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H1 CARRIER TELEPHONE EQUIPMENT

Instructions for Use

1. INTRODUCTION

General

1.01 The Western Electric H1 Carrier Telephone System is a single-channel system which provides for superimposing an additional telephone circuit upon an existing voice-frequency telephone circuit working over an open-wire line. The carrier equipment includes provision for operation on a ringdown basis and can be applied on a line without the loss of any existing service. It is suitable for use as a permanent installation and also for temporary or emergency circuits. Without an intermediate repeater, the system will find its widest application on open wire circuits of about 50-200 miles in length; with one or two intermediate repeaters it will be applicable on circuits up to as much as 500 or 600 miles in length (depending on the gauge of the open wire conductors, the amount of intermediate cable in the line, the number of bridged way stations, etc.).

1.02 The H1 system employs copper-oxide modulators and demodulators, heater type pentode tubes, and improved filters made possible by new magnetic alloys. The copper-oxide varistors used as modulators, demodulators and rectifiers in the power supply are of smaller size than the customary vacuum-tube devices, have the advantage of long life and small power consumption, and provide better balanced and more stable modulation. A single heater-type pentode tube in the transmitting amplifier works at approximately the same output level as two tubes in the older systems. It simplifies the problem of working from 110-volt a-c. supply by obtaining grid biases from across a resistance in the cathode circuit.

1.03 The terminal unit and the repeater may be operated either directly from a 115-volt 50-60 cycle alternating current source or from 24-volt and 130-volt batteries. This system employs the same carrier frequency, 7150 cycles, for both directions of transmission. The carrier frequency is generated locally at each terminal and only the sidebands are passed over the circuit. The upper sideband is used for transmission in one direction and the lower sideband for the other.

1.04 Because of the relatively short distances over which the system is designed to operate, no equalization is provided and no automatic regulation of the circuit net loss is employed. However, for the longer systems a manual compensating adjustment has been included in each terminal whereby the receiving gain may be changed in three steps of 2 db each. Similar arrangements are also provided to control the gain of a repeater, two steps of 4 db each being provided. These adjustments will compensate for changes in loss due to weather and temperature changes in the line.

1.05 It is necessary to compute and specify transmitting levels, repeater output levels, receiving levels, and circuit net loss for each H1 carrier circuit placed in service. This data should be based on the transmission performance of the carrier equipment and the characteristics of the open wire line and intermediate cable over which the system operates. Sufficient information for determining the required levels in the majority of cases has been included as a part this publication. The testing procedures herein presuppose that the levels have been determined and specified for the system which is to be put into service, and the section on "Overall System Line-Up" gives instructions for adjusting the system to the specified levels.

1.06 This equipment includes coils which require precautions to avoid possible injury through core magnetization during tests. Excessive direct current through such coils causes the cores to become permanently magnetized, changing the characteristics of the coils and rendering them unsatisfactory for the purpose for which they were designed. Since in many cases the detection of such damage to coils requires tests which cannot be made in the field, precautions must be taken to avoid injury to the coils and consequent unsatisfactory performance of the circuits under service conditions. The installer's ordinary buzzer should not be used, nor should test receivers or similar testing devices which will conduct direct current be used in continuity testing or trouble shooting on the equipment or its associated wiring or terminal strips unless protected by a series condenser. A tone buzzer set which does not make use of direct current in the circuit under test should be used for continuity testing wherever available. A voltmeter continuity test set is satisfactory because it limits the possible direct current to a very small value, but has the disadvantage of indicating continuity through a high resistance or an inductance.

1.07 The vacuum tubes in the terminals and repeaters should be allowed to heat at least five minutes after power supply connection has been made before making any tests or adjustments.

List of Drawings

1.08 The individual circuits employed in the H1 carrier telephone terminal, repeater, and carrier line equipment are covered schematically on the following drawings, which supplement the information given in this bulletin. A detailed description of each circuit is covered in a circuit description sheet (CD) numbered to correspond to the schematic drawing (SD).

SD & CD-64081-01—H1 Carrier Telephone Terminal Circuit
SD & CD-64082-01—H1 Carrier Telephone Repeater Circuit
SD & CD-64083-01—H1 Carrier Telephone Application Schematic

Wiring diagrams for the above circuits are covered by the following drawings:

P-412130—H1 Carrier Telephone Terminal Circuit Label
P-412131—H1 Carrier Telephone Repeater Circuit Label
T-64083-30—H1 Carrier Telephone Interconnecting and Battery Supply Circuit

NOTE: The circuit labels are furnished with each order for the equipment and should be fastened on the inside of the cover if the equipment is mounted in a cabinet, or on a suitable mounting board if the equipment is mounted on a relay rack. This should be done by the installer.

Typical arrangements for mounting H1 carrier telephone equipment on relay racks or in cabinets are covered by ED-61467-01—Typical Arrangement.

1.09 The schematic drawings are made up for use in testing and maintaining the equipment and a copy of the schematic of each circuit installed together with the associated circuit description should be kept on the premises for the use of the maintenance force. An explanation of the Circuit Requirement Table, associated with the schematic of each circuit employing relays, is given in Section 11, "Apparatus Requirements and Adjusting Procedures."

1.10 Some of the wiring diagrams employ the so-called "Airline" systems of showing connections. In the airline system, each individual piece of apparatus (each group in some cases) is numbered, and the lines representing the individual wire from each piece of apparatus are carried a short distance and terminated at a common or base line. These individual lines between 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 of the connection 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 jump directly between pieces of apparatus.

Testing Equipment

1.11 A 1-milliwatt source of 1000-cycle testing power is specified in the detailed procedures. This test power may be obtained from any suitable oscillator which will deliver 1 milliwatt of testing power into

600 ohms impedance. The portable 1000-cycle machine per KS-5472 is suitable for this purpose. Some of the tests for trouble location outlined in Section 10 specify testing power at frequencies of 6150, 7150 and 8150 cycles. In the event an oscillator is not available to provide these frequencies other tests can probably be devised locally which do not require these frequencies.

1.12 A transmission measuring set is specified in the detailed procedures. Any good 600 ohm set capable of measuring frequencies up to 10,000 cycles and having a range of 0-20 db may be employed. Voice-frequency transmission measuring sets can be used to make measurements in the carrier-frequency range employed by the H1 system provided their sensitivity does not fall off too rapidly with frequency. They should be calibrated for the particular frequencies above the voice range at which they will be used. The frequencies involved in the Type H system are 6150, 7150 and 8150 cycles. The Western Electric 12A Transmission Measuring Set is suitable, although primarily a voice frequency set. When it is used, and a calibration is not available, it may be assumed for the purpose of the tests in this section that the set is reading 0.8 db low for the frequencies given above, provided the set is properly calibrated at 1000 cycles.

1.13 An attenuator is specified in some of the test procedures. The Western Electric 1A Attenuator is suitable. Where a 600 ohm attenuator is not available, a locally assembled pad circuit may be used. Such a 600 ohm pad may be assembled by employing two Western Electric 1C Pads, into which 89 Type Resistance may be inserted. These resistances are provided in a wide range of values up to 15 db, and the code numbers are given below for pads which should meet the requirements of the tests given in this section.

Res. Code	*db Value*
89A	Zero (strapped thru)
89E	1
89J	2
89T	4
89AA	5
89BL	15

1.14 The following list of miscellaneous apparatus will be found useful in conducting the tests outlined below. Any equivalent apparatus which may be available may be used.

1. Model 564 Weston Volt-ohmmeter per KS-7345—Range 0-15, 0-30, 0-150 and 0-300 volts. If another type of voltmeter is used, it should have a resistance of not less than 1000 ohms per volt.

2. One model 280 Weston milliammeter—Range 0-1, 0-10 and 0-50 milliamperes.

3. Two Western Electric 893 Cords equipped with a 360A Tool at each end. These are 6-foot single-conductor test cords equipped with spring chucks for connection to Western Electric 364 or 365 Tools.

4. Four Western Electric 364 Tools. These are flat terminals for connection to the building posts on portable testing equipment.

5. Two Western Electric 365 Tools. These are spring clips for making temporary connections to apparatus terminals.

6. Two Western Electric P2AA Cords, 6-feet long, equipped with 241A Plugs at each end. These are double conductor test cords equipped with twin plugs at each end.

7. Two Western Electric S3F Cords equipped with 241A Plugs at one end. These are 6-foot triple conductor test cords equipped with cord tips at one end and a twin plug at the other.

8. One Western Electric 528 Receiver.

9. One Western Electric W2AB Cord equipped with 360A Tools at one end. This is a 6-foot double-conductor cord arranged to connect to the 528 receiver at one end and equipped with spring chucks at the other for connection to 364 or 365 tools.

10. One Western Electric 241A Plug. This is a twin plug for providing an open circuit condition.

2. DESCRIPTION AND FUNCTIONS OF COMPONENT UNITS

Terminal Panel

2.01 The H1 carrier terminal panel includes all the equipment required at a terminal with the exception of the line filter, line filter balancing unit, networks for balancing voice repeaters, and test jacks. It includes the hybrid coil, modulator, transmitting amplifier, demodulator, receiving amplifier, carrier supply oscillator, signaling equipment, various filters and pads, and a-c. power supply equipment.

2.02 The circuit is shown schematically in Figure 1. The transmission path is indicated by the heavy lines on the drawing. This drawing is sufficiently general to cover either the east or the west terminal, but it should be understood that there are differences in the filters, oscillator circuit and some of the resistance units.

2.03 The incoming talking currents enter the equipment from the switchboard, and after passing through the hybrid coil are connected to the modulator through a low-pass filter (TLF). The low-pass filter suppresses undesirable speech and noise frequencies above the useful voice-frequency band. The output of this filter connects to a varistor (MOD) which serves as a balanced modulator. A carrier of 2.5 volts having a frequency of 7150 cycles is supplied to the modulator from the oscillator circuit described below, being impressed at the midpoints of one winding of the hybrid coil (HYB) and the repeating coil (MOD OUT) which serves as a modulator output coil. The lower sideband extending from about 4150 to 6900 cycles if it is a west terminal, or the upper sideband extending from about 7400 to 10,150 cycles if it is an east terminal, is passed through the filter (MOF) the transmitting gain pad (TR) and transmitting amplifier (SB) to the directional filter which affords additional suppression for unwanted frequencies. From the directional filter the outgoing circuit passes through the carrier equipment jacks and the high-pass filter unit of the line filter set to the outgoing line.

2.04 The transmitting gain pad has an impedance of 600 ohms and is adjustable by means of soldered straps to permit introducing attenuation in 0.5-db steps from 0 to 31.5 db. The entire pad is contained in a small metal case and mounted as a single apparatus unit with the terminals for adjustment accessible from the front of the panel.

2.05 The transmitting amplifier consists of an input transformer, a 328A Vacuum Tube, an output transformer, and associated circuits. The circuit is arranged to provide negative feedback through two paths. One of these is formed by the common resistance (G) between the grid and plate circuits; the other is due to 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.

2.06 Incoming transmission after passing through the line filter and (CARR EQPT) jacks is selected by the proper filter unit of the directional filter and is passed through two pads which can be manually switched either into or out of the circuit, thus affording a means for readily changing the receiving gain to take care of variations in line attenuation due to weather. The incoming currents are then passed through the receiving gain pad (REC) which is similar to the transmitting gain pad and is employed to adjust the level at the input to the demodulator to a specified value. After passing through this pad the incoming currents go to the varistor (DEM), which acts as a demodulator, the carrier supply being received from the oscillator circuit through the midpoints of the repeating coil (DEM IN) and the amplifier input transformer (V IN). The output from the demodulator is connected to a low-pass filter which suppresses the frequency above the voice range. The incoming voice frequencies are amplified by the receiving amplifier, which is similar in design to the transmitting amplifier.

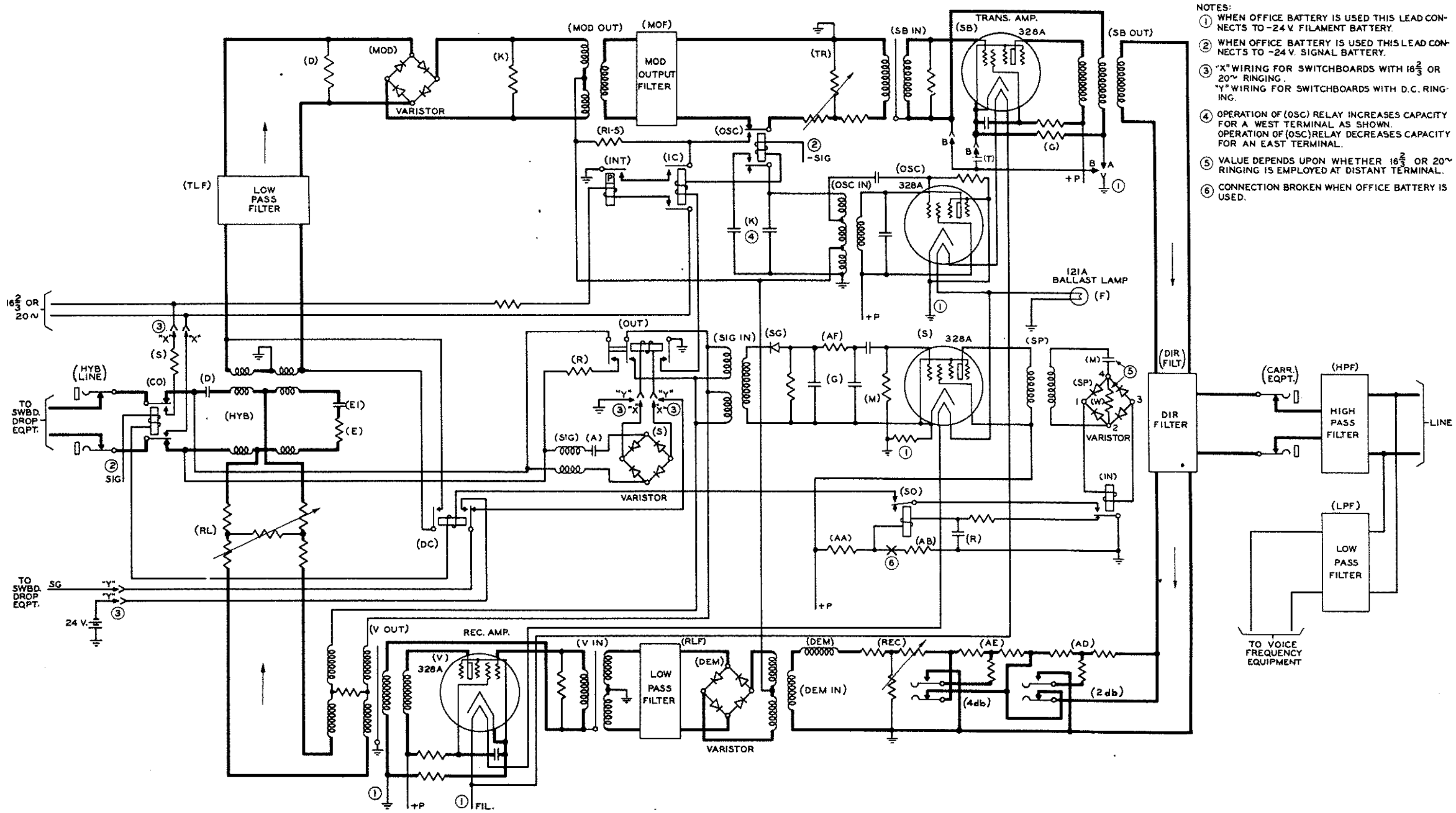


Fig. 1—Schematic of Terminal Transmission and Signaling Circuits

2.07 The receiving amplifier has a hybrid type output coil (V OUT) which provides means for taking off both the incoming signaling and voice currents. This hybrid coil is an inequality ratio coil which is so designed that the loss to the voice circuit is 7.5 db and to the signaling circuit 1.5 db. The voice-frequency output from the receiving amplifier output coil passes through the receiving level pad (RL) which is generally similar to the transmitting gain pad, to the voice-frequency hybrid coil (HYB), and thence to the switchboard. The voice-frequency level at the hybrid line jacks is adjusted to the desired value by means of the receiving level pad.

