw .....switch
sx .....simplex telegraph circuit

term .....terminal
tg .....telegraph
tp .....telephone
transf .....transformer

v .....volt(s)
v-f .....voice-frequency (adjective)
vt .....vacuum tube

W .....West
w .....watt(s)

xmtg .....transmitting
xmtr .....transmitter

z .....impedance

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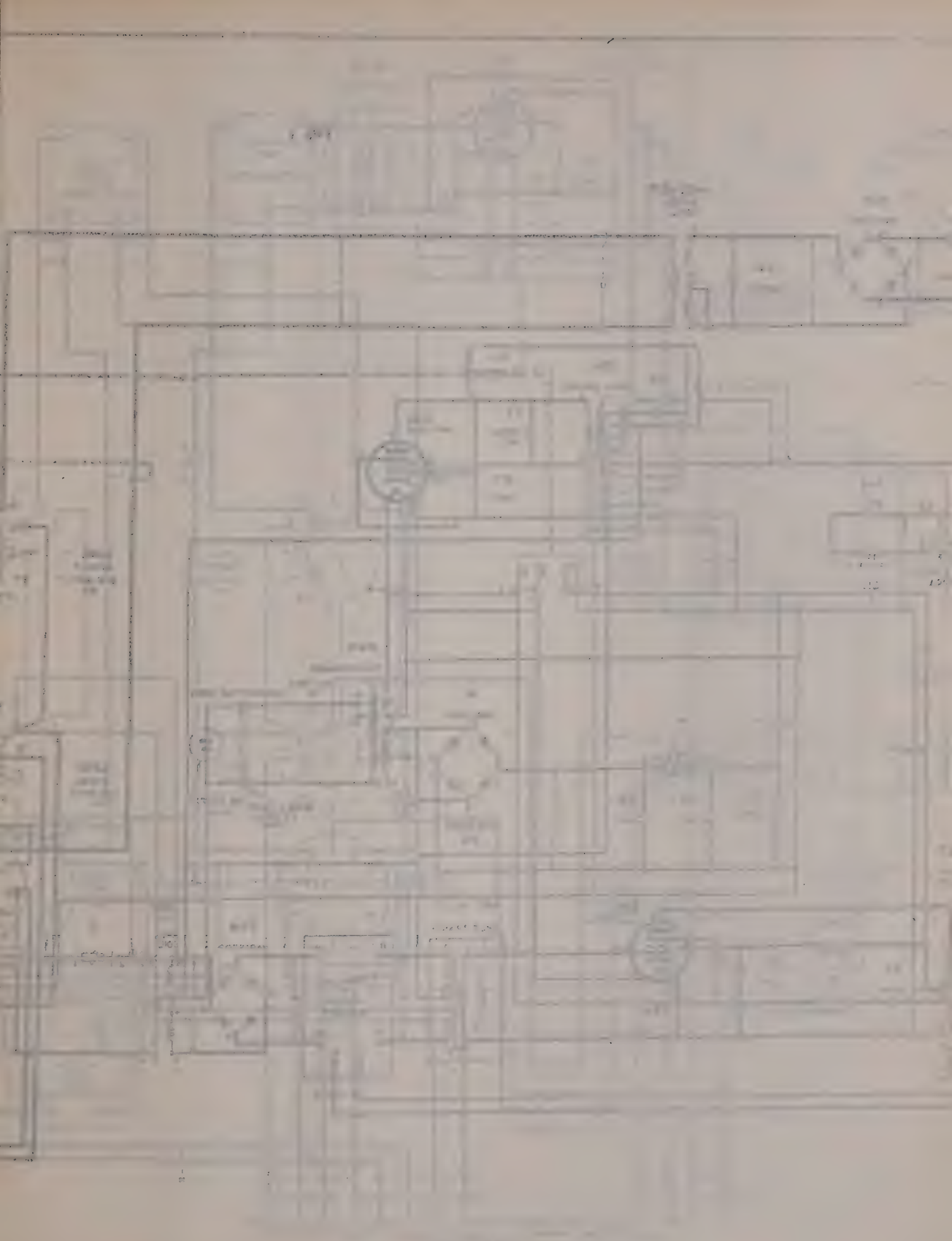
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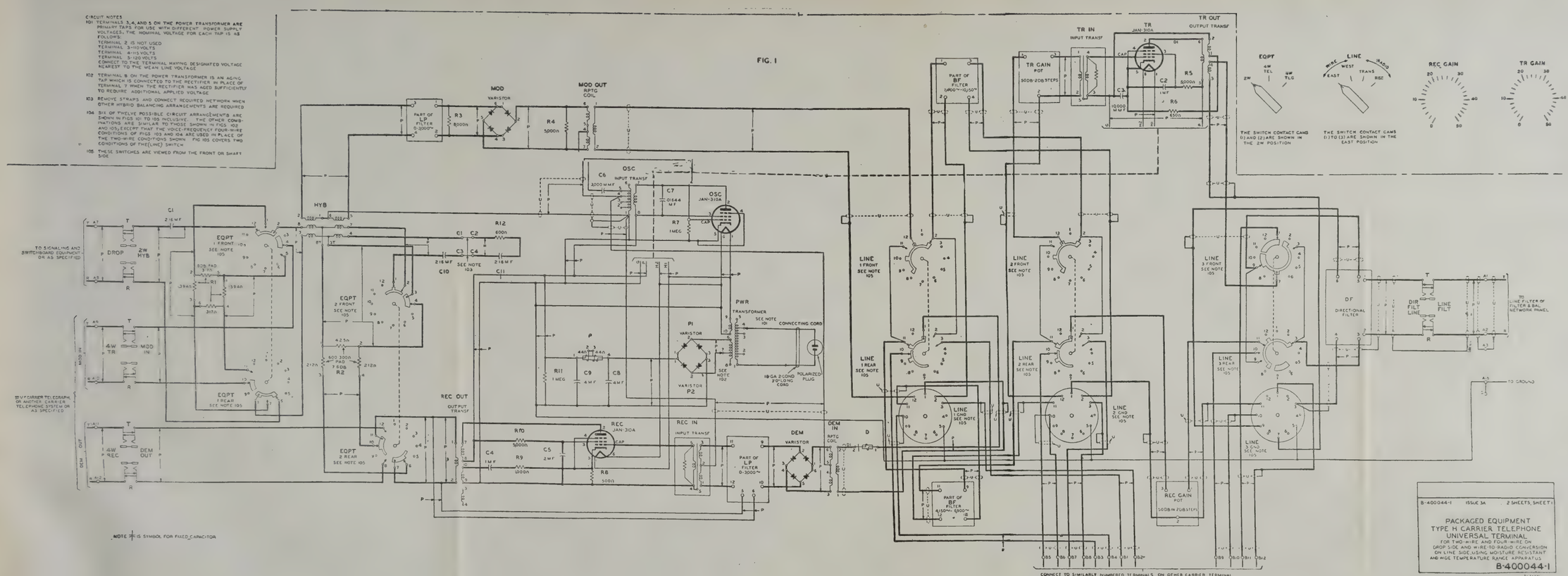
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Unpacking instructions (table IV, figs. 23 to 25)	26	28
Unsatisfactory Equipment Report (WD AGO Form 468) (fig. 74)	76	91
Vacuum tube:		
Checks	33	39
Test	47	62
Voltage adjustment. (*See* adjustments.)		
Voltages, tube socket and power supply:		
Repeater (fig. 102).		
Terminal (fig. 100).		
WD AGO Form 468 (Unsatisfactory Equipment Report) (fig. 74).		
Weight:		
Packed	26	28
Unpacked	2	2
Wiring diagrams. (*See* diagrams.)		