2.08 Carrier frequency supplied to the modulator and demodulator is derived from a vacuum tube oscillator employing a 328A Vacuum Tube. This oscillator is normally adjusted to produce 7150 cycles, the output being taken off across one winding of the oscillator coil (OSC IN), one side of which is grounded. The oscillator circuit is so arranged that for signaling purposes the carrier frequency at the transmitting terminal may be increased or decreased 1,000 cycles for an east or a west terminal. This is accomplished by decreasing or increasing the capacitance of the condenser (K).

2.09 The signaling circuit in the schematic shown in Figure 1 provides for ringdown operation of the circuit, either from switchboards utilizing 16⅔ or 20-cycle ringing or from switchboards employing d-c. signaling. This current will be referred to as 20 cycle current. No provision is made for through supervision or dialing.

2.10 Signaling currents over the line are transmitted at a frequency of 6150 cycles for a west terminal or 8150 cycles for an east terminal and interrupted at the rate of 20 cycles. The signaling current is started by a 20-cycle current entering the carrier terminal circuit on the "T" and "R" leads in a switchboard employing 20-cycle ringing, or by battery received over the "SG" lead in a switchboard employing d-c. signaling.

2.11 The incoming high-frequency signaling current from the distant terminal appears at the output of the demodulator as 1000-cycle current interrupted at a 20-cycle rate. It causes relays to operate to send 20-cycle current out to the switchboard over the "T" and "R" leads, or battery over the "SG" lead, depending on the type of switchboard. The circuit is so adjusted that it will not function on a ring of less than about 4/10 of a second. This delay guards against false operation of the incoming signal circuit by speech currents or noise.

2.12 In some cases it may be desired to extend the carrier system by a voice circuit and employ 1000—20 cycle ringing over the combination circuit. In this case signaling arrangements for the carrier terminal at the junction point may be disabled by removing signal battery from the terminal.

2.13 The a-c. power supply for the H1 carrier terminal, shown schematically in Figure 2, is included as part of the carrier terminal panel. The power supply unit is designed to function from an alternating current source of 100 to 130 volts, 50 to 60 cycles. The output of one winding of the power transformer is rectified by means of the 274A Vacuum Tube to give a plate voltage of approximately 160 volts. A second winding on the secondary side of the transformer supplies 24 volts a-c. for the filament circuit of the tubes. A third winding provides 5 volts for the filament circuit of the rectifier tube. The fourth winding supplies alternating voltage which is rectified by the varistor and provides direct current at a minimum of 20 volts for the relay circuits. The line contacts and wiring of the power supply unit are completely enclosed in a metal housing, so arranged that it can not be removed without first disconnecting the primary power source, in order to prevent accidental contact with the high voltages developed.

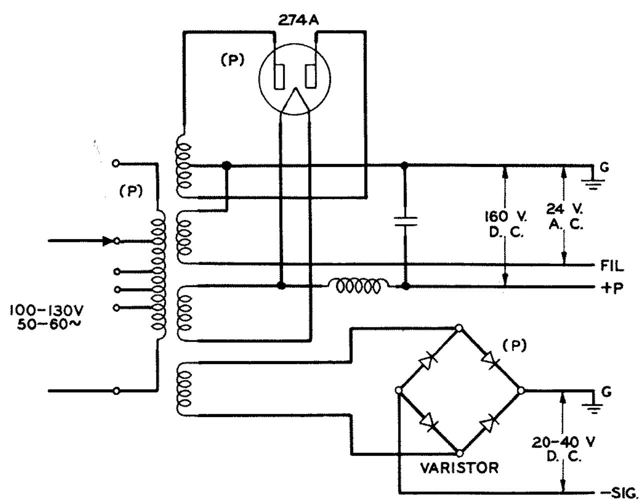


Fig. 2—Schematic of Terminal Power Supply Circuit

2.14 Optional connections are included in the terminal panel for connecting directly to office filament and plate battery supplies where these are available. The plate voltage required is then obtained from the office filament and plate batteries which in series supply about 154 volts.

Line and Balancing Equipment

2.15 The line filter and balancing equipment required for use with the H1 equipment is mounted on a panel suitable for mounting adjacent to the terminal equipment. A typical application of the various units of the line filter and balancing network panel is shown in Figure 3. This illustration shows a phantom group equipped with an H1 system on one side circuit only. The insertion of a carrier 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. Accordingly a line filter balance unit (LFB) is employed for this purpose. This network, which consists of a retard coil, is coded as the 156A Network. It is always included in the line filter and balancing panel assembly, although it is not required in non-phantom circuits or where both sides of the phantom group are equipped with an H1 system.

2.16 Lines employing voice-frequency repeaters require the addition of balancing networks when carrier equipment is added. For a voice repeater in the side circuit over which the H1 system is operated, a network called the line filter net (LFN) is required to balance the line filter. This network is paired at the factory with its associated line filter and the combination coded as the 86A Filter. In the case of a voice repeater used on a physical circuit equipped with a line filter balance unit, a resistance, designated LF BN is all that is required to balance the network. A single resistance termed the line filter phantom net (PH LFN) is also all that is required to balance a voice repeater in a phantom circuit over one or both sides of which an H1 system is operating. The balancing equipment is included on the panel assembly.

Repeaters

2.17 A repeater is available for extending the transmission range of the H1 system. A schematic diagram of the repeater is shown in Figure 4. The amplifier tubes and circuits employed in the repeater are the same as those utilized for the high-frequency amplifier at the terminal. The repeater panel also includes directional filters, manually adjustable gain control pads, and an alternating current power supply unit.

2.18 The repeater may be operated from 100-130 volts, 50-60 cycle alternating current or from central-office filament and plate battery supply.

2.19 The power supply unit is similar to that shown in Figure 2 for use with the carrier terminal, except that 24-volt direct current supply is not required for relay operation, and therefore the varistor is omitted. Optional wiring for operation from filament and plate batteries is included in the repeater panel assembly.

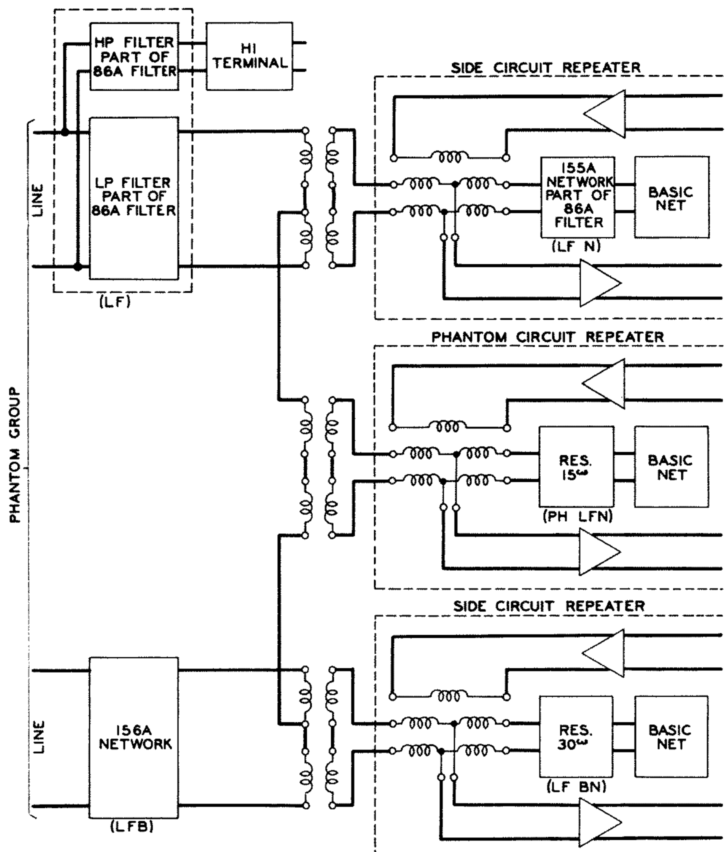


Fig. 3—Typical Line Filter and Voice Repeater Balancing Equipment Repeaters

2.20 Two line filter and balancing panels of the type used with the carrier terminal equipment are required with each repeater. Each panel is equipped with two sets of jacks, although only the jacks designated CARR EQPT are normally employed for the repeater. The jacks associated with one panel are employed for the west side of the repeater and those associated with the second panel for the east side.

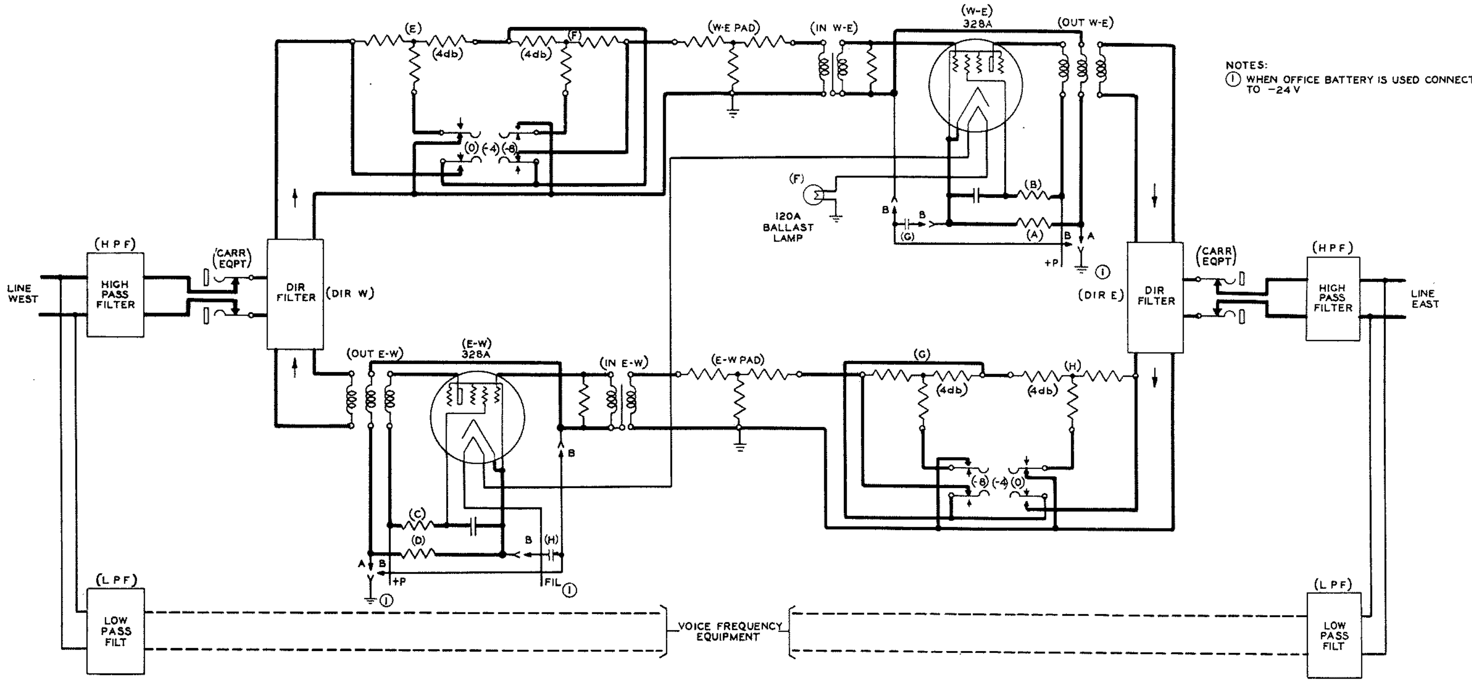


Fig. 4—Schematic of Repeater

Carrier Transfer Equipment

2.21 Where it is necessary to transfer the carrier circuit from one pair of wires to another or to by-pass voice-frequency equipment, such as a repeater, a carrier transfer circuit is used. No special equipment has been designed for this purpose since a complete carrier transfer circuit can be formed by utilizing two of the line filter and balancing panels described above. The high frequency drops of the line filters are connected together and the drops of the low-pass filters connected to the voice-frequency equipment. Longitudinal currents of carrier frequency are prevented from passing from one line to the other by the coils in the high-pass units of the line filters.

3. POWER SUPPLY REQUIREMENTS

Terminal

3.01 The H1 carrier telephone terminal requires 24 volts d-c. or a-c. for the vacuum tube filaments and 24 volts d-c. for all but one of the relay circuits. 160 volts d-c. is required for the plates of the tubes and one relay. A power supply unit operating from an alternating current source is included in the panel assembly and this unit takes care of the power requirements. However, the 20-28 volt and 125-135 volt office batteries can be used if desired, the sum of the two providing an effective plate voltage of about 154 volts. A source of either 16⅔ or 20 cycle power of at least 70 volts is required for interrupting the outgoing high-frequency ringing currents. It is assumed that the 16⅔ cycle supply will be within the limits of 15.6 to 16.75, or the 20 cycle supply within the limits of 18⅓ to 20 cycles. However, the frequency limits can be extended to about 14.5 to 23 cycles by changing a resistance in the receiving signaling circuit.

3.02 The current drains for the various circuits are given in the following table:

Current Drains for H1 Terminal

24-volt Filament Circuit	0.850 ampere
160-volt Plate Circuit	0.030 ampere
24-volt Relay Circuit	0.250 ampere
160-volt Relay Circuit	0.005 ampere

The power supply unit provided with the equipment functions from an alternating current source of from 100 to 130 volts, 50 to 60 cycles and requires a power of 50 watts.

Repeater

3.03 The H1 carrier telephone repeater requires 24 volts d-c. or a-c. for the vacuum tube filaments and 160 volts for the plates. As in the case of the terminal equipment, the repeater panel includes a power supply unit for operation from 110 volt a-c. supply; or 20-28 volt and 125-135 volt office batteries can be used if desired.

Current Drains for H1 Repeater

24-volt Filament Circuit	0.420 ampere
160-volt Plate Circuit	0.015 ampere

The power supply unit functions from an alternating current source of from 100 to 130 volts, 50 to 60 cycles and requires 35 watts of power.

4. TRANSMISSION PERFORMANCE

4.01 This section describes the transmission performance of the H1 carrier telephone system. The transmission range of the system is discussed and other pertinent data relative to the overall characteristics of the system are included. The description is illustrated by graphic data on the performance of the equipment and system. A brief discussion of crosstalk and noise is included.

Transmitting and Receiving Gain

4.02 A transmitting gain of about 19 db should be obtained in an H1 carrier terminal, measured between the hybrid line and carrier equipment jacks with the (TR) pad set for zero db. The receiving gain, measured between the same points with all of the pads in the receiving circuit adjusted for zero db, is of the order of 14 db for an east terminal and slightly higher for a west terminal. Although there will be slight variations in individual terminals due to manufacturing tolerances, the gains given above will be secured in all cases. The variation in these gains with tubes is slight, as is also the variation due to small changes in the voltage supply. Over long periods slight decreases in the transmitting and receiving gains may result because of aging of the varistors but these changes are not expected to be large.

4.03 The maximum transmitting and receiving gains cannot be utilized at the same time since these gains are limited by the permissible loop gain which is defined as the sum of the net transmitting and receiving gains at any one terminal. The permissible loop gain has been established as 22 db for a west terminal and 20 db for an east terminal. If higher gains are employed the voice-frequency impedance of the carrier circuit may be adversely affected by currents circulating around the terminal itself. However, an increase of 2 db at each terminal will, in general, not be greatly objectionable.

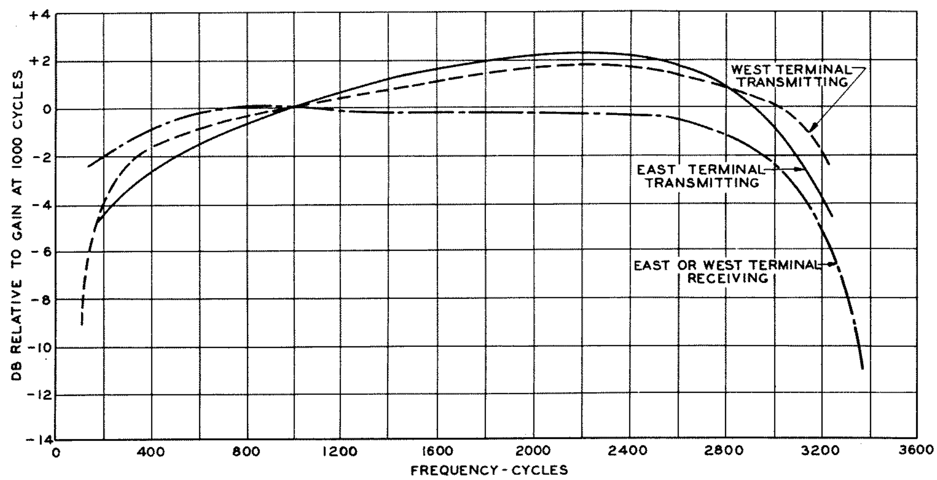


Fig. 5—Representative Transmitting and Receiving Gain-Frequency Characteristics for Terminals

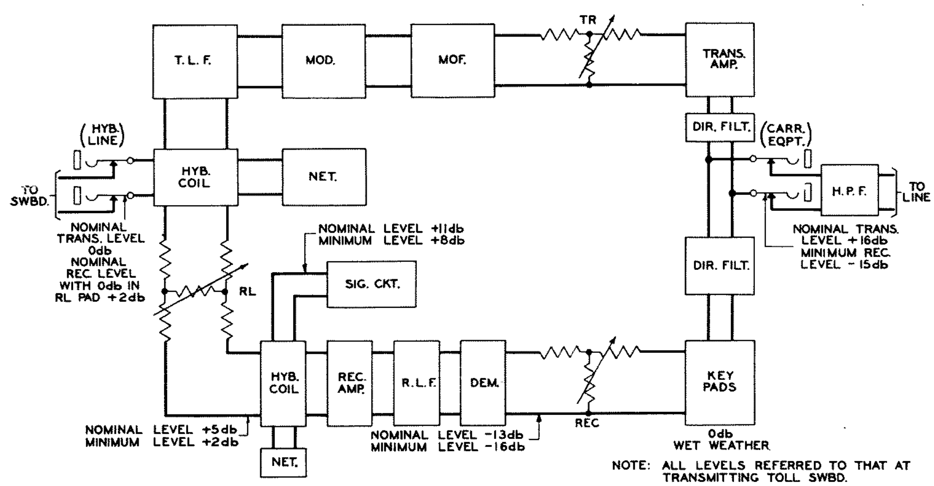


Fig. 6—Nominal Transmission Levels for H1 Terminal

4.04 Representative transmitting gain-frequency characteristics for an east and a west terminal are given in Figure 5. The receiving gain-frequency characteristic is substantially the same for either terminal, and a representative curve is given in the same figure. The frequencies shown are those of the voice band although the currents transmitted to or received from the line are actually of high frequency. The curves show the gains at various frequencies relative to those at 1000 cycles.

Operating Levels

4.05 Figure 6 shows the levels at which the H1 terminal is designed to operate. All the levels in this figure are referred to that at the transmitting switchboard and are determined primarily by the load-carrying capacities of the amplifiers, signaling requirements, and line noise considerations.

4.06 The transmitting level at the (CARR EQPT) jacks should not exceed +16 db. The incoming high frequency level at the input to the demodulator (DEM) should preferably be −13 db. This level is obtained by adjusting the receiving gain pad (REC). Since the loss between the demodulator and the (CARR EQPT) jacks, when the receiving gain and key controlled pads are adjusted to have zero loss, is about 1 db, it follows that the receiving level at the (CARR EQPT) jacks cannot be less than −12 db to obtain this condition. In general, the minimum level at this point should not be less than −15 db.

4.07 Since the maximum receiving gain for the terminal is about 14 db, the receiving level at the (HYB LINE) jacks will be about +2 db for an input level of −12 db at the (CARR EQPT) jacks or −13 db at the demodulator input with no loss in the receiving level pad. When the input level at the (CARR EQPT) jacks is −15 db, or −16 db at the demodulator, the receiving level at the (HYB LINE) jacks will be about −1 db with the receiving level pad adjusted for 0 db. The practicability of obtaining these receiving levels depends, of course, upon the line loss and loop gain limitations.

4.08 The receiving signaling circuit is taken off the receiving amplifier output hybrid coil at a level referred to the switchboard about 6 db higher than the level of the voice output from this coil, which is +5 db. Accordingly the level at the input to the signaling circuit is about +11 db with an incoming high frequency level of −13 db at the (DEM) input or +8 db for a (DEM) input of −16 db. These levels are adequate for proper functioning of the signaling circuit when the signal output power at the carrier equipment jacks at the distant terminal is properly adjusted. If possible the higher level should be employed, as with the lower level the signaling margin is reduced 3 db.

Transmitting Signaling Power

4.09 The uninterrupted signaling power can be adjusted to a value of from 1 to 21 db above 1 milliwatt at the carrier equipment jacks when the terminal is adjusted for a transmitting gain of 16 db. The transmitting signaling power referred to 1 milliwatt is ordinarily adjusted to 2 db below the specified transmitting level.

Carrier Supply

4.10 The carrier frequency oscillator circuit utilized in the H1 terminal can be adjusted by means of the condensers provided to within

±0.3 cycle of the nominal carrier frequency of 7150 cycles and to within ±4 cycles of the signaling frequency. These adjustments are made at the factory and no adjustment need be made at the time the system is installed. The frequencies at either terminal are not expected to change appreciably with different tubes nor to vary greatly for differences in filament or plate supply likely to be encountered. A maximum change of ±20 cycles is possible due to aging and the total variation should not be more than ±25 cycles even over long periods. If necessary, the carrier frequencies at the two terminals can be synchronized at any time.

Repeater

4.11 The H1 repeater will provide a maximum gain of about 29 db in either direction of transmission for those frequencies equivalent to the 1000-cycle point in the voice frequency currents. The usable gain is, however, limited by the permissible loop gain (the sum of the net gains in each direction), which is 45 db. The total of the gains in the two directions must, therefore, be held to this value in order to meet singing margin requirements. Representative gain-frequency characteristics for both directions of transmission are given in Figure 7 for a gain of 15 db in each direction, corresponding to a loop gain of 30 db. As the loop gain is increased the transmission-frequency characteristics may be expected to become somewhat less uniform.

Transmission Range of System Without Intermediate Repeater

4.12 The maximum length of line over which the H1 system can operate satisfactorily depends, of course, upon the type of line facili-

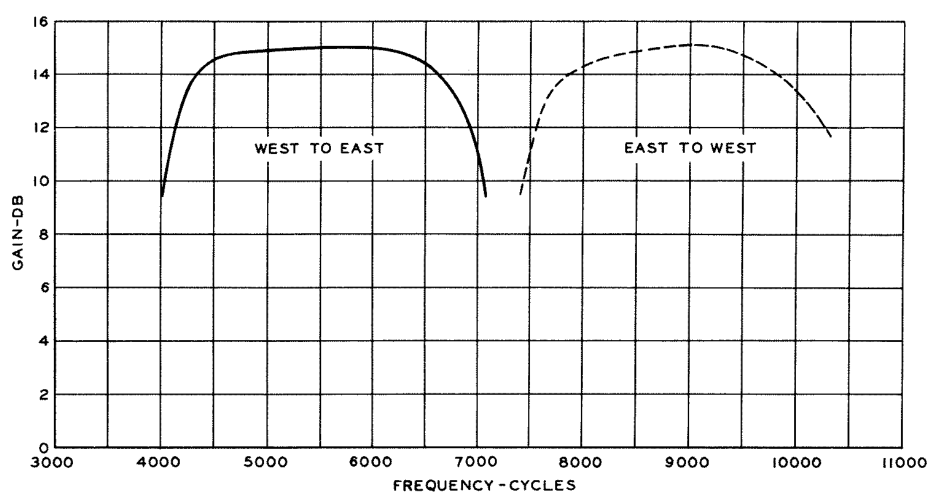


Fig. 7—Representative Gain-Frequency Characteristic of Repeater—30 db Loop Gain

ties involved. For this reason, it is more convenient to express the transmission range of the system in terms of the maximum attenuation which can be spanned than in terms of geographical length. The maximum attenuation over which the system can be operated is based on that at 8150 cycles which corresponds to the 1000-cycle point in the east to west high frequency band.

4.13 When an intermediate repeater is not employed, the transmission range of the system is limited by the permissible loop gains, noise, and the levels required at the input to the demodulator as explained in Section 4.06. As pointed out in Section 4.03, there is a difference of 2 db between the loop gain limitation for a west terminal and that for an east terminal. Since the line loss for the limiting length of line in the west to east direction is somewhat less than that in the opposite direction, due to the lower frequency employed, the difference of 2 db in the loop gain requirement for the two terminals is about cancelled by the difference in line attenuation. The transmission range of the system is limited therefore by the loop gain limitation for the west terminal.

4.14 For 22 db of loop gain at a west terminal, and with a transmitting gain of 16 db, the usable receiving gain is limited by the loop gain to 6 db so that the available 14 db of receiving gain must be reduced by 8 db. For the limiting length of line there will be no loss in the receiving gain pad (REC) and hence the entire 8 db must be introduced by the receiving level pad (RL). The maximum transmission range of the system for a transmitting gain of 16 db and a receiving level of —13 db at the input to the demodulator (—12 db at the carrier equipment jacks), is, accordingly, limited to facilities having a maximum 8150-cycle attenuation of 28 db; and the lowest circuit net loss for such a condition is 6 db.

4.15 However, by accepting a somewhat decreased signaling margin (or, where conditions permit, by increasing the outgoing signaling power as indicated in a later paragraph) the transmission range of the system can be extended slightly. As already explained, the signaling margin should not be reduced more than 3 db corresponding to an input to the demodulator of —16 db (—15 db at the input to the terminal). In this case the maximum 8150-cycle attenuation which may be spanned is extended to 31 db. However, because of loop gain limitations, the corresponding lowest circuit net loss is 9 db. In cases where the loop gain can be increased by 2 db, the lowest net loss can be reduced to 7 db.

4.16 The following table gives the transmission range of the system when operated without an intermediate repeater and with a transmitting level of +16 db, normal transmitting signaling power, and a loop gain of 22 db at the west terminal and 20 db at the east terminal. The table shows the maximum 8150-cycle attenuations which can be spanned together with the corresponding lowest circuit net losses. The signaling power at the (SIG IN) transformer and the setting for the receiving level and west terminal receiving gain pads are also included in this table. The setting for the corresponding receiving gain pad at the east terminal is slightly different due to the difference in line attenuation for the two directions of transmission. All the values given are based on a terminal having a maximum receiving gain of 14 db and a usable gain, due to the loop gain requirement, of 6 db. Inasmuch as the maximum receiving gain varies slightly for different terminals the figures given are approximate.

TRANSMISSION RANGE OF SYSTEM WITHOUT INTERMEDIATE REPEATER

*Max. 8150-Cycle Attenuation**	*Lowest Circuit Net Loss*	*Signaling Power at* (SIG IN) *Transformer*	*Receiving Level Pad*	*West Terminal Receiving Gain Pad*
31 db	9 db	+6 above 1 mw.	8 db	0 db
30	8	+7	8	0
29	7	+8	8	0
28	6	+9	8	0
27	5	+9	7	1
26	4	+9	6	2
25	3	+9	5	3

*For 114-mil wire wet weather attenuation at 8150 cycles is approximately 0.102 db per mile.

4.17 Where circuit net losses greater than 9 db will be satisfactory, and if noise and crosstalk conditions will permit, the transmission range of the system can be extended somewhat by allowing the input level to drop below −15 db at the carrier equipment jacks and increasing the signaling power at the transmitting terminal. The increase in signaling power available when the transmitting level is +16 db is about 10 db.

4.18 When an H1 system is extended by another type of facility at either or both ends, it may be possible where good return losses are obtained on the extended facilities to use lower net circuit losses on the carrier system than are indicated in the preceding table. Where this is done, however, the maximum attenuation which can be spanned is, of course, reduced accordingly.

Effect of Repeaters on Transmission Range

4.19 The use of one or more intermediate repeaters permits the distance over which an H1 system can be operated to be considerably increased and still obtain the circuit net losses referred to above. In general, the number of intermediate repeaters should not be greater than two or three. Also, as the circuit is lengthened the maintenance will be increased since more frequent adjustments of the overall net loss are required to compensate for variations in line attenuation with weather.

4.20 The maximum usable repeater gains are limited by the loop gain requirement which is 45 db and by the maximum allowable transmitting output level of +16 db. With a repeater located approximately midway (from an attenuation standpoint) between terminals or midway between a terminal and a repeater, the usable gains are thus about 23.5 db in the east to west direction (8150 cycles) and 21.5 db in the west to east direction (6150 cycles). For such cases the additional 8150-cycle attenuation which may be spanned by each repeater is about 23.5 db. Where it is not possible to locate the repeater approximately midway in the line, this figure will, in general, be reduced due to the transmitting output level limitation.

Overall System Transmission-Frequency Characteristics

4.21 Since no equalization is provided in the terminal equipment, the transmission-frequency characteristics of the system without an intermediate repeater will depend largely on the terminal equipment and on the attenuation-frequency characteristic of the line over which the system is operated. In general, it should be possible, where repeaters are not employed, to obtain transmission bands having losses at 250 and 3000 cycles not greater than 10 db referred to the 1000-cycle point. Some variation will occur due to manufacturing variations in the equipment, but such variations are expected to be small.

4.22 Representative overall transmission-frequency characteristics of an H1 system operating over a 114-mil open-wire line 150 miles in

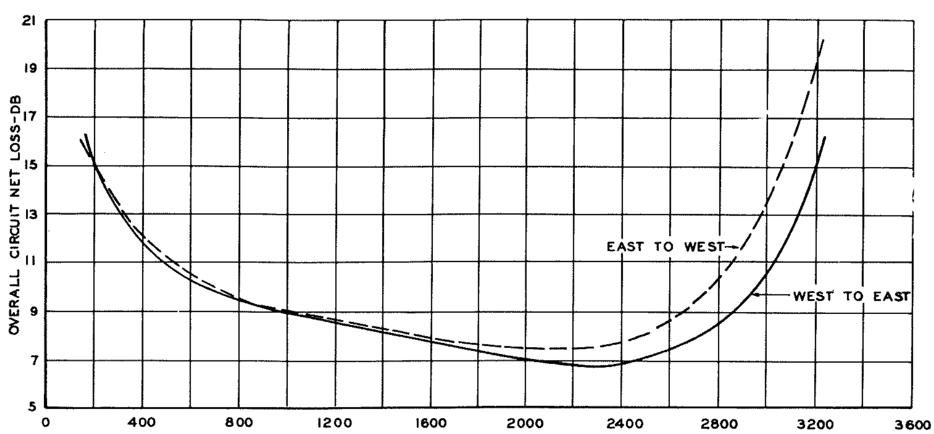


Fig. 8—Representative Overall Circuit Net Loss Characteristic of System Without Intermediate Repeater

length with no intermediate or entrance cable and without an intermediate repeater are given in Figure 8.
This drawing shows the circuit adjusted for an overall circuit net loss of 9 db at 1000 cycles. The introduction of short lengths of cable unless loaded for carrier frequencies or equipped with impedance matching transformers at their ends will, as explained later, cause impedance irregularities with their resulting effects upon the transmission-frequency characteristic.