☆ U. S. GOVERNMENT PRINTING OFFICE: 1943—628191—TM 120

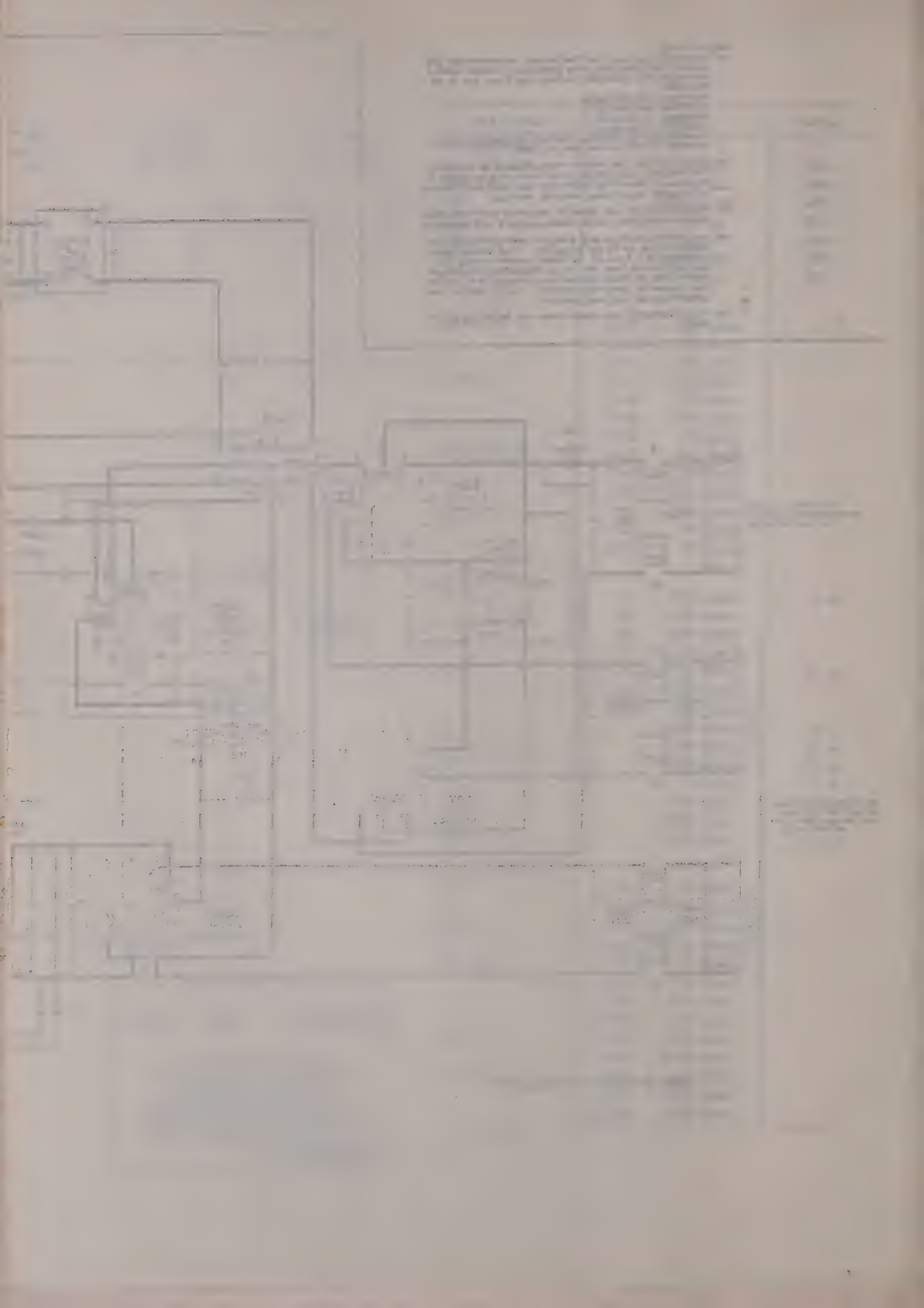


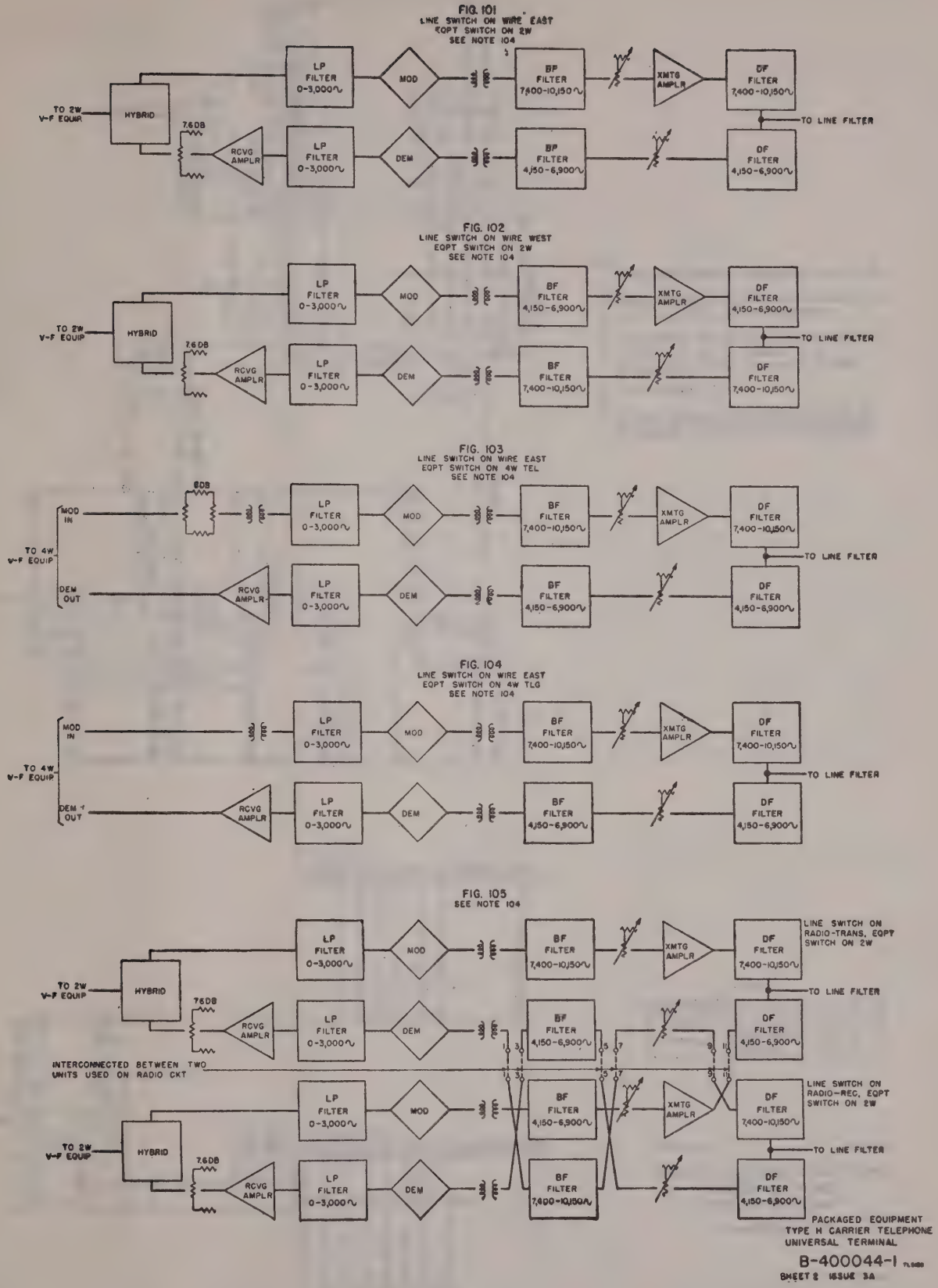


Drawing B-400044-1, Sheet 1. Type H carrier telephone terminal, schematic diagram.