4.23 As with the terminal equipment, no equalization is provided with the repeater. Thus, when one or more repeaters are added, a narrowing of the overall transmission bands will result due to the attenuation characteristics of the additional line and the loss characteristics of the filters included in the repeater or repeaters. However, these effects should not be serious if the number of repeaters is limited to two or three. Representative transmission-frequency characteristics of the system when operated over 450 miles of 114-mil open-wire line with two intermediate repeaters are given in Figure 9.

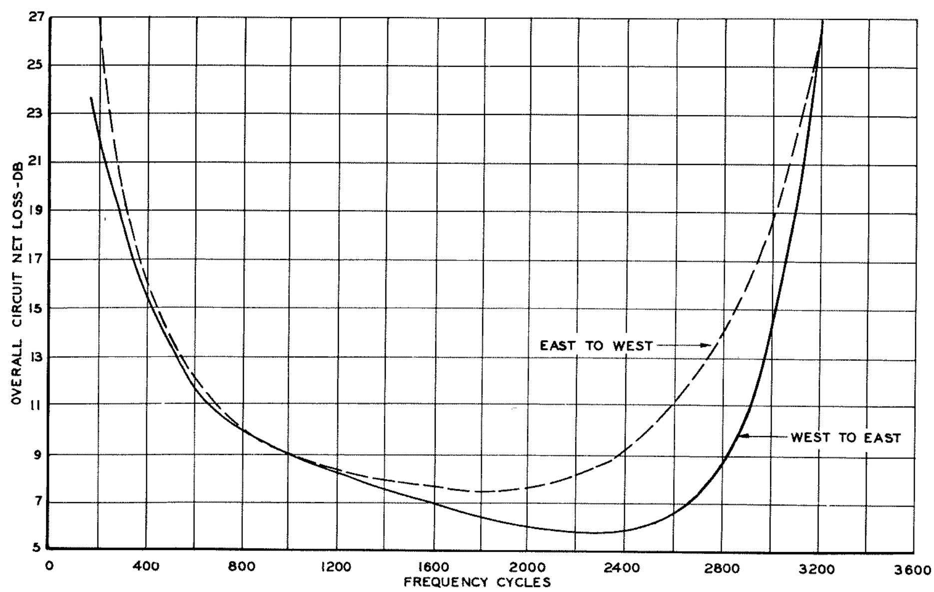


Fig. 9—Representative Overall Circuit Net Loss Characteristic—System with Two Repeaters

Overall System Stability

4.24 The principal variation in the overall 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 5 db. Additional smaller changes due to variation of temperature also occur. However, the two often partially neutralize each other as the temperature is likely to fall with wet weather. Since it is unlikely that the most unfavorable weather conditions will prevail over the entire line, the manual adjustments provided at each terminal and each repeater for compensating for changes in the line attenuation should make it possible with the aid of transmission measurements to maintain the circuit net loss to within the limits of $\pm$ 2 db.

Load Capacity

4.25 With the transmitting terminal properly adjusted, ordinary speech inputs should not result in appreciable overloading at the output of the terminal or repeater when operating at output levels of +16 db. The equipment is so designed at the receiving end of the circuit that overloading will not occur with a receiving level of +2 db at the hybrid line jacks when the system is properly lined up and adjusted. Receiving levels up to +5 db can be employed but in such cases some distortion may occur. This, however, is not expected to be serious.

Crosstalk and Noise

4.26 With the system properly lined up, the crosstalk between the carrier circuit and the voice-frequency circuit on which the carrier is superimposed is such that the noise resulting from crosstalk at the voice drop of either circuit should not be important.

4.27 The only appreciable source of noise contributed by the apparatus is that resulting from incomplete suppression of the carrier frequency in the receiving circuit at each terminal. This appears as a single frequency of 7150 cycles at the voice frequency drop but is so small that it will not materially affect the performance of the system. Any extraneous hum resulting from operating the terminals from a-c. power is negligible. Since the system has been designed to operate at levels which should be sufficient to keep it above the line noise likely to be encountered, trouble should not be experienced from this standpoint.

5. CHARACTERISTICS OF OPEN-WIRE LINES AND CABLES

5.01 In order to determine the proper layout for an H1 carrier system, an understanding of the more important transmission characteristics of the open wire and cables over which it has been designed to operate is necessary. These properties are important inasmuch as they determine, to a considerable extent, the length of circuit over which the system will operate. In the following section the attenuation and impedance of open-wire lines and cables over the frequency range employed by the H1 system are discussed briefly. Reflection effects resulting from impedance mismatch are considered and the section is concluded with a brief discussion of loading and other devices which can be employed for minimizing these effects.

Attenuation

5.02 The losses offered to currents of carrier frequencies by open-wire lines are considerably greater than those for voice-frequency currents, since the attenuation of the lines rises fairly rapidly with frequency. Figure 10 gives the variation of attenuation with frequency for four commonly employed gauges of open-wire side circuits. These curves are for 12-inch spaced, non-pole-pair, copper wires equipped with the type of insulators ordinarily employed for long distance circuits. They are for dry weather at a temperature of 58 degrees Fahrenheit. Because of the increase in leakage resulting from wet weather, the attenuation at such times is increased. Curves for the wet weather condition are given in Figure 11 for the same four wire gauges. These latter curves give about the maximum attenuation likely to be expected and are the figures generally used in engineering a system.

5.03 The attenuation of pole pairs is slightly less than that for non-pole-pairs. The differences are so small, however, that they may be neglected and Figure 11 can be used for determining approximately their maximum attenuation.

5.04 Phantom circuits are not ordinarily employed for carrier operation because their impedance is different from that of side circuits for which the carrier equipment is designed, they have higher crosstalk coupling, and the difficulty of maintaining good balance on them increases the noise. Also, there may be no other phantom circuit available to which the carrier system can be transferred in case of line trouble. However, in some cases it would be possible with special arrangements to operate the H1 system over a phantom circuit. The attenuation of open-wire phantom circuits in the carrier frequency range is only slightly less than that for side circuits. Accordingly, the curves given in Figures 10 and 11 can be considered as applying approximately to phantom circuits.

5.05 The carrier-frequency attenuation of cable circuits is much greater per unit length than that for open wire lines. Hence the losses introduced by the cables often employed at entrance and intermediate points are of considerable importance. Figure 12 shows the variation of attenuation with frequency measured between characteristic impedance terminations for the several gauges of non-loaded cables likely to be encountered. These curves apply only when reflection losses (discussed in section 5.09) are not involved.

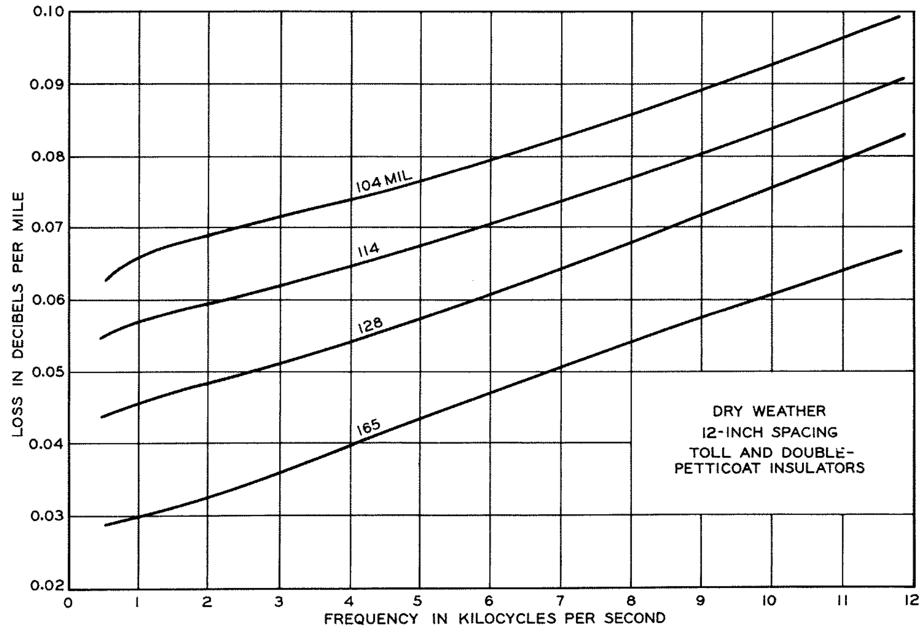


Fig. 10—Attenuation of Open Wire Side Circuits—Dry Weather

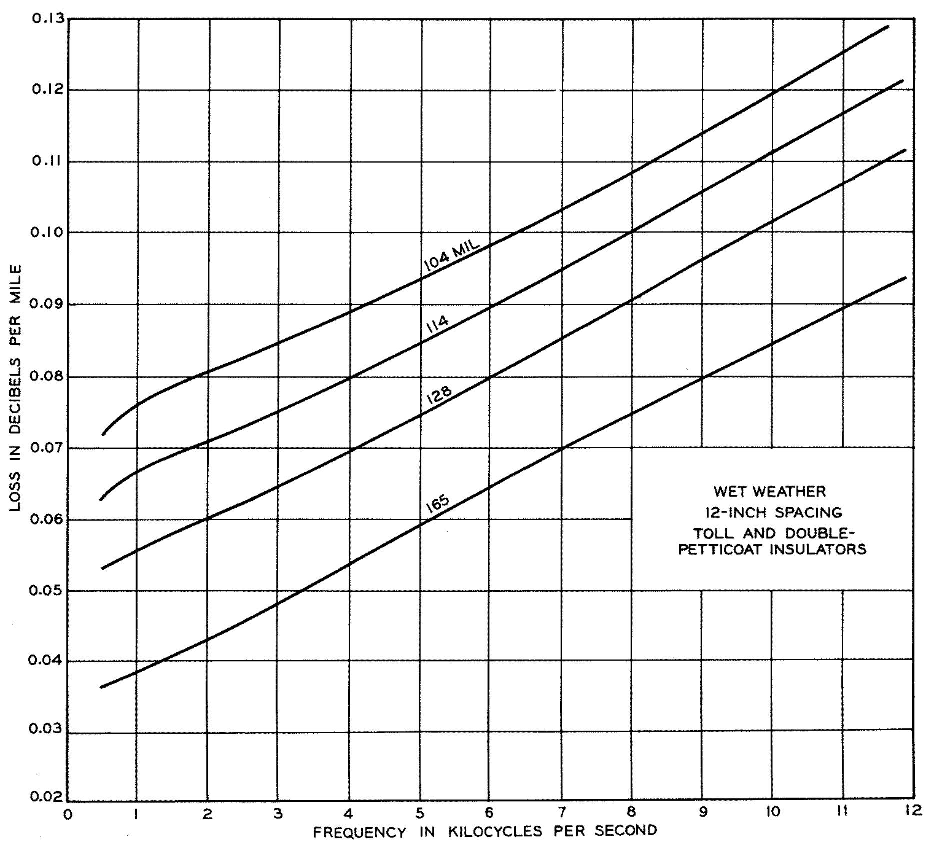


Fig. 11—Attenuation of Open Wire Side Circuits—Wet Weather

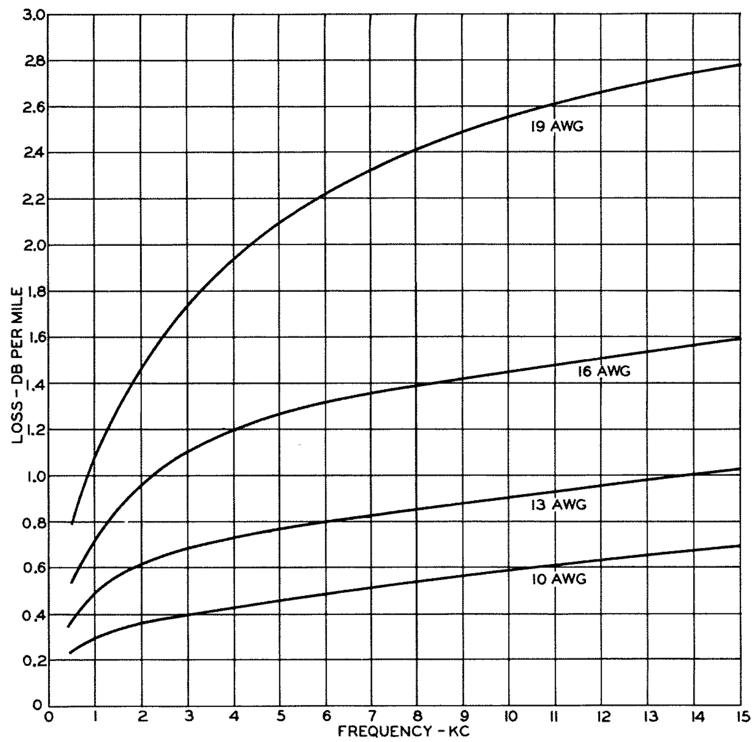


Fig. 12—Attenuation of Non-Loaded 0.062 mf. Cable Circuits Terminated in Characteristic Impedance

Characteristic Impedance

5.06 The characteristic impedance of open-wire lines and cables is also of interest as it is desirable to avoid circuit irregularities and to match the impedance of the line to that of the carrier equipment which, for the H1 system, is about 660 ohms. In the frequency range employed by the H1 system, about 4000 to 10,000 cycles, the characteristic impedance of open-wire lines is very nearly a pure resistance of approximately constant value. It is substantially independent of weather conditions and is somewhat higher for pole pairs than for non-pole pairs. The characteristic impedance of open-wire non-pole pairs composed of any gauge likely to be encountered in practice is given in Figure 13.

5.07 The characteristic impedance of non-loaded cable circuits is much lower than that of open-wire lines. Over the frequency range employed by the H1 system it is not so constant as the open-wire impedance and, in addition, it has a much larger reactive component.

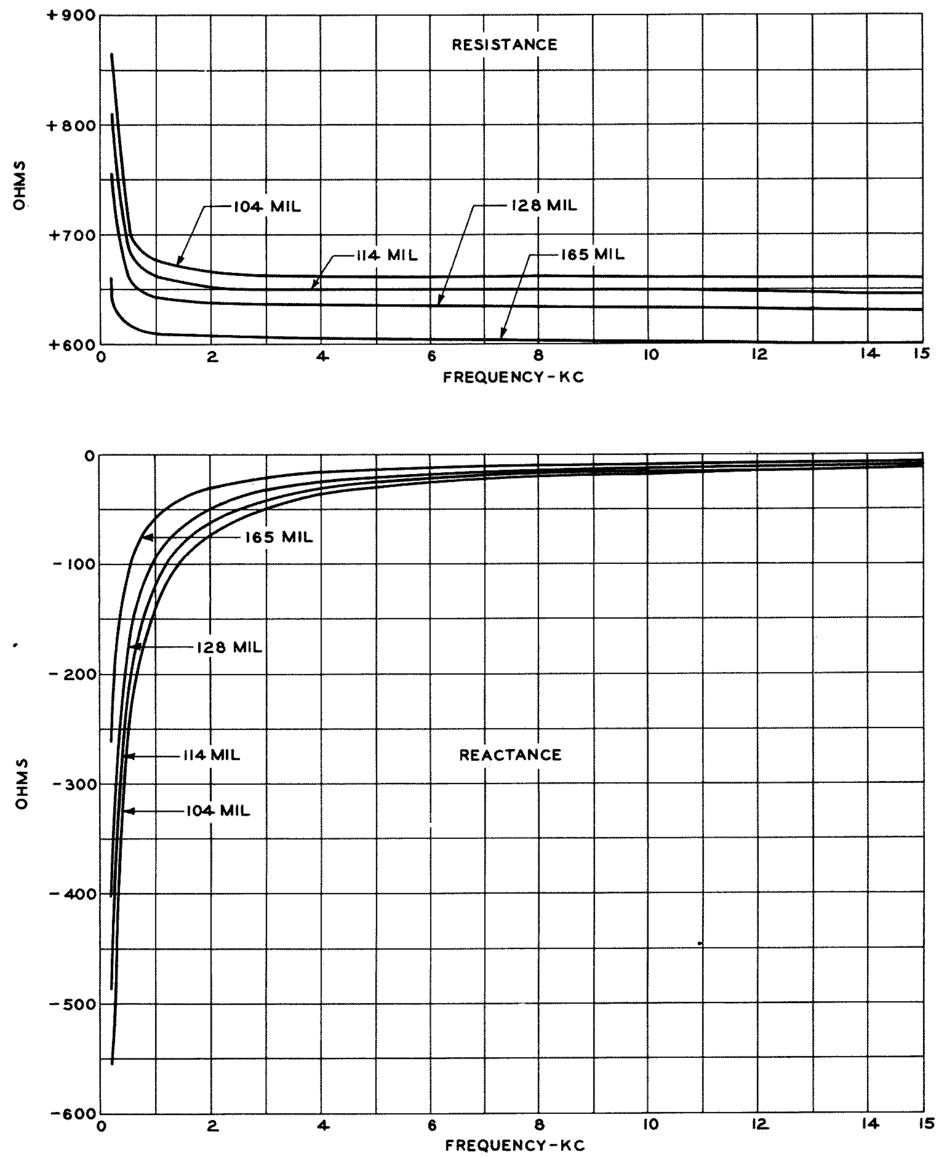


Fig. 13—Characteristic Impedance of Open-Wire Non-Pole Pairs

The characteristic impedance of non-loaded cable circuits is given in Figure 14. By the use of loading, the side-circuit impedance of these cable circuits can be raised to about 650 ohms so that it very nearly matches that of the open-wire lines and the carrier equipment.