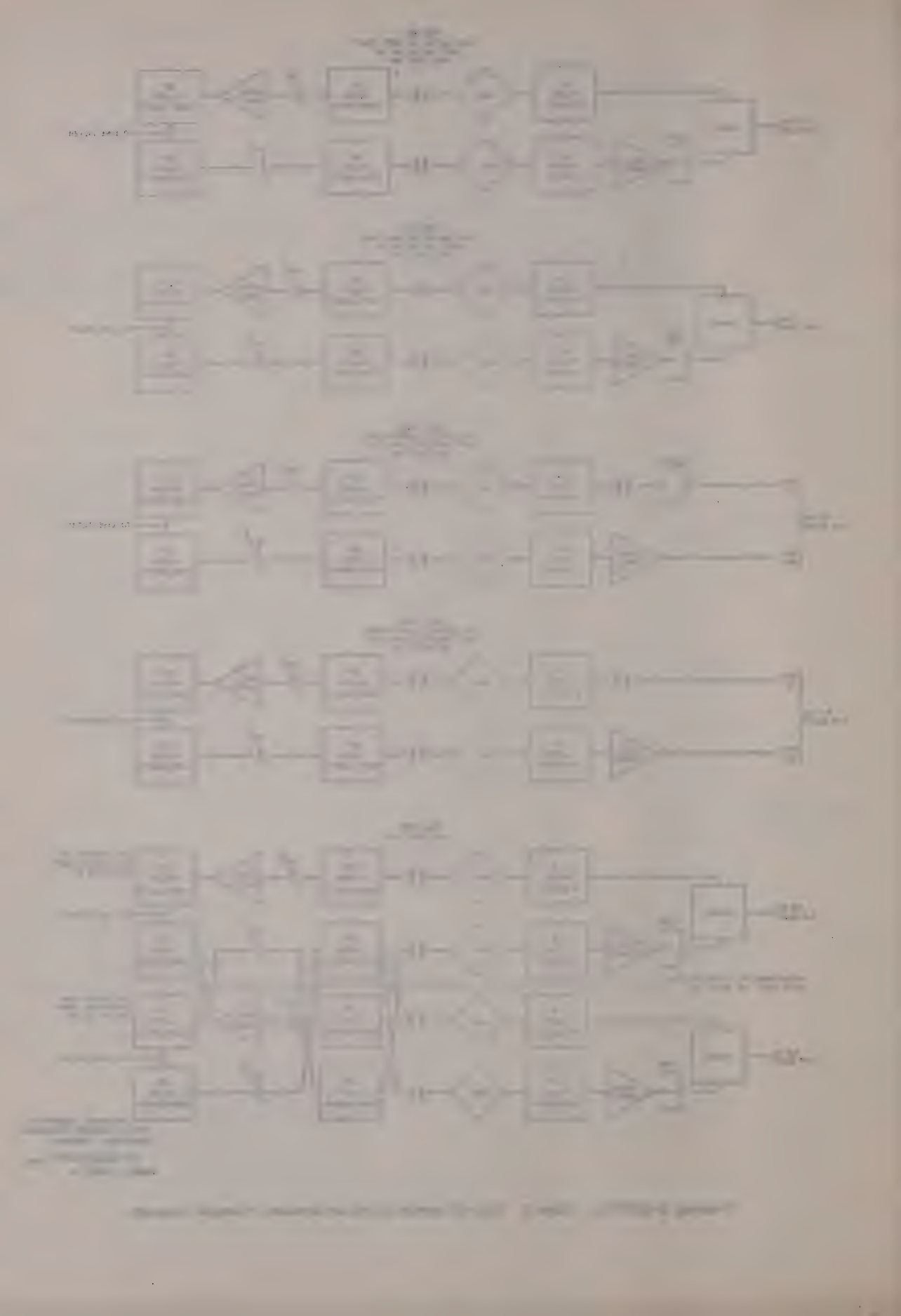
Ref. symbol		Value	Rating
Capacitors			
C1, C10, C11		2.16 mf	200 v
C2, C4		1 mf	200 v
C3		10,000 mmf	400 v
C5		2 mf	200 v
C6		3,000 mf	400 v
C7		16,440 mmf	500 v
C8, C9		4 mf	500 v
Coils			
DEM IN	(1-2)	8.9 ohms	..
	(3-4)	12 ohms	
	(5-6)	12 ohms	
HYB	(1-2)	25.5 ohms	..
	(3-4)	15 ohms	
	(5-6)	25.5 ohms	
	(7-8)	15 ohms	
MOD OUT	(1-2)	8.4 ohms	
	(3-4)	19.5 ohms	
	(5-6)	19.5 ohms	
D		1.45 ohms	..
P	(1-2)	44 ohms	
	(3-4)	44 ohms	..
Resistors			
R1	(1)	317 ohms	½ w
	(2)	317 ohms	
	(3)	1,394 ohms	
	(4)	1,394 ohms	
R2	(1-3)	212 ohms	½ w
	(1-2)	425 ohms	
	(2-4)	212 ohms	
R3		8,000 ohms	½ w
R4, R5, R10		5,000 ohms	½ w
R6		650 ohms	½ w
R7, R11		1 meg	½ w
R8		500 ohms	½ w
R9		1,000 ohms	½ w
R12		600 ohms	½ w
Transformers			
OSC	(1-6)	5.9 ohms	
	(7-8)	51 ohms	
REC IN	(pri)	1,600 ohms	z*
	(sec)	500,000 ohms	z*
REC OUT	(1-2)	17 ohms	
	(3-4)	13.4 ohms	
	(7-8)	835 ohms	
	(9-10)	88 ohms	
TR IN	(1-2)	25.2 ohms	
	(3-4)	4,190 ohms	
TR OUT	(1-2)	4.4 ohms	
	(3-4)	11.6 ohms	
	(5-6)	284 ohms	

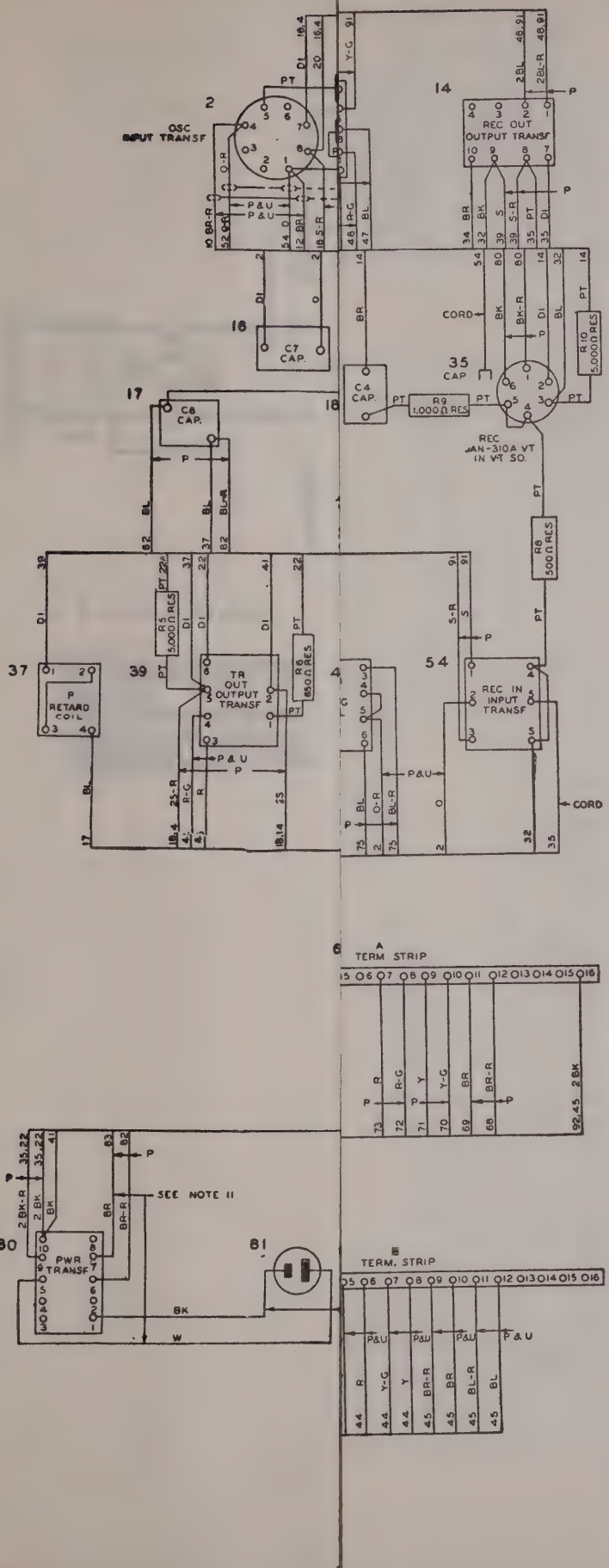
* Impedance





Drawing B-400044-1. Sheet 2. Type H carrier telephone terminal, schematic diagram.





NOTES

1. WIRES NOT OTHERWISE DESIGNATED ARE 22 GA.
2.
3. LEADS DESIGNATED "U" ARE 22 GA SHIELDED WIRE
4. ⊂⊃--- DENOTES SHIELD CONNECTION.
5.
6. "K1" DENOTES TOP OR LEFT TERM. ON STRIP.
7. "P", "P1", "P2", & "P3" DENOTE PAIR
8. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS.
9. —⊣⊢— DENOTES SPLICE.
10.
11. ON PWR TRANSFORMER RECONNECT LEAD ON TERM. 7 TO TERM. 8, AND RECONNECT LEAD ON TERM. 5 TO TERM. 4 OR 3 AS REQUIRED.

NOTES:

THIS DRAWING ISSUE AGREES WITH	1	2	3	4	5
B-400044-1	1 UNOFF	2	2	3	3

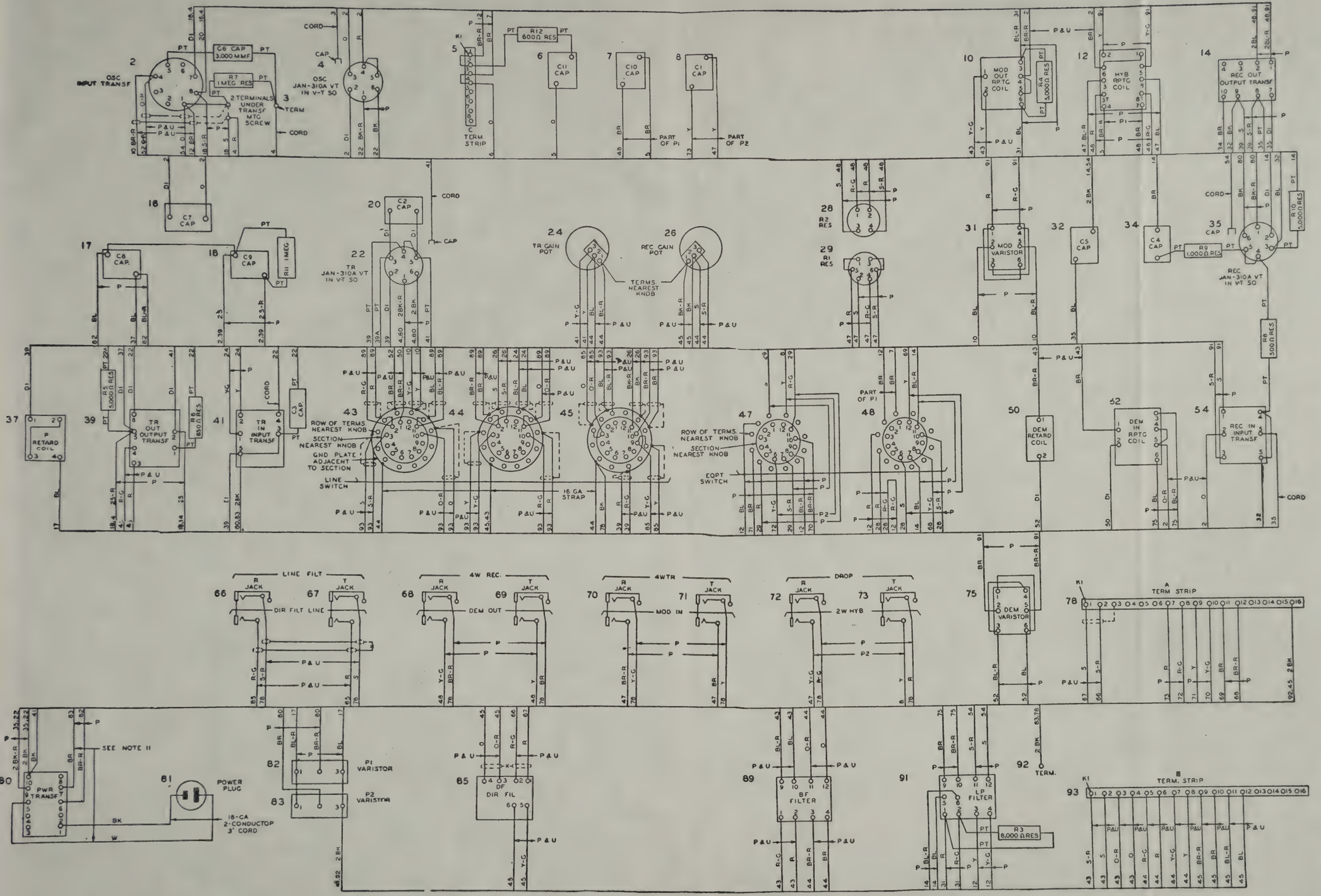
B-400044-2 ISSUE 5A

TYPE H CARRIER TELEPHONE TERMINAL PANEL WIRING DIAGRAM

B-400044-2

TL 51369





NOTES

1. WIRES NOT OTHERWISE DESIGNATED ARE 22 GA.
2.
3. LEADS DESIGNATED "U" ARE 22GA SHIELDED WIRE
4. DENOTES SHIELD CONNECTION.
5.
6. "KI" DENOTES TOP OR LEFT TERM. ON STRIP
7. "P", "P1", "P2", & "P3" DENOTE PAIR
8. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS.
9. —⋇— DENOTES SPLICE.
10.
11. ON PWR TRANSFORMER RECONNECT LEAD ON TERM 7 TO TERM. 8, AND RECONNECT LEAD ON TERM. 3 TO TERM. 4 OR 3 AS REQUIRED

NOTES:

THIS DRAWING ISSUE AGREES WITH	1	2	3	4	5
B-400044-1	1 UNOFF	2	2	3	3

B-400044-2 ISSUE 5A

TYPE H CARRIER TELEPHONE TERMINAL PANEL WIRING DIAGRAM

B-400044-2

Drawing B-400044-2. Type H carrier telephone terminal, wiring diagram.