5.08 For phantom circuits the characteristic impedance of both open-wire lines and cables is somewhat less than that of side circuits, although the impedance curves are in general similar in shape.

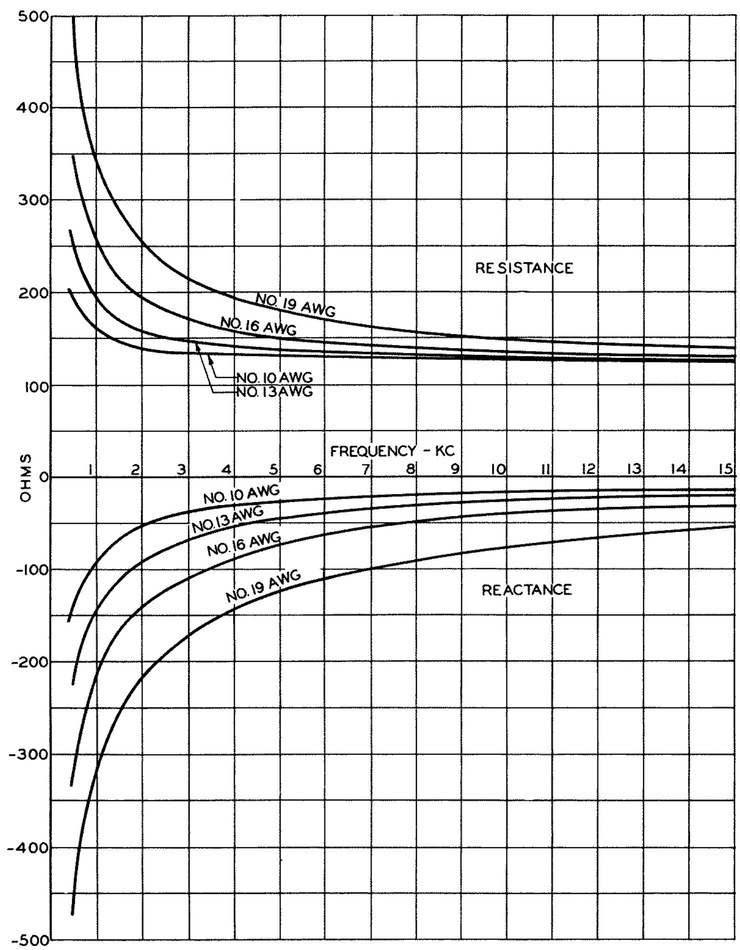


Fig. 14—Characteristic Impedance of Non-Loaded Cable Circuits

Reflection Effects

5.09 Due to the large differences in the impedance of open-wire and non-loaded cable pairs the introduction of cable into open-wire circuits utilized for carrier transmission will result in reflections at the junction points unless suitable arrangements are employed to match the impedances. Since the carrier equipment is designed to match the open-wire side-circuit impedance, reflections will also occur between the carrier equipment and non-loaded entrance cable and between the carrier equipment and open-wire phantom circuits unless impedance matching arrangements are provided. Among other effects, these reflections produce irregularities in the attenuation-frequency characteristic and cause reflection losses which raise the total insertion loss due to the cable. Also they tend to increase crosstalk when more than one carrier system is operated over the same line.

5.10 The total loss, including the cable loss plus the reflection losses at each end, introduced by inserting given short lengths of non-loaded, 13-gauge cable pair between two 600-ohm resistances is shown in Figure 15. The curves may also be considered as representative for 16- and 19-gauge cable pairs. Inserting the cable pair between impedances of values slightly different from 600 ohms would not change the losses materially. Accordingly, the curves represent the approximate losses which would occur when a single length of non-loaded cable pair of 13, 16 or 19 gauge is inserted in an open-wire side circuit.

Cable Loading

5.11 The undesirable effects of intermediate and entrance cables can be minimized by the use of suitable loading. Loading not only raises the impedance of the cable to approximately that of the open-wire line so that impedance-matching devices are not required, but also reduces the attenuation at both voice and carrier frequencies so that its use is of considerable advantage. Several loading systems have been developed for use on cables through which carrier systems are operated. One of these, designated BH-15-15 loading, is a phantom group loading system using carrier loading coils in the side circuits at 3000-foot intervals in 0.062 mf. per mile cables to provide for satisfactory transmission up to about 11,000 cycles. Associated with this side circuit loading, is a phantom circuit voice-frequency loading, using coils at 6000-foot intervals. The loading apparatus and potting arrangements are sufficiently flexible so that when desired the cable side circuits may be loaded without loading the phantom. The attenuation of cable circuits equipped with this type of loading is shown in Figure 16, and it may be seen that a substantial reduction in the attenuation at carrier frequencies is obtained by this means. However, this loading system does not transmit frequencies above about 11,000 cycles so that it is not suitable for use with carrier systems employing frequen-

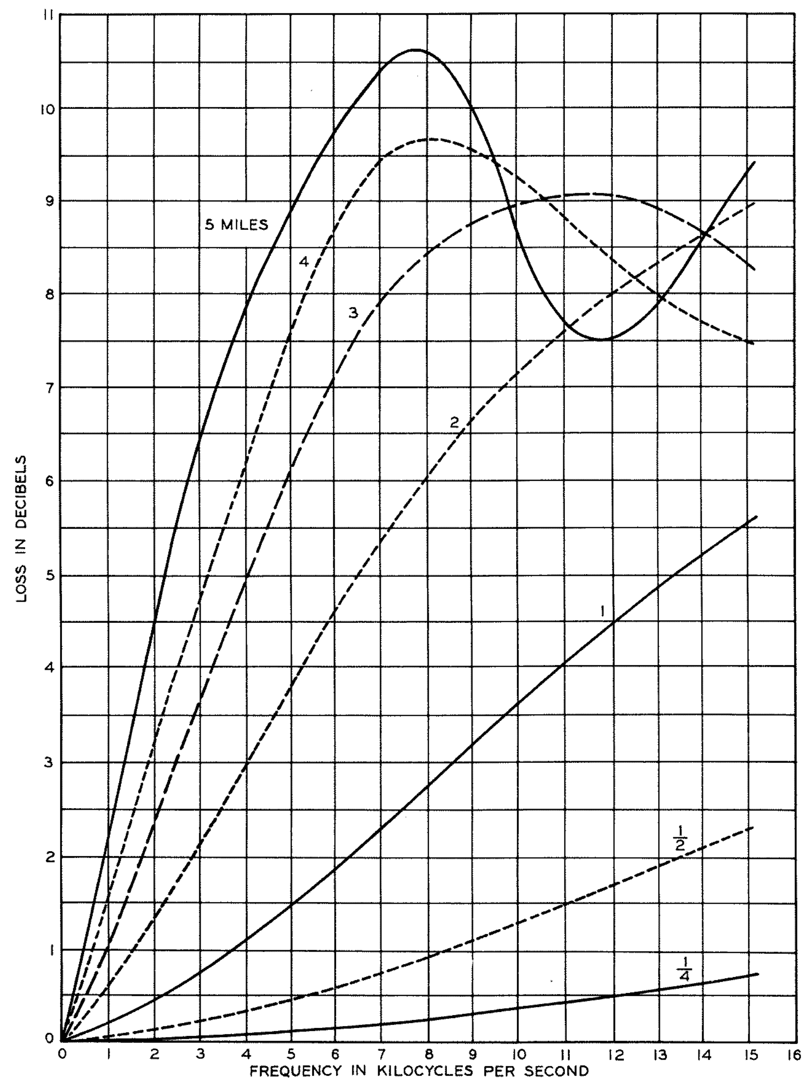


Fig. 15—Insertion Losses Due to Short Lengths of Cable Between 600-Ohm Resistances

cies above this value. Similarly voice-frequency loading, which cuts off frequencies above the voice range, is not satisfactory for use with the H1 carrier system.

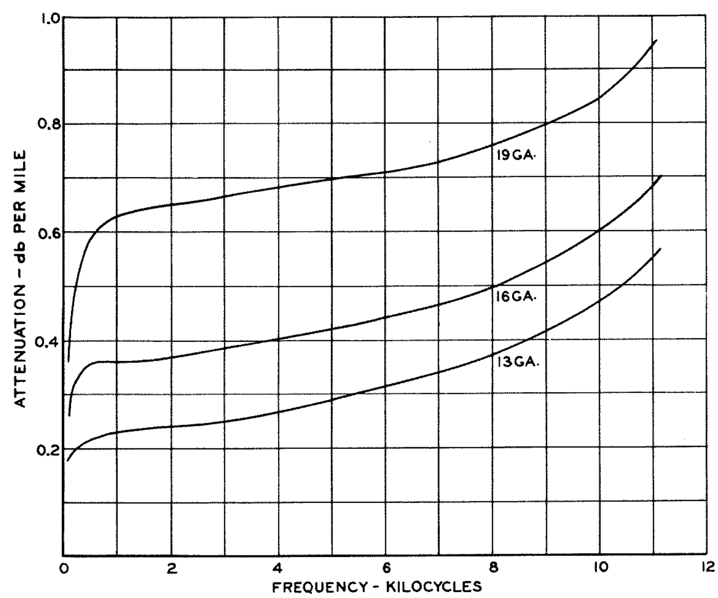


Fig. 16—Attenuation-Frequency Characteristic of BH-15-15 Loaded Cable

Impedance-Matching Transformers

5.12 In cases where substantial transmission margins exist on the voice-frequency circuit it is sometimes practicable to use impedance-matching transformer networks at the cable terminals as a substitute for carrier loading. At the present stage of development this so-called transformer treatment is much less satisfactory in the voice-frequency range than in the carrier-frequency range, and where grounded composite telegraph operation is required serious restrictions may be imposed. Certain inherent limitations in simple transformer treatments result from the fact that the ratio of the non-loaded cable impedance to that of the open-wire impedance varies widely over the transmitted frequency band and the impedance ratio that is optimum at carrier frequencies is distinctly disadvantageous in the voice-frequency range. An additional complication, which is most important when the use of voice-frequency telephone repeaters with high gains is involved, results from the fact that the difference between the ratios of the reactive and resistance components of the cable characteristic impedance, and the corresponding ratios of open wire reactance to resistance are much greater at low voice frequencies than at the upper voice and the carrier frequencies. Thus, at present, the choice of the most suitable transformer arrangement for the complete transmission band involves different compromises for different sets of conditions and service requirements.

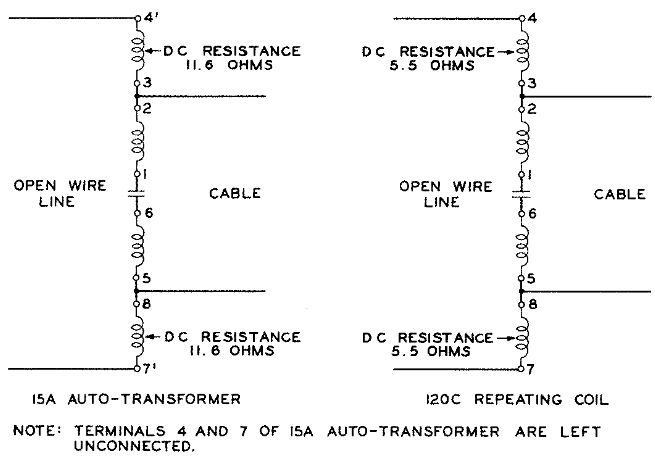


Fig. 17—15A Auto-Transformer, and the 120C Repeating Coil Connected as an Auto-Transformer

5.13 Auto-transformers with condensers located at the electrical center of their bridged windings rather than repeating coils are preferred for impedance modification since they permit through d-c. testing, facilitate the use of superimposed grounded d-c. telegraph circuits, and do not in general impair 20-cycle or 135-cycle signaling. Where there is a substantial margin in the carrier transmission band and little, if any, margin in the voice-frequency band, it is preferable to use auto-transformers having a low impedance ratio. The Western Electric 15A Auto-Transformer having an impedance ratio of 2.15:1 connected as shown in Figure 17 is a good choice under these conditions. On the other hand, if there is a transmission margin in the voice-frequency circuit, higher ratio impedance transformation may be desirable to improve the carrier circuit transmission. The Western Electric unit ratio 120C Repeating Coil connected as a 4:1 auto-transformer as illustrated in Figure 25 may be used advantageously under these conditions. It should be noted in this connection, however, that if auto-transformers which increase the impedance mismatch at voice frequencies are used on voice-frequency repeatered circuits, the return losses may be appreciably impaired. The 15A Auto-transformer introduces approximately 11.6 ohms d-c. series resistance into each wire while the 120C repeating coil introduces approximately 5.5 ohms d-c. series resistance into each wire.

5.14 When a grounded d-c. telegraph circuit is operated on the line through composite sets, two balanced condensers connected in series, with their common connection grounded, are inserted at the midpoint of the auto-transformer. This arrangement is employed to reduce telegraph cross-fire. At the same time, however, the added capacitance to ground increases the distortion of the telegraph signals. Since telegraph distortion and cross-fire effects are cumulative, the capacitance to be employed at any single auto-transformer depends upon the number of auto-transformers used in the circuit between telegraph terminals. Furthermore, the restrictions placed upon the midpoint condensers by telegraph requirements may result in objectionable impairments in telephone transmission, particularly in the low voice range. In general, two 2-mf. condensers should be a satisfactory compromise when the 15A Auto-Transformer or the 120C Repeating Coil connected as an auto-transformer are employed. Circumstances may, however, require other values of capacitance.

5.15 At the office end of entrance cables when the auto-transformer can be located on the drop side of the telegraph composite set, or where simplex telegraph is employed, a single 1- or 2-mf. condenser at the electrical center of the coil should be satisfactory with the 15A Auto-Transformer or 120C Coil connected as an auto-transformer. If 135 cycle signaling is used, the 120C repeating coil should not be employed as an auto-transformer. The condensers in this case do not affect telegraph transmission and are chosen solely from the telephone transmission and signaling standpoints.

5.16 The auto-transformers mentioned above are designed for office mounting. Accordingly, where these coils are used in outside locations weatherproof mounting arrangements should be provided. Also, appropriate electrical protection should be installed. Where impedance-matching transformers are employed on one side circuit of a phantom group, it is necessary to connect similar coils into the opposite side circuit to preserve the longitudinal balance in the phantom circuit.

Way Station Bridging Filter

5.17 If telephone sets at way stations are bridged directly across a line over which the carrier system is operating, such as a dispatching circuit, there will be interference to the carrier system from talking at the way stations, and interference at the way stations from talking on the carrier system. There are a number of types of telephone sets now in use at bridged intermediate way stations on lines over which it may be desired to operate carrier systems. The commonest of these is the 501-type subscriber set. A filter, coded the 87A, has been developed for use with the 501-type set and the 1317 BU Telephone Set and will effectually suppress mutual interference between the carrier and voice circuits due to the way-station sets. This filter is not suitable for use with other types of subscriber sets having lower impedance, but a filter of new design for use with such sets will soon be available.

5.18 The 87A Filter consists of two different filter units mounted together. One of these is connected into the circuit when listening only and the other is introduced when the transmitter switch is operated.

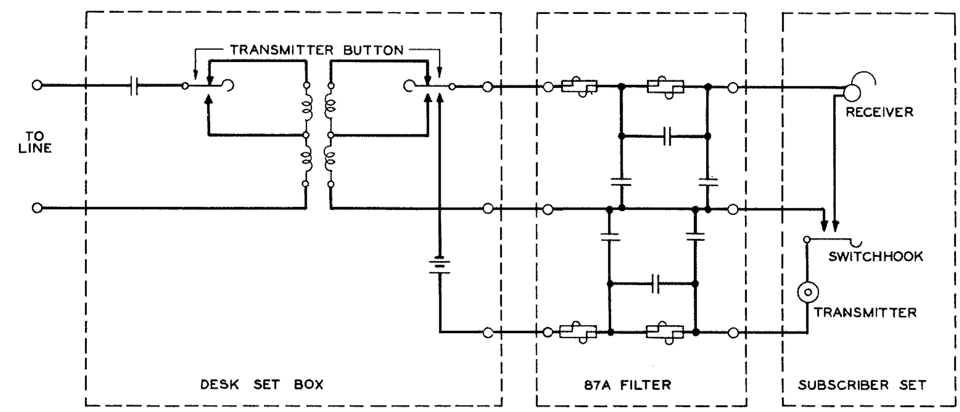


Fig. 18—501-Type Subscriber Set Equipped with 87A Filter

Separate filters are employed because of the differences in the impedance of the telephone set under the monitoring and talking conditions. The circuit of the 87A Filter as applied to the 501-Type Subscriber Set is shown in Figure 18.

5.19 The 87A Filter introduces a loss between the carrier and voice circuits of some 30 db, which is sufficient to reduce any mutual interference to a tolerable value. The effect on the through voice and carrier circuits is small. The bridging loss to the voice circuit of a 501-type set equipped with this filter is 0.15 db or less with the receiver on the hook or in the monitoring condition; its effect on the carrier circuit is less than 0.05 db except for the talking condition, when the loss is of the order of 0.25 db. If the way station is some distance from the through line, the bridging effect of the connecting open wire or cable must, of course, be taken into account. The loss to listening at the way station due to addition of the 87A Filter is about 2 db. The bridging losses to both the voice circuit when the way station telephone set is not in use and to the carrier circuit under all conditions of the telephone set are shown in Figure 19.

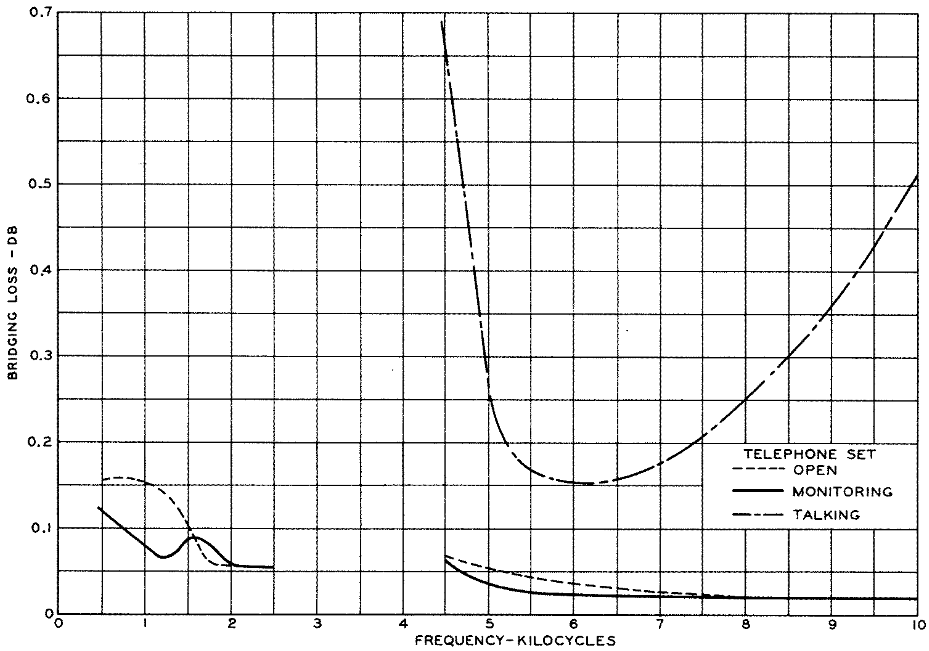


Fig. 19—Bridging Loss Due to 87A Filter and 501-Type Telephone Set Across 600-Ohm Line

6. APPLICATION TO SPECIFIC CASES

6.01 This section discusses the various factors to be considered in determining the arrangements to be employed for any specific case. These factors include the overall attenuation of the circuit at carrier frequencies, the effect of the carrier system on existing voice and telegraph facilities, crosstalk and noise signaling and power requirements.

6.02 It is first necessary to have complete information regarding the line over which the carrier system is to be operated, the various facilities operated over the line, and other pertinent information. The following list summarizes the information required.

1. Length of open wire line between the proposed carrier terminals together with the size and kind of wire, pin positions, and phantom grouping of circuit over which carrier system is to be operated.

2. Length, make-up and location of all intermediate and entrance cables together with loading information if these cables are loaded. Also, length and type of all drop wire.

3. Complete information regarding all voice-frequency facilities operated over the circuit or phantom group on which it is proposed to superimpose the carrier system, including—

   a. Type and location of any simplex or phantom coils or insulating transformers.

   b. Type of signaling employed together with information as to type of equipment if selective signaling is used.

   c. Location of any voice-frequency repeaters.

   d. Number, type and location of intermediate way-station telephone sets and information as to whether these sets are connected directly to the line or looped on through open wire, cable or drop wire.

4. Complete information regarding telegraph circuits operated over the circuit proposed for the carrier system, including a statement as to whether such telegraph circuits utilize simplex or composite arrangements.

5. Complete information regarding any other carrier system, either telephone or telegraph, now operating or contemplated for future operation over any part of line.

6. Transposition layout.

7. Data regarding any severe exposures to power systems, including power-line data, length of exposure and separation.

Attenuation of Line

6.03 In order to determine whether the H1 system has sufficient gain to permit operation over any specific line the attenuation of the line should be computed at the frequencies of 6150 and 8150 cycles, which correspond to the 1000-cycle points in the two voice frequency bands. The computations should include the effect of all equipment associated with the line such as simplex or phantom coils together with any additional equipment required for the carrier circuit including impedance-matching devices, bridged way stations, and carrier transfer equipment.

6.04 In making such computations the curves given in Figures 10-12 can be employed for the open-wire and cable circuits. The loss for each section of open-wire line and each section of entrance or intermediate cable should be figured separately. For open-wire lines the data given in the curves on Figure 11, which are for the wet weather condition, should be employed as it is desirable to make the computations for the worst attenuation condition to be expected.

6.05 For non-loaded entrance and intermediate cables less than about 0.5 or 0.75 miles in length, for which no special treatment is required, the curves of Figure 15 should be used, since these curves include the reflection losses at the junctions between the sections of non-loaded cable and open-wire line or carrier equipment. Where short lengths of open wire up to several miles occur between sections of cable, the open wire may be neglected and the combination considered as a single cable having an equivalent length equal to the sum of the cable lengths. If telephone repeaters are required to operate with large gains in the voice-frequency channel, or if the existence of more than one H-1 system on the same lead makes it necessary to meet severe reflection crosstalk requirements, non-loaded cables shorter than 0.5 mile may require impedance modification to reduce reflection effects.

6.06 For cables longer than 0.5 or 0.75 miles it will usually be desirable to load the cables or employ impedance matching devices at each end of the circuit. When BH-15-15 loading is employed the losses due to the cable can be determined from Figure 16. Where impedance-matching transformers are used, the curves of Figure 12 should be employed to determine the attenuation of the cable circuit. These curves give fairly accurate results when 120C Coils connected as auto-transformers are employed, since these coils reduce the impedance looking into the open-wire line or carrier equipment to about that of the cables. An additional loss of 0.3 db caused by the coil itself should be added, however, for each coil employed. Where 15A Auto-Transformers, which have an impedance of 2.15 to 1, are to be used, the impedance looking into the cables will be about 300 ohms instead of the desired 150 ohms. Hence some reflection will still occur. For such cases the data of Figure 12 will afford a first approximation. A loss of 1 db should be added for each 15A Auto-Transformer included in the circuit.

6.07 Where rubber-covered wire or cable is employed to loop the circuits into intermediate offices, its effect upon the attenuation can usually be ignored if the total length of such cables is less than a few hundred feet. Where the total length of such cables is more than this the attenuation of these cables should be included in determining the overall attenuation of the line. In general, the carrier-frequency attenuation of these cables is comparable to that for 19-gauge cable, the attenuation for which is given in Figure 12. The characteristic impedance of this type of cable is of the order of 100 to 150 ohms.

6.08 As explained in Sections 5 and 19 there is a loss presented to the carrier currents by the bridging filters required at each way-station telephone set and, accordingly, these losses should be included in determining the overall attenuation. For a bridged telephone set of the 501-type equipped with an 87A Filter, the loss for various frequencies in the carrier range is given in Figure 19. In general, the curve for the open or on-hook condition should be employed since this is the most usual connection of the telephone set.

6.09 Wherever voice-frequency equipment, such as repeaters, etc., is included in the circuit, carrier transfer sets must be added to pass the carrier frequencies around such equipment. Each carrier transfer set will introduce a loss of about 0.4 db over the carrier frequency range and these losses should be included in determining the overall line loss.

6.10 When simplex or phantom repeating coils are present at intermediate points along the line the losses introduced by such coils must be considered. Where it is not necessary to pass low-frequency signaling currents through the coil the 94E Repeating Coil is often used. This coil introduces a loss of from about 1 to 1.5 db to the carrier currents. If this loss cannot be tolerated the coil can be replaced with the 120C Repeating Coil. This coil has slightly less loss than the 94E Coil to the voice frequencies and reduces the carrier-frequency loss to about 0.3 db.

6.11 Where it is required to pass 20-cycle signaling currents but not the very low frequencies employed for selective signaling (3½ to 4 cycles) coils such as the 46A, 67C, 75A, 76A and 77A Repeating Coils, are commonly employed. These coils transmit voice-frequency currents satisfactorily but are not very efficient at carrier frequencies and will introduce a loss of some 1 to 1.5 db per repeating coil to frequencies in the H1 range. This loss can be reduced somewhat by paralleling such coils with the 120C Repeating Coil and connecting a 2-mf. condenser at the midpoint of each winding of the 120C coil, using an arrangement similar to that illustrated in Figure 20 below. The combination of two coils connected in parallel in this manner will not materially affect the loss at voice frequencies but will reduce the loss at carrier frequencies to about 0.5 db.

6.12 Where selective signaling which requires the transmission of very low frequencies is used, special repeating coils to pass the very low frequencies are employed for simplex or phantom coils. The more usual coils of this type are the 70A Repeating Coil and the 341A Transformer. These coils have a high loss to carrier frequencies. Accordingly, when an H1 system is to be operated over a line in which coils of this type are present, it will be necessary to parallel each coil with a repeating coil which can pass the carrier frequencies. Various types of repeating coils, such as those referred to in the preceding discussion, with 2-mf. condensers at the mid-points of their windings can be employed in parallel with the 70A Repeating Coil or the 341A Transformer. However, it is desirable to employ the 120C Repeating Coil with 2-mf. condensers for this purpose. With such a combination the voice frequency loss is low and that at carrier frequencies is in the order of 1 to 2 db. The arrangement employing the 341A Transformer and 120C Repeating Coil in parallel is shown in Figure 20.

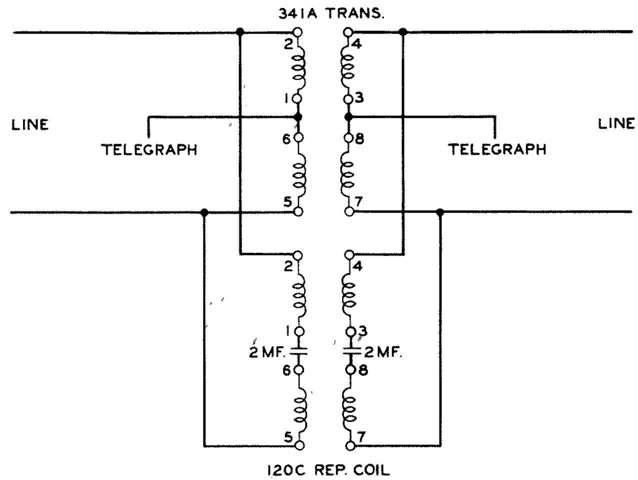


Fig. 20—341A Transformer with 120C Repeating Coil for Passing Voice and Carrier Frequencies

6.13 Where open-wire telephone lines are in close proximity to high-voltage power lines, protective arrangements which include insulating transformers, are usually employed on the telephone lines to isolate possible high potentials from equipment or other parts of the line not subject to these potentials. The Western Electric 50A Repeating Coil is often used for this purpose. This coil, while affording reasonably good transmission for voice frequencies, introduces considerable loss to carrier currents. Furthermore, the loss is not uniform over the carrier frequency band. A carrier system cannot therefore, be operated satisfactorily through the coil.

6.14 Where standard protective arrangements are employed on the line side of the 50A coil which limit the possible voltage at the transformer, condensers can be bridged around the coil to make good the carrier path. Either 0.1 or 0.2 mf. condensers having a dielectric capable of withstanding the highest voltage the protective arrangements will pass should be employed. Two condensers are required; one of these should be connected from the tip wire on the line side of the transformer to the ring wire on the drop side and the other should be connected from the ring wire on the line side of the transformer to the tip wire on the drop side. With this arrangement the attenuation in the frequency range of the H1 system is reduced to the order of from 0.2 to 0.3 db. Care should be taken, however, that the addition of such condensers does not upset the balance of any voice-frequency repeater associated with the circuit. Since other types of insulating transformers usually have similar characteristics to the 50A Repeating Coil, a similar arrangement of bridging condensers should be employed when it is desired to transmit carrier frequencies through them.

6.15 Another form of protection sometimes used on exposed telephone lines consists of drainage coils connected at various points along the line to reduce the voltage to ground on the wires caused by induction. Standard distribution transformers are usually employed for this purpose, the high side of the transformer being connected across the telephone line and the midpoint grounded. The secondary winding is left open. Since, under this condition, the impedance of distribution transformers at carrier frequencies is comparatively high, their use has in general little effect on carrier-frequency transmission so that such drainage coils may be neglected in determining the attenuation of the line.

6.16 If the total 8150-cycle attenuation is equal to or less than the maximum 8150 cycle attenuation for the circuit net loss required, as given in the table in section 4.16, the H1 system without intermediate repeaters is probably suitable for application to the particular line in question. For greater attenuations the use of one or more repeaters is indicated.

6.17 Where computations indicate that the attenuation is close to the limit and the use of additional repeaters is questionable, it will generally be desirable to measure the attenuation of the line at carrier frequencies. Such measurements should include any impedance-matching devices to be employed and the effect of other additional equipment required for the carrier circuit should be added to the measured attenuation to determine the overall high-frequency loss. If desirable the line may be split up into several sections to facilitate measurements.