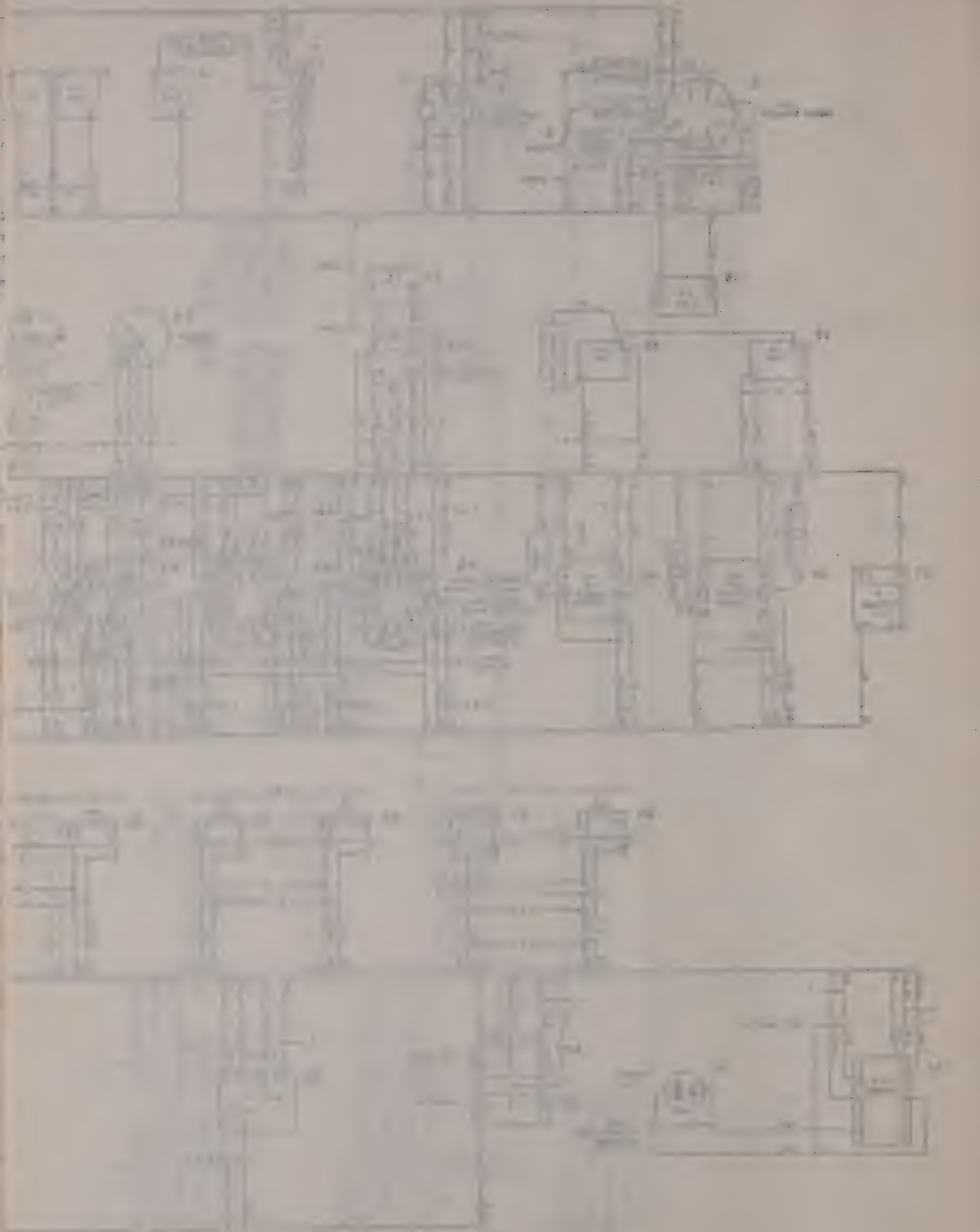
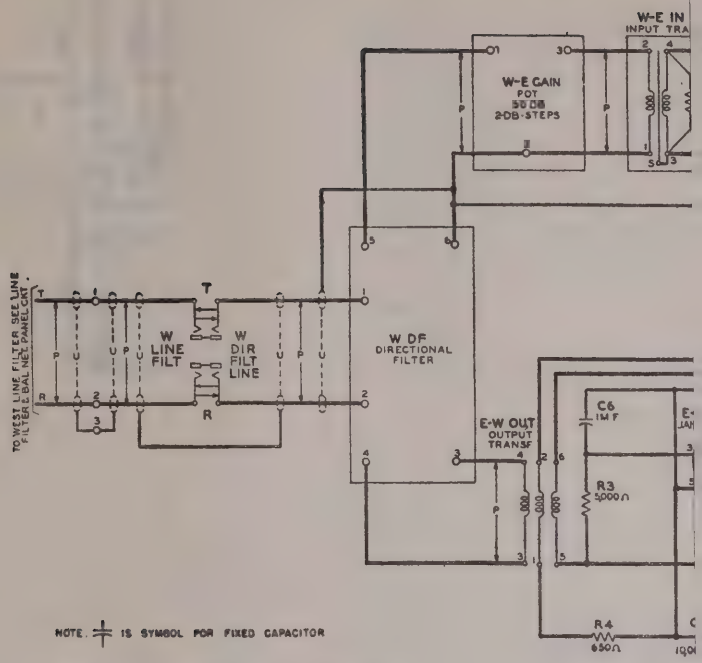


FIG. 1



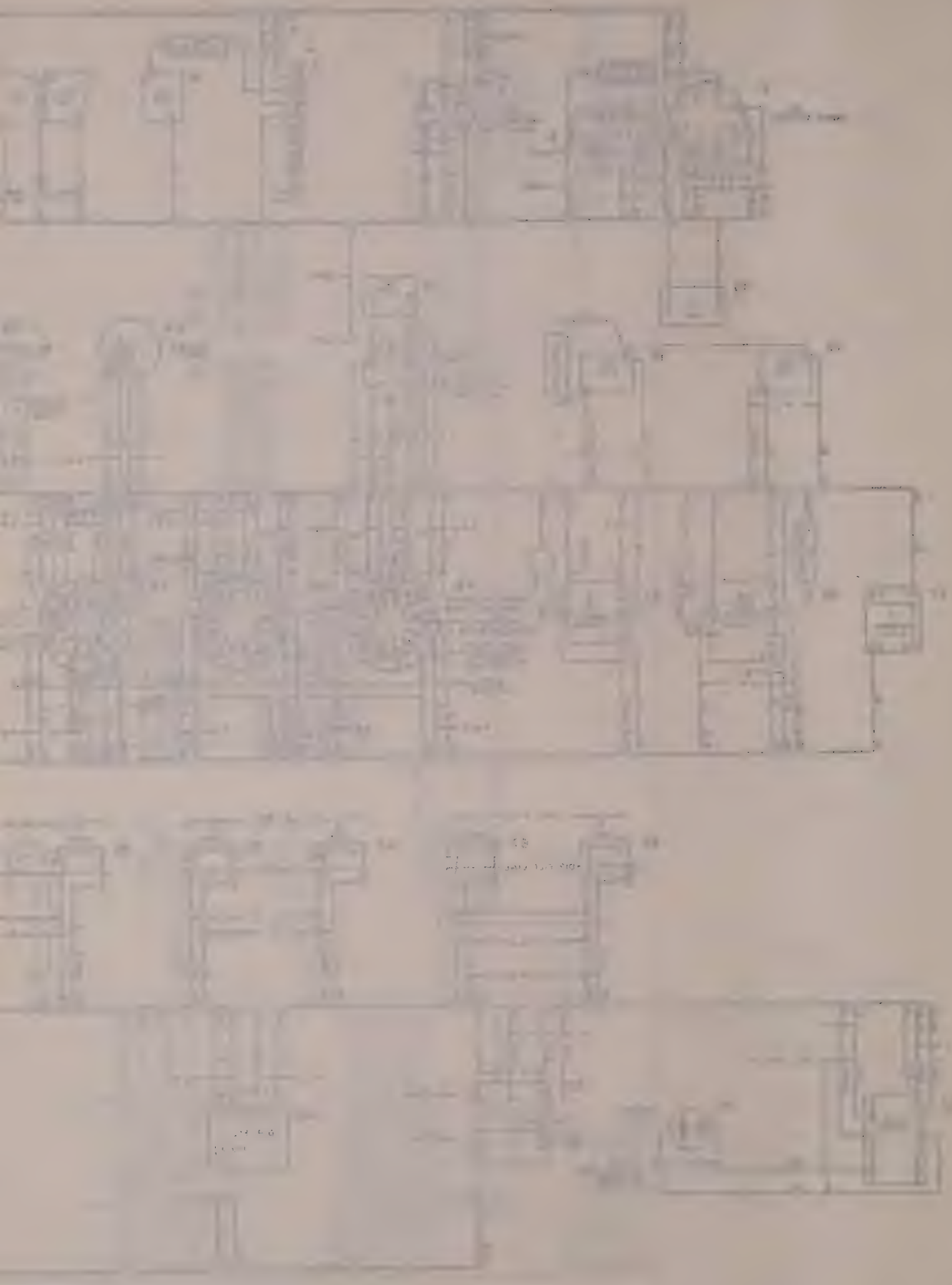
CIRCUIT NOTES:

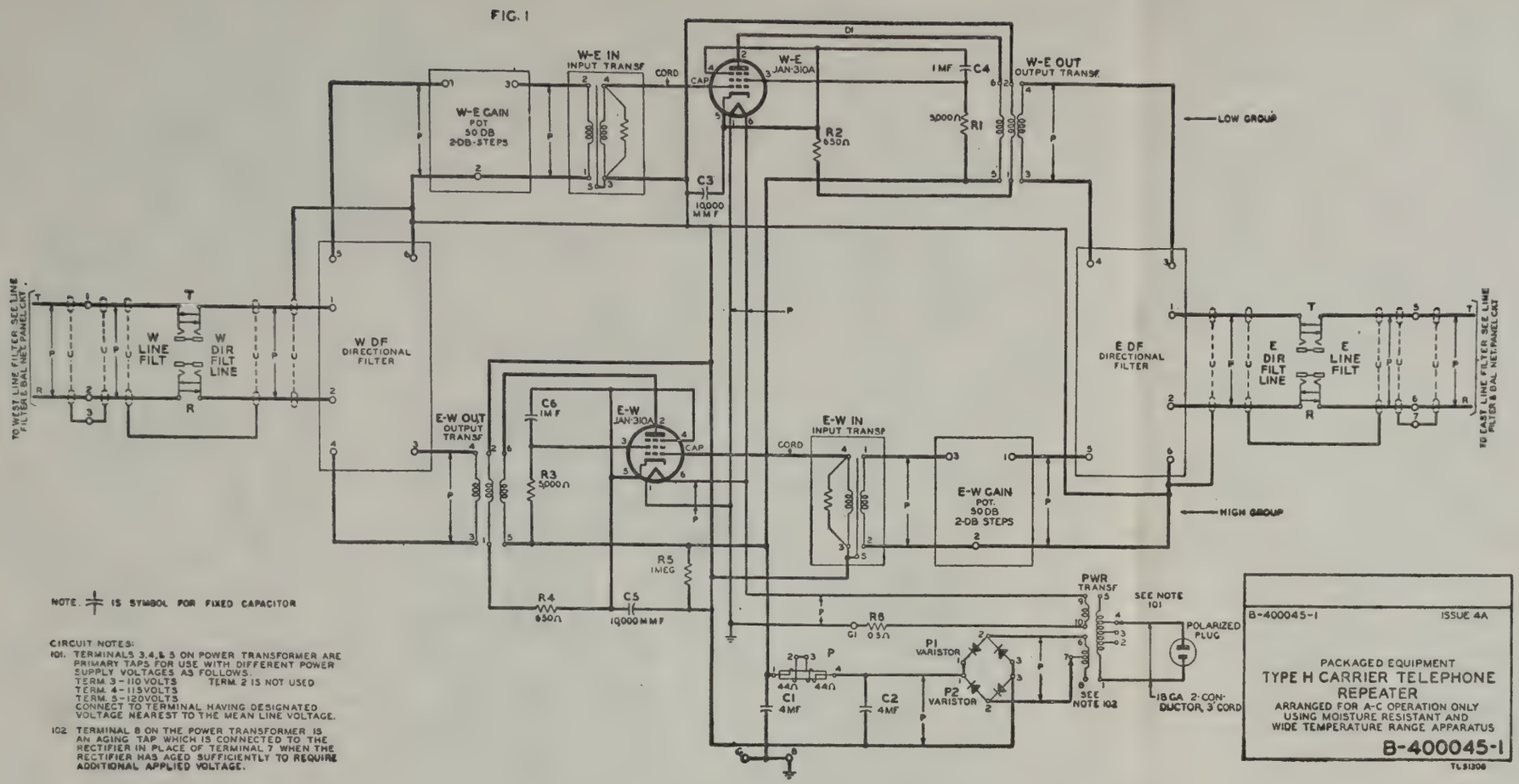
101. TERMINALS 3,4,& 5 ON POWER TRANSFORMER ARE PRIMARY TAPS FOR USE WITH DIFFERENT POWER SUPPLY VOLTAGES AS FOLLOWS.
TERM. 3 – 110 VOLTS TERM. 2 IS NOT USED
TERM. 4 – 115 VOLTS
TERM. 5 – 120 VOLTS
CONNECT TO TERMINAL HAVING DESIGNATED VOLTAGE NEAREST TO THE MEAN LINE VOLTAGE.

102. TERMINAL 8 ON THE POWER TRANSFORMER IS AN AGING TAP WHICH IS CONNECTED TO THE RECTIFIER IN PLACE OF TERMINAL 7 WHEN THE RECTIFIER HAS AGED SUFFICIENTLY TO REQUIRE ADDITIONAL APPLIED VOLTAGE.

Ref.	
Capac	
C1, C2	
C3, C5	
C4	
C6	
Co	
P	
Resis	
R1, R3	
R2, R4	
R5	
R6	
Transfo	
E-W IN	
W-E IN	
E-W OU	
E-W OU	

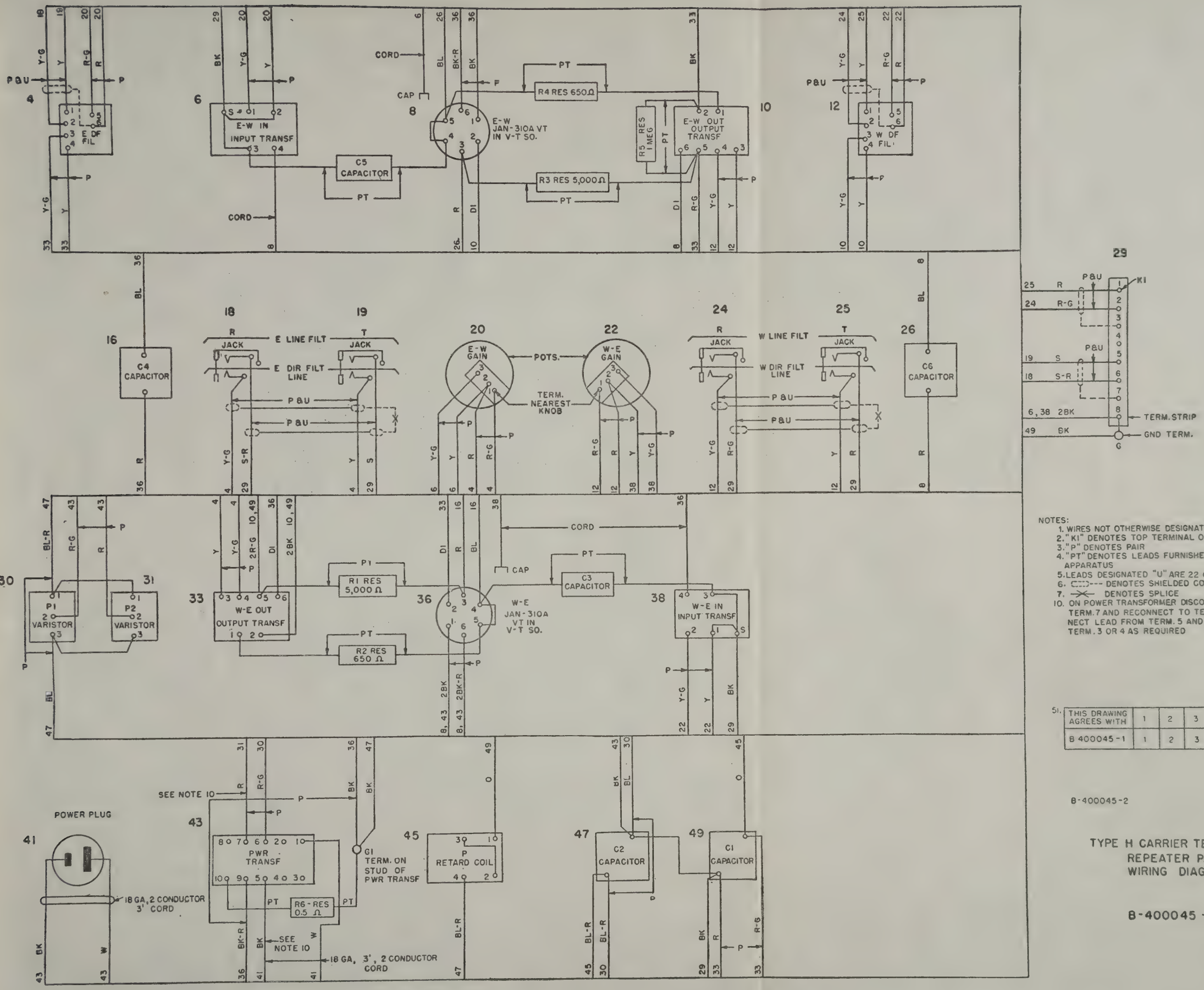
Drawing B-400045-1.