Effect on Voice-Frequency Telephone Circuits

6.18 The effect of the carrier equipment on the voice-frequency circuit on which it is to be superimposed should be carefully considered. The principal effects are the additional loss introduced in the voice circuit and the reduction in return losses caused by the carrier equipment. Also, where repeatered voice circuits are involved additional equipment is necessary in the repeater networks to balance each line filter and line filter balance unit required. As already noted, equipment for this purpose is included with the carrier equipment.

6.19 Losses are introduced into the voice circuit by the line filters, line filter balance units, carrier transfer sets, impedance-matching transformers, and bridging filters in way station telephone sets. When carrier loading is applied to intermediate or entrance cables, transmission in the voice circuit will, on the other hand, be improved.

6.20 Each line filter or balance unit will introduce a loss of about 0.2 db into the voice-frequency side circuit with which it is associated. The loss to the phantom circuit is about 0.15 db for each point at which this equipment is inserted. Wherever carrier transfer equipment is required a loss of 0.4 db will be introduced into the voice-frequency circuit and 0.3 db in the phantom circuit since two line filters are employed to form a carrier transfer circuit. Except at the very low frequencies practically no additional losses will be introduced in the voice circuit where 15A Auto-Transformers are inserted for impedance-matching purposes, since the losses in the transformers themselves are about offset by the improvement obtained from their use. The addition of each 120C Repeating Coil connected as an auto-transformer, however, increases the loss to the voice-frequency circuit somewhat due to the impedance mismatch at voice frequencies. The losses to the voice circuit caused by way station bridging filters are given in Figure 19.

6.21 Where the voice-frequency circuit is equipped with repeaters and return loss conditions permit, the additional losses introduced into the voice-frequency circuit may be taken care of by readjusting the voice repeater gains. In extreme cases, particularly where a considerable number of filters are to be added, it may be necessary to resort to other means of improving the transmission of the voice-frequency circuit, such as loading of incidental cables or the addition of a voice-frequency repeater. Any loading employed should, of course, pass carrier as well as voice frequencies.

6.22 Where line filters and carrier transfer circuits are employed on circuits having intermediate way stations, care must be taken that the low-pass filters of the line filter sets are properly terminated at all times in order to avoid reflections back through the low-pass filters. When such low-pass filters are not normally terminated by voice-frequency equipment a resistance of 690 ohms should be connected to the drop terminals of the filters. Accordingly, when the drop of a low-pass filter is connected to a telephone set or other apparatus which is open-circuited or of high impedance except when in use, arrangements should be provided to connect automatically a terminating resistance to the filter when the connected apparatus is in the open circuit or high impedance condition. Care should be taken, however, that the ringer is not disconnected when such an arrangement is utilized.

Effect on Telegraph Circuits

6.23 The carrier system has little effect on either composited or simplex telegraph circuits operated over the same line wires except that, when composited telegraph is employed, the distortion of the telegraph signals may be increased due to the addition of auto-transformers with midpoint condensers. If necessary, to avoid the use of telegraph composite sets at points where carrier transfer equipment is employed, either simplex or composited telegraph circuits may be carried through the low-pass units of the line filters which form the carrier transfer sets. In such cases, however, where composited telegraph circuits are involved, the noise on the voice-frequency circuit will be increased somewhat due to modulation of the carrier currents by the coils in the filter units through which the telegraph signals pass. This effect is not expected to be serious, but the arrangement is not recommended.

Crosstalk and Noise

6.24 Where only one carrier system is to be operated over the line no crosstalk problem will be introduced. Crosstalk resulting from the operation of more than one system on the same line will depend upon the types of systems involved, the relative energy levels, reflection effects and the transposition layout. For cases involving more than one carrier system on the line the transposition layout should be studied and tests made if possible to determine whether crosstalk difficulties are likely to be encountered and whether carrier transpositions are needed.

6.25 With the H1 carrier system properly adjusted, the operating levels should hold it above the line noise normally present in open wire lines. Any severe exposures to high voltage power lines should, however, be considered, and high frequency noise measurements should be made if possible.

Signaling at Terminal Offices

6.26 The signaling arrangements employed at the terminal offices should be investigated to determine that they will function satisfactorily in conjunction with the H1 system. As already pointed out, ringdown operation can be provided with switchboards equipped with nominal 16⅔ or 20 cycle or d-c. signaling arrangements. For interrupting the outgoing high-frequency ringing currents a source of from 15.6 to 16.75 or from 18⅓ to 20 cycles is required at each terminal. These frequency limits can be extended to cover frequencies from about 14.5 to 23 cycles by changing the value of the (W) resistance of the terminal circuit to 200 ohms. This broadens the tuning of the signaling receiving circuit so that it becomes more susceptible to false operation from speech and noise currents, but it is expected that ordinarily no difficulty will be experienced if this resistance is not greater than 200 ohms.

Selector Sets

6.27 In addition to the interference to the carrier system produced by talking from bridged telephone sets, another type of interference will occur when the carrier system is superimposed on a dispatcher's circuit equipped for selective signaling with selector sets having an audible answerback feature. In selector sets of this type, such as the Western Electric 160C Selector Set, the audible answerback is produced by rapidly interrupting a d-c. circuit. Carrier as well as audible frequencies are generated in such an arrangement and the carrier frequencies if not suppressed will produce noise in the carrier system.

6.28 This difficulty can be minimized by modifying the selector sets. The several Western Electric 160-type selector sets can be modified to include resistances and condensers to reduce sparking and cut down the high frequencies impressed on the line. These modifications will reduce the answerback interference to the carrier system by about 45 db which is sufficient to reduce it to a level of relative unimportance. The modification for the 160C and 160R Selector Sets is illustrated in Figure 21 which shows the wiring arrangements and the values of the additional resistances and condensers to be employed.

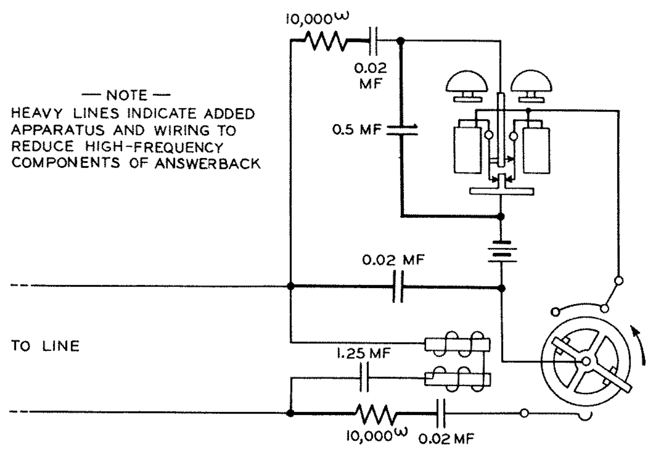


Fig. 21—160C or 160R Selector Set Modified for Use with Carrier Telephone Systems

6.29 Specific information for the modification of the various selector sets is shown on the following drawings which may be obtained from the distributor:

ES-612360—Modification of 160AC, 160AR, 160BC and 160BR Selector Sets for Use with Type H Carrier Telephone.

ES-612361—Modification of 160A and 160B Selector Sets for Use with Type H Carrier Telephone.

ES-612362—Modification of 160C and 160R Selector Sets for Use with Type H Carrier Telephone.

7. INSTALLATION

7.01 The component units of the H1 Carrier Telephone Equipment are assembled, wired, and tested in the shop, and the installation of the equipment is, therefore, comparatively simple and should be performed without difficulty by an installer who has had an average amount of experience with communication equipment.

7.02 The H1 carrier telephone terminal is shipped to the field wired for operation from 60-cycle 115-volt a-c. supply, and is arranged to work with a 20-cycle signaling switchboard and to receive ringdown signals from a distant terminal arranged for 20-cycle ringing. The transmitting pads are strapped to provide a transmitting gain of 16 db between the (HYB LINE) and (CARR EQPT) jacks. The (RLA) and (RLB) pads are strapped at the factory for 6 db loss and the (REC) pad is strapped to provide a net receiving gain of 4 db between the (CARR EQPT) jacks and the (HYB LINE) jacks. The H1 carrier repeater is shipped to the field wired for operation from 60-cycle 115-volt a-c. supply. The pads are strapped to provide approximately 27 db gain in each direction of transmission. Optional wiring is provided in both the terminal and repeater for various local conditions likely to be encountered as explained in the notes on the circuit drawings, and the installer should make any changes required.

Installing Procedure

7.03 The installing operations will consist, in general, of mounting the equipment on relay racks or in cabinets, making any changes required in the optional wiring on the panels, runnings leads to the a-c. supply (or battery fuse panels), to the source of 20-cycle supply and to the distributing frame for cross-connection to the line, switchboard, repeating coil, and VF repeater equipment, and making circuit operation tests.

7.04 Typical bay and cabinet arrangements with the locations of the local and power cables are shown on ED-61467-01. Suitable terminal room space should be assigned to the H1 Carrier Telephone Equipment with due consideration given to future additions, length of cable required, and accessibility. The space in the front and rear of the equipment for maintenance purposes should not be much less than three feet.

7.05 When the apparatus cabinet is used, it may be placed on the floor or mounted on a table or other support. One cabinet may be placed upon another, in which case it will be necessary to remove the handles, clinch rings, No. 18 screws, washers and nuts from the top of the lower cabinet and to make use of the screws, etc., of the bottom of the upper cabinet for fastening the two cabinets together. When cabinets are set side by side, they should be placed on centers of at least 1 foot 10¼ inches, which will permit the doors to be open 90 degrees.

7.06 Two knockouts are provided at the top of each cabinet and two at the bottom. Those at the top or bottom may be used depending upon which is more suitable in each installation. A2 Federal bushings are shipped loose for use in the knockouts. A-c. power leads should be run through one bushing, and the line and signaling leads through the other. In a case where one cabinet is mounted on top of another the knockouts between the two may be removed and the bushings furnished with one of the cabinets installed in their place. With such an arrangement it may be necessary to bring two a-c. power supply leads through one bushing in the top or bottom cabinet. In this event a ½ inch Chase nipple and ½ inch conduit lock nut should be substituted for the A2 Federal bushing to provide a large enough aperture.

7.07 Detailed wiring information required by the installer is shown on T-64083-30. Wiring of the type indicated on the drawing or a satisfactory equivalent should be used in running all leads. 500CL cable is recommended for leads designated 22-gauge quadded cable. This cable provides 2 quads. Larger capacities are the 501CL to 506CL cables, which provide 4 to 20 quads.

7.08 When the equipment is to be operated from an a-c. power supply the ground terminal should be connected to the office ground or other suitable ground point, and the proper strapping provided on the terminal strips.

7.09 The carrier line filter and balancing panel is assembled in the shop but not wired, since most of the wiring required on this panel connects to equipment located outside the panel and must be run by the installer. Sufficient slack should be looped in the leads to the jacks on this panel to permit their removal from the front of the panel for inspection and adjustment.

7.10 Pairs marked "U" should be copper braid shielded No. 20 ESCB (enamel silk cotton braid insulation), except that leads less than 3 inches in length need not be shielded. Where shielded wire per D-99444 having a bare ground wire run under the shield is used, the ground leads or other connecting leads should be spliced to the ground wire where it leaves the shield with a "pigtail" splice. The shield should be terminated about 1½ inches back of the wire insulation. The outer braid should be pulled down to cover the end of the shield and should be held in place by means of cable butt lacquer or by friction tape. The splice, including the exposed portion of the shield ground wire should be protected by friction tape. Where punchings are provided at the apparatus, panel, or unit for terminating the shield ground wire, splices will not be required but the ground wire should be covered with black cotton sleeving and run directly to the ground punching.

Circuit Operation Tests

7.11 At the completion of all installation work, the installer should make a visual inspection to insure that optional wiring and strapping are connected to meet job conditions as specified on the circuit drawings, and to insure that no wires have been broken off in shipment.

7.12 Continuity tests to detect opens, reverses and direct or low-resistance crosses and grounds should be made on all wiring and cabling connected by the installer, including wiring to shields of shielded cable, using a tone buzzer or voltmeter continuity test set. (See paragraph 1.11.)

7.13 The installer should test all relays and adjust them to meet their electrical and mechanical requirements as outlined in Section 6 of this bulletin. The relays have been adjusted at the factory prior to shipment, but the adjustment may have been disturbed during shipment or installation.

7.14 At the conclusion of installation of either repeater or terminal equipment it is also recommended that the installer check the supply voltages and measure the plate voltages as outlined in paragraphs 10.02 to 10.04.

7.15 In the case of a terminal installation it is advisable to make a check of the relay circuit operation on an incoming ring as follows: Operate the (IN) relay manually and note that the (SO) relay releases, after about 0.5 second, and causes the (DC) and (CO) relays to operate. If "X" wiring is being used, the operation of the (CO) relay should connect 20 cycle ringing to the (HYB LINE) jack. If "Y" wiring is being used, the operation of the (DC) relay should connect 24 $\pm$ 4 volts d-c. to punching 6 on the terminal strip B.

7.16 Also make a check of relay circuit operation on an outgoing ring as follows: (a) With "X" wiring: Connect 75 to 105 volts a-c. ringing current to the (HYB LINE) jack thorugh an 8C lamp. This should cause the (OUT), (IC) and (OSC) relays to operate and the (INT) relay to vibrate. The voltage across terminals 2RB and 4RT of the (OUT) relay, measured with a d-c. voltmeter having a resistance of at least 15000 ohms should be at least 17.5 volts. (b) with "Y" wiring: Connect 24 $\pm$ 4 volts d-c. to punching 6 on terminal strip B and note that the (OUT), (IC) and (OSC) relays operate and the (INT) relay vibrates.

7.17 In the event the apparatus appears to have been damaged in transit the transmission tests outlined in paragraph 10.06 to 10.21 should be performed and defective apparatus should be replaced before turning the equipment over to the operating forces.

8. OVERALL SYSTEM LINE-UP

8.01 This section describes the various tests and adjustments which should be made in lining up an H1 carrier telephone system prior to placing it in service. The method of making the tests and adjustments is described and also the requirements to be met. In this section and subsequent sections the requirements are based on the use of 600-ohm testing equipment.

8.02 The tests listed in this section should be made in connection with the initial placing in service of systems or the reassignment of previously working systems. When reassignments are made only those tests where the results may be affected by the change need be repeated.

8.03 It is recommended that the tests outlined in this section be performed at least once a year as preventive maintenance to show up any changes which may have taken place in the performance of the system due to line changes, aging of varistors, deterioration of vacuum tubes or other apparatus.

8.04 After the completion of the initial tests and before the system is placed in service, a short observation period is desirable to insure that satisfactory service operation may be expected. During the observation period the system should be maintained as though in regular service and supplemented by 1000-cycle net loss measurements.

8.05 *General Procedure.* The system is lined up by adjusting the transmitting terminal, the output levels of the intermediate repeaters, and finally the gain of the receiving terminal so that the net loss specified for the circuit will be obtained. The system should be lined up in both directions of transmission. The first adjustment is to set the gain pad (TR) at the transmitting terminal to give the specified transmitting level. This will usually be 16 db referred to one milliwatt at the (CARR EQPT) jacks and the terminal is adjusted to this level before shipment to the field. If a different transmitting level is specified, it will be necessary to restrap the transmitting gain pad and adjust the signaling output power by strapping the R1 to R5 resistances. The output levels of any intermediate repeaters should be set at the specified output levels by adjusting the (E-W) and (W-E) pads. The (RLS) and (RLB) pads at the receiving terminal are then adjusted to 2 db more than the circuit net loss specified. Finally the receiving gain pad (REC) is adjusted to obtain this circuit net loss. If the desired net loss cannot be obtained with 0 db in the (REC) pad the (RLA) and (RLB) pads are reduced until the desired circuit net loss is reached. If these pads are reduced more than 3 db the signaling margin will not be adequate and the transmitting signaling power must be correspondingly increased. The signaling power can be increased, however, only as crosstalk conditions permit. After lineup in both directions of transmission, a check should be made to see if the permissible loop gain of either terminal has been exceeded. The procedures described in the balance of this section give detailed methods for accurately carrying out the various steps in the system lineup as outlined above. Instructions are also given for synchronizing the carrier frequently at the two terminals of a system.