Ref. symbol	Value		Rating
Capacitors			
C1, C2		4 mf	500 v
C3, C5		10,000 mmf	400 v
C4		1 mf	200 v
C6		1 mf	800 v
Coil			
P	(1-2)	44 ohms	..
	(3-4)	44 ohms	
Resistors			
R1, R3		5,000 ohms	¼ w
R2, R4		650 ohms	½ w
R5		1 meg	¼ w
R6		0.5 ohm	½ w
Transformers			
E-W IN	(1-2)	25.2 ohms	..
W-E IN	(3-4)	4,190 ohms	
E-W OUT	(1-2)	4.4 ohms	..
E-W OUT	(3-4)	11.6 ohms	
	(5-6)	284 ohms	

Drawing B-400045-1. Type H carrier telephone repeater, schematic diagram.



NOTES:
1. WIRES NOT OTHERWISE DESIGNATED ARE 22 GA.
2. "K1" DENOTES TOP TERMINAL ON STRIP
3. "P" DENOTES PAIR
4. "PT" DENOTES LEADS FURNISHED AS PART OF APPARATUS
5. LEADS DESIGNATED "U" ARE 22 GA. SHIELDED WIRE
6. ⊏⊐--- DENOTES SHIELDED CONNECTION
7. —✕— DENOTES SPLICE
10. ON POWER TRANSFORMER DISCONNECT LEAD FROM TERM. 7 AND RECONNECT TO TERM. 8 AND DISCONNECT LEAD FROM TERM. 5 AND RECONNECT TO TERM. 3 OR 4 AS REQUIRED

51.

THIS DRAWING AGREES WITH	1	2	3	4	5	
B 400045-1	1	2	3	4	4	

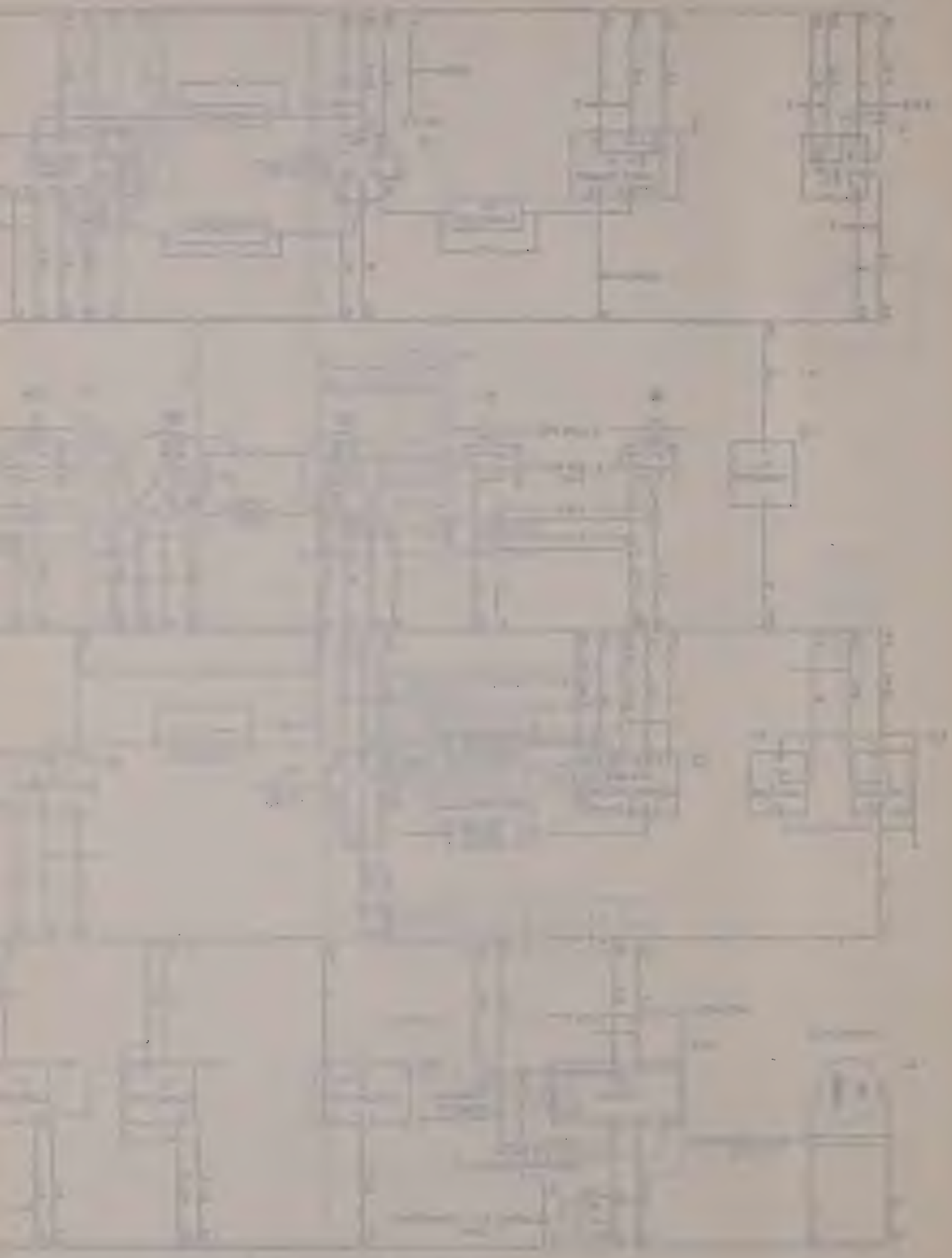
B-400045-2 ISSUE 5A

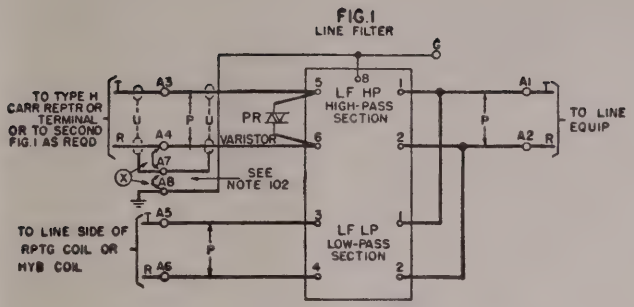
TYPE H CARRIER TELEPHONE REPEATER PANEL WIRING DIAGRAM

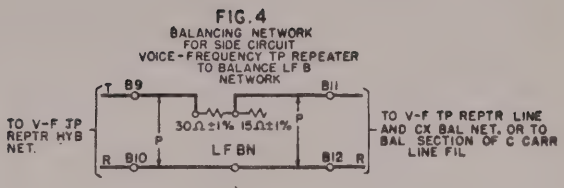
B-400045-2

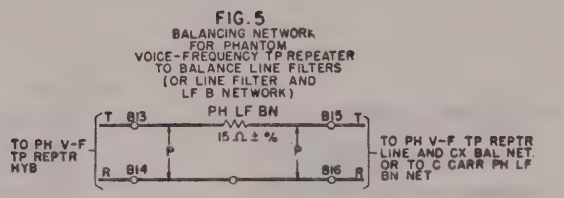
EL 51307

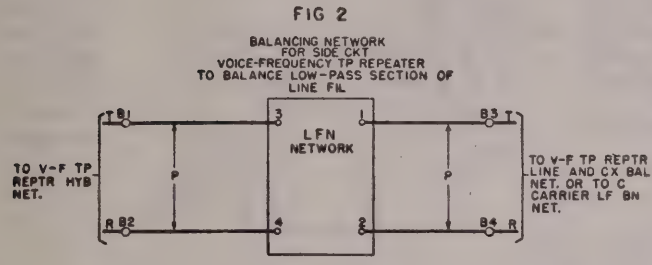
Drawing B-400045-2. Type H carrier telephone repeater, wiring diagram.







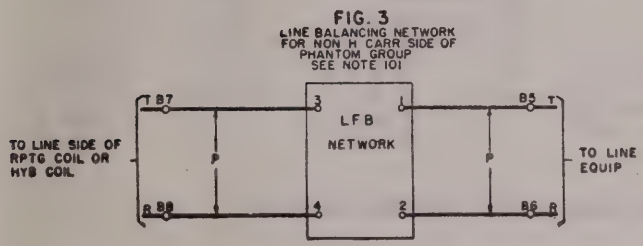




CIRCUIT NOTES:

101 PROVIDE FIG 3 IN SIDE CIRCUIT 2 OF A PHANTOM GROUP, TO BALANCE THE PHANTOM IMPEDANCE OF THE LOW-PASS SECTION OF A FIG 1 IN SIDE CIRCUIT 1, WHEN SIDE CIRCUIT 2 IS NOT EQUIPPED WITH TYPE H CARRIER.

102 WHEN FIG.1 IS USED AS A CARRIER TRANSFER CIRCUIT, "X" WIRING WILL BE PROVIDED BY THE INSTALLER.



B-400046-1 ISSUE 3A 3 SHEETS, SHEET 1

PACKAGED EQUIPMENT

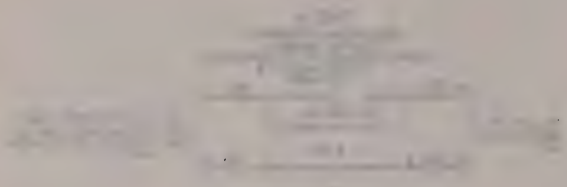
TYPE H CARRIER TELEPHONE
LINE FILTER AND BALANCING NETWORK PANEL
USING MOISTURE-RESISTANT AND WIDE TEMPERATURE RANGE APPARATUS

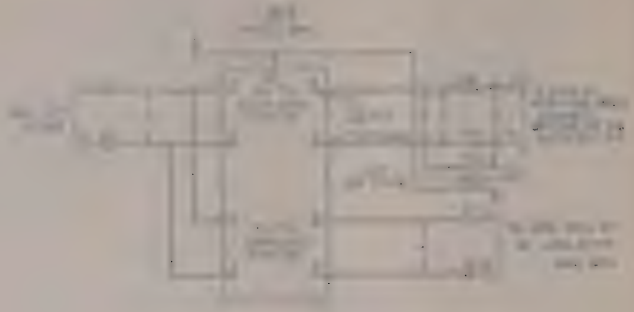
B-400046-1 TL 91304

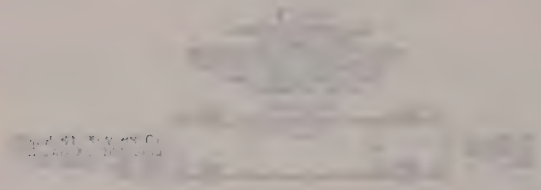
Ref. symbol	Value	Rating
Network		
LF B	8.5 ohms*	..
Resistors		
PH LF BN	15 ohms	5 w
LF BN	15 ohms, 30 ohms	5 w

* Effective resistance.

Drawing B-400046-1. Type H carrier telephone line panel, schematic diagram.

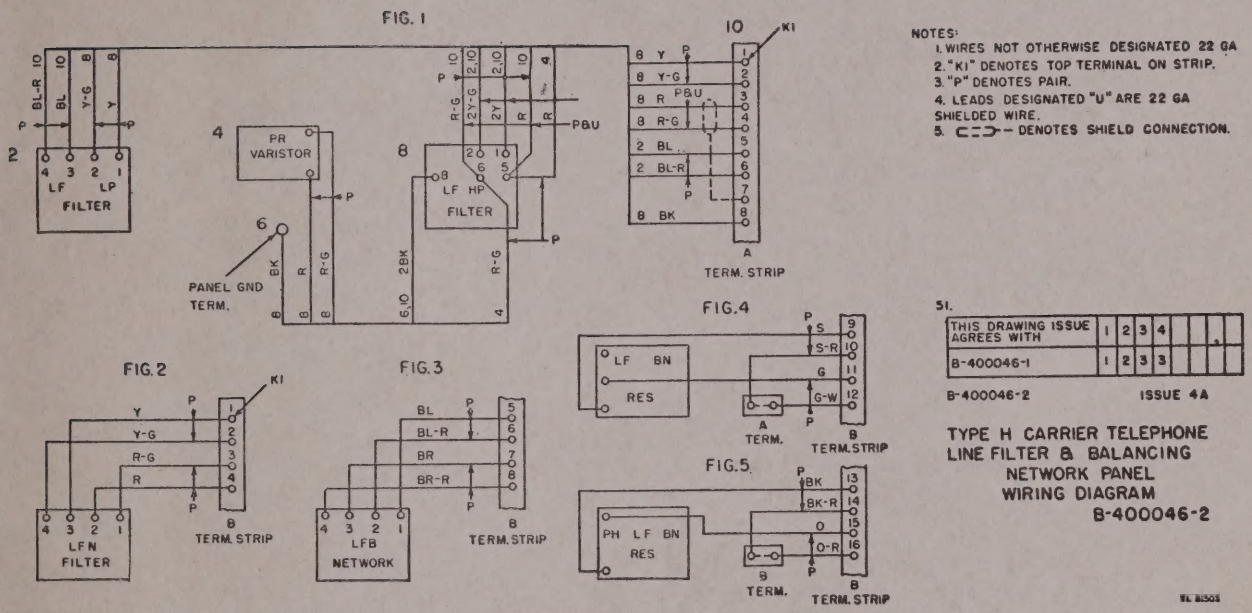




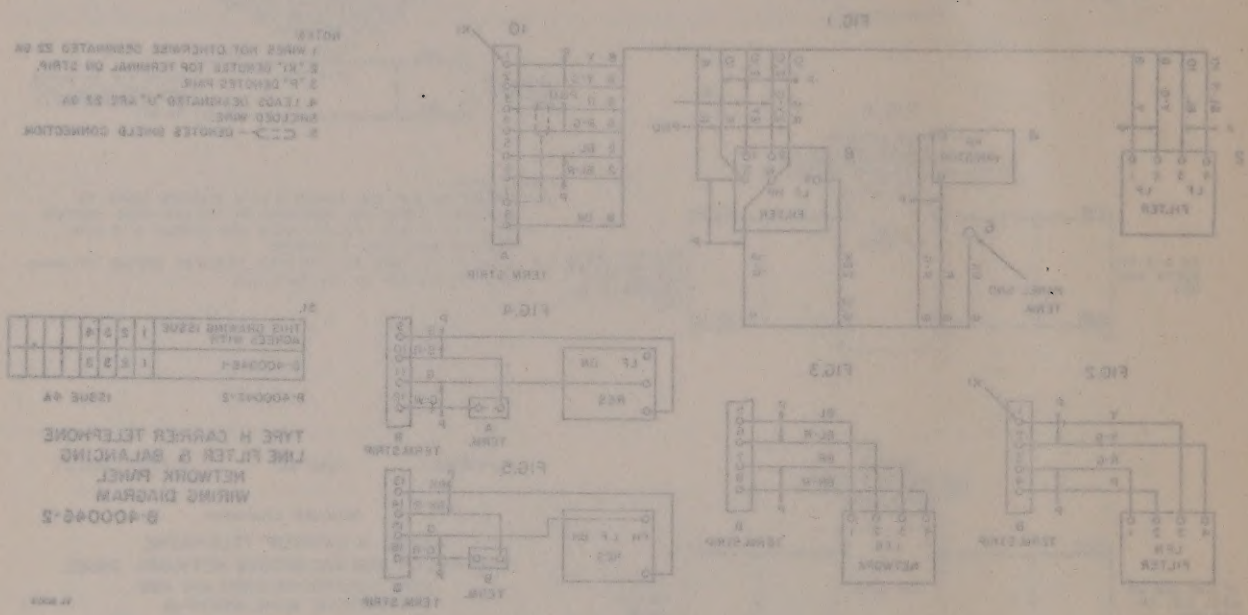








Drawing B-400046-2. Type H carrier telephone line panel, wiring diagram.



Drawing B-400046-2. Type H carrier telephone line panel wiring diagram.