8.06 The procedures given in the following paragraphs apply in cases where the circuit terminal is in the same office with the carrier terminal. In cases where an extension facility is involved and the levels in the circuit are referred to 1 mw. at the termination of the extension facility, the procedures outlined hereinafter will apply if a pad having a loss equal to the loss of the extension facility is inserted between the 1000-cycle 1-milliwatt test power and the (HYB LINE) jacks. If such a pad is not available the procedures outlined hereinafter may still be applied by adding the numerical value of the loss of the extension facility to the specified levels for the output of the terminals and repeaters involved.

Terminal Transmitting Level

8.07 The purpose of this test is to measure and adjust the transmitting gain of the terminal so that the transmitting level to the high-frequency line under the operating condition will meet the specified requirements.

8.08 *Procedure.* Connect 1000-cycle one-milliwatt test power to the (HYB LINE) jacks, and connect the input of the attenuator to the (CARR EQPT) jacks as shown in Figure 1. Connect the output of the attenuator to the transmission measuring set. Adjust the attenuator to give a reading in the portion of the transmission measuring set meter scale where the greatest accuracy is secured. (This is usually at the zero or one-milliwatt division of the meter.) Correct the meter reading for any error at 6150 cycles for a west terminal or at 8150 for an east terminal. (See paragraph 1.17.) The transmission gain is the reading of the attenuator minus the corrected reading of the transmission measuring set if the corrected set reading is a loss or plus the corrected set reading if the corrected reading is a gain. For example, assume a transmission measuring set error of 0.8 db, meter reading of 0.5 db loss and attenuator setting of 16 db. The corrected meter reading is a gain of 0.3 db and the transmitting gain is 16.3 db.

8.09 *Adjustments and Requirement.* The transmitting level should be adjusted to within 0.5 db of the specified value by changing the value of the transmitting gain pad at the input of the transmitting amplifier.

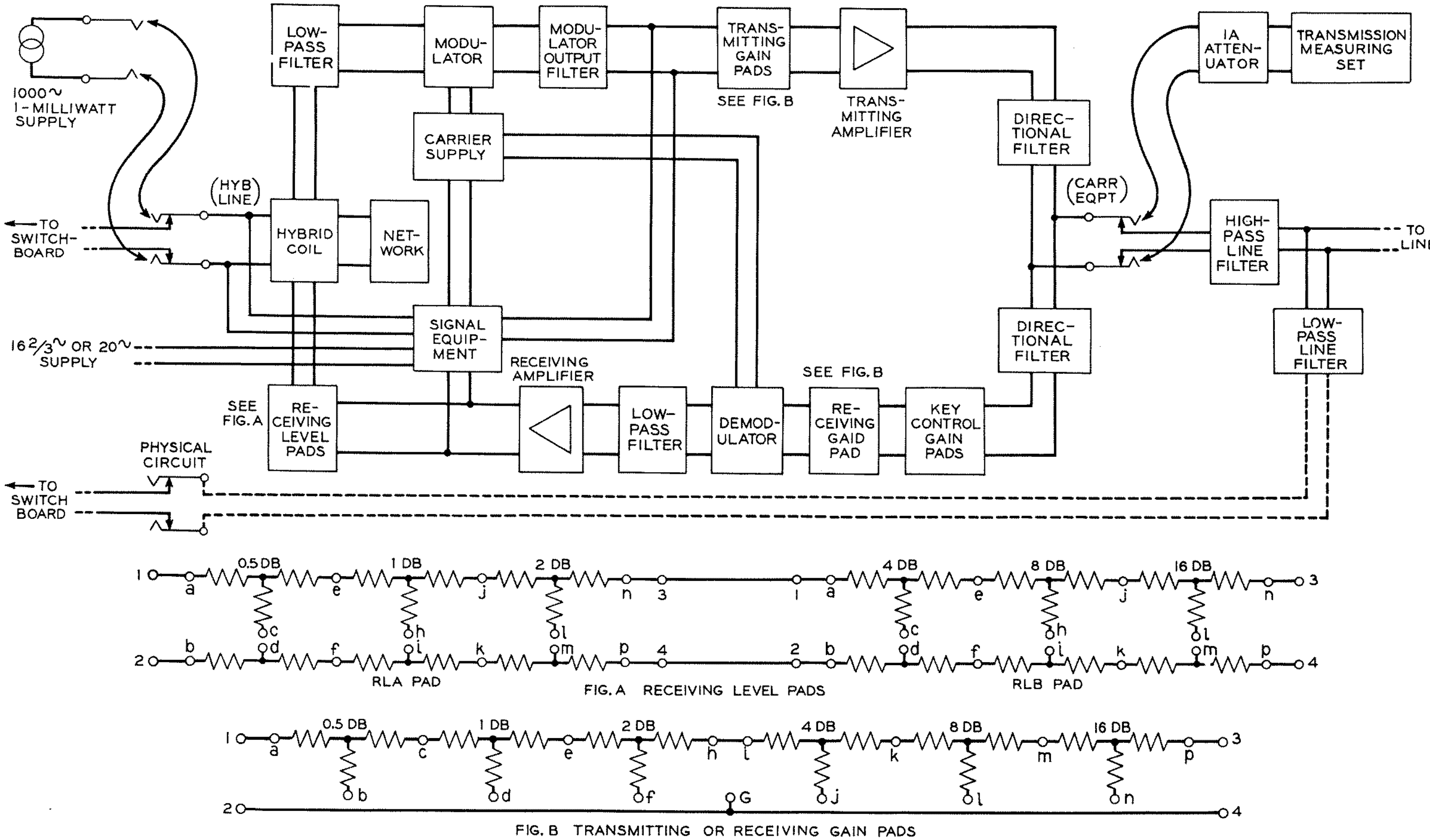


Fig. 22—Terminal Schematic

Terminal Transmitting Signal Output Power

8.10 Signaling power is produced by shifting the carrier 1000 cycles into the transmitting band and interrupting it at the rate of 20 or 16⅔ cycles per second depending upon the frequency of the office ringing supply. The purpose of this test is to adjust the uninterrupted signaling output power of the transmitting terminal to the proper value. This adjustment is accomplished by adjusting the resistances in the carrier supply circuit.

8.11 *Procedure.* Connect the attenuator and the transmission measuring set to the (CARR EQPT) jacks as shown in Figure 22. Set the attenuator for a loss equal to the specified transmitting level irrespective of any loss between the (HYB LINE) jacks and the switchboard. Block the (OSC) relay in the operated position. This will produce an uninterrupted supply of signaling current in the transmitting band of the terminal at a frequency of 1000 cycles from the carrier. The transmitting signal output power referred to one milliwatt is the reading of the attenuator minus the corrected reading of the transmission measuring set if the corrected set reading is a loss or plus the corrected set reading if the corrected reading is a gain.

8.12 *Adjustments and Requirements.* The signaling output power referred to one milliwatt should be as close as possible to 2 db below the specified transmitting level. For example, assume a specified transmitting level of 16 db, the signaling output power should be as close as possible to 14 db above one milliwatt.

Repeater Output Level

8.13 The repeater output level is measured in db above the switchboard level at the circuit terminal, which is also the level at the hybrid line jacks unless an extension facility is involved. (See paragraph 8.06.) The purpose of this test is to measure the output level of a repeater and to adjust it to the specified value. It is assumed that the terminal transmitting level has been adjusted as described in the preceding paragraphs.

8.14 *Procedure.* Connect 1000-cycle, 1-milliwatt test power to the (HYB LINE) jacks at the transmitting terminal (Figure 22). When measuring in the WE direction of transmission, connect the (CARR EQPT) (EAST) jacks (Figure 23) to the input of the attenuator and connect the output of the attenuator to the transmission measuring set. When measuring in the EW direction connect the attenuator input to the (CARR EQPT) (WEST) jacks. Set the attenuator initially for at least 20 db loss in order to protect the measuring set. The (AG WE) or (AG EW) key controlled pads should be adjusted in accordance with the weather conditions at the time of lineup. If the lineup is made in dry weather set these keys for 4 db loss and in wet weather set for 0 loss. The repeater output level is the reading of the attenuator plus or minus the reading of the transmission measuring set depending upon whether the set is reading a loss or a gain.

8.15 *Adjustments and Requirements.* The repeater output level should be adjusted to within 0.5 db of the specified value by adjusting the WE or EW gain pads, depending upon the direction of transmission. When adjusting the repeater output levels, care should be taken that the sum of the repeater gains in the two directions of transmission does not exceed 45 db.

Receiving Level

8.16 The receiving level at the hybrid line jacks will have the same value in db as the specified circuit net loss in those cases where there is no extension facility involved between the (HYB LINE) jacks at which the receiving level is being measured and the circuit terminal. When there is a loss between the hybrid coil at the receiving terminal and the circuit terminal, the required receiving level is the specified circuit net loss minus the loss of the extension facility. For example assume a 3-db extension facility at the receiving terminal and a specified net loss of 9 db. The receiving level should be −6 db. The purpose of the test described in this section is to measure the receiving level at a terminal and to adjust it to the required value. It is assumed that the terminal transmitting level, transmitting signal output power, and repeater output levels have been adjusted as described in the preceding paragraphs.

8.17 *Procedure.* Connect 1000-cycle, 1-milliwatt test power to the (HYB LINE) jacks at the transmitting terminal. At the receiving terminal strap the (RLA) and (RLB) pads for a total loss 2 db greater than the required receiving level at the (HYB LINE) jacks at the receiving terminal. Set the key controlled pad in accordance with the weather conditions at the time of lineup. If the lineup is made in dry weather set these pads for 4 db loss, for average weather set for 2 db loss and for wet weather set for 0 loss. Patch the transmission measuring set to the (HYB LINE) jacks and measure the level.

8.18 *Adjustments and Requirements.* The receiving level should be adjusted to within 0.5 db of the required value by adjusting the (REC) pad. If the requirements cannot be met after all the (REC) pad has been removed from the circuit, reduce the (RLA) and (RLB) pad values to meet requirements leaving the (REC) pad adjusted for 0 db loss. The (RLA) and (RLB) pads cannot be reduced more than 3 db without impairing the signaling margin. When adjusting the receiving level care should be taken that the terminal loop gain requirement is not exceeded.

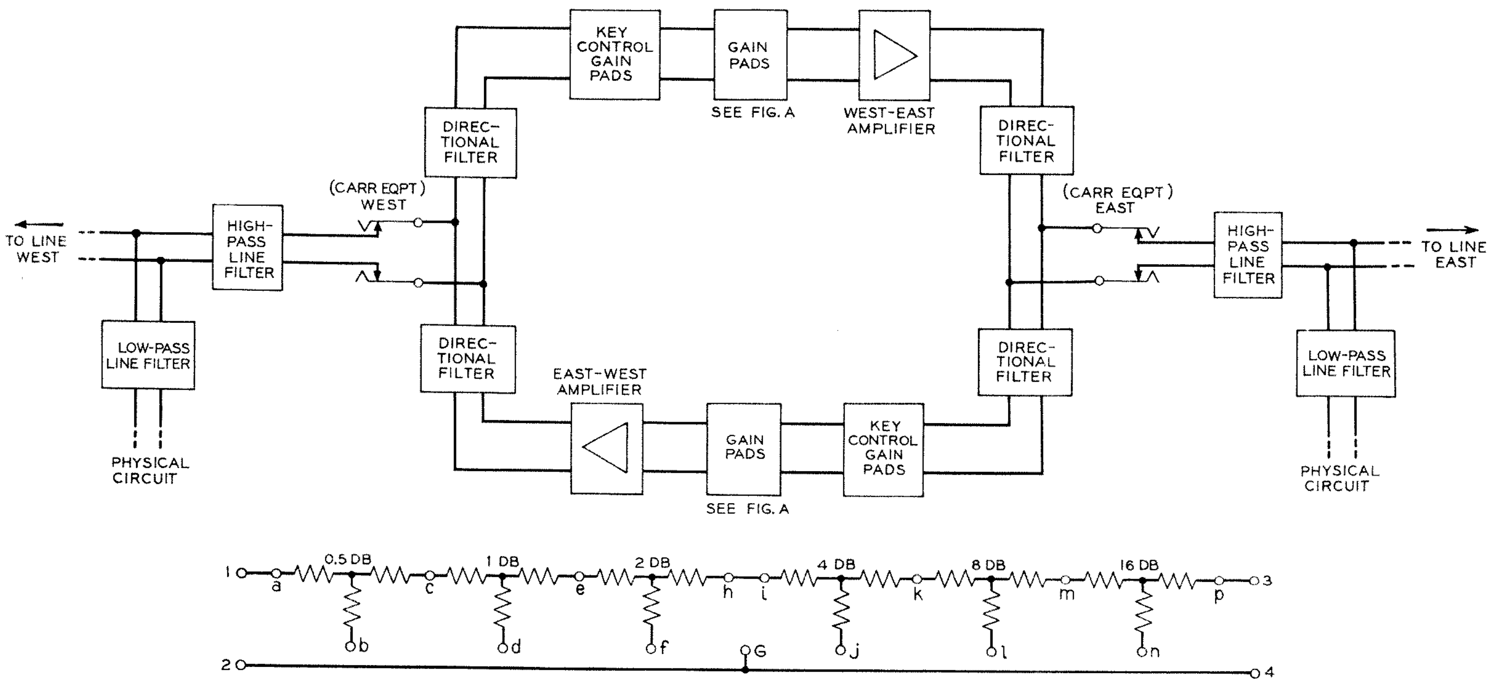


FIG. A EAST-WEST OR WEST-EAST GAIN PADS

Fig. 23—Repeater Schematic

Carrier Supply Synchronization

8.19 This test provides a means for determining whether the carrier supply of the two terminals is in proper synchronism and provides for adjustment if necessary. The terminals are adjusted quite accurately at the factory and should not ordinarily require further adjustment. Since the same oscillator supplies the carrier for both modulation and demodulation at each terminal, and therefore the carrier is the same frequency (7150 cycles) for both directions of transmission, adjustment need be made at only one terminal. The method consists of unbalancing the hybrid coil at the distant terminal and comparing the frequency of a 1000-cycle test tone transmitted from the test terminal with the tone received at the same terminal after it has passed over the carrier circuit in one direction, through the unbalanced hybrid coil and back over the carrier circuit in the opposite direction. Since both modulation and demodulation occur at the distant terminal, the difference in frequency as determined at the test terminal by this method will be twice the difference between the frequencies of the oscillators at each terminal.

8.20 *Procedure.* Connect 1000-cycle, 1-milliwatt test power to (HYB LINE) jacks at the test terminal. Unbalance the voice hybrid coil at the distant terminal by inserting an open-circuit plug in the (HYB LINE) jacks. Connect a test receiver across terminals (a) and (b) of the (RLA) pad at the test terminal as shown in Figure 24. If the two tones are not sufficiently equal in strength to make an easy comparison, the test receiver may be connected to other terminals (such as e, f, or j, k) of the (RLA) and (RLB) pads to equalize the volume. This assumes that some of the (RLA) and (RLB) pads have been strapped to place them in the circuit.

8.21 *Adjustments and Requirements.* Beats should be heard in the test receiver at a frequency not greater than 8 cycles per second (indicating 4-cycle difference in carrier frequency). If the requirement is not met adjust condensers (K2) and (K3) in the case of a West terminal or adjust condensers (K4) and (K5) in an East terminal to reduce the beats as near zero as possible, and within the limit of eight beats per second.

Channel Net Loss Frequency Measurement

8.22 This test is made to determine the channel quality and will serve to indicate the effects of impedance irregularities such as would be caused by faulty filters or line impedance irregularities. It should be made in both directions of transmission. This test may be omitted, if a variable frequency oscillator is not available in the terminal offices, since the other tests outlined herein together with the results obtained in actually talking over the circuit will provide a good indication of its quality.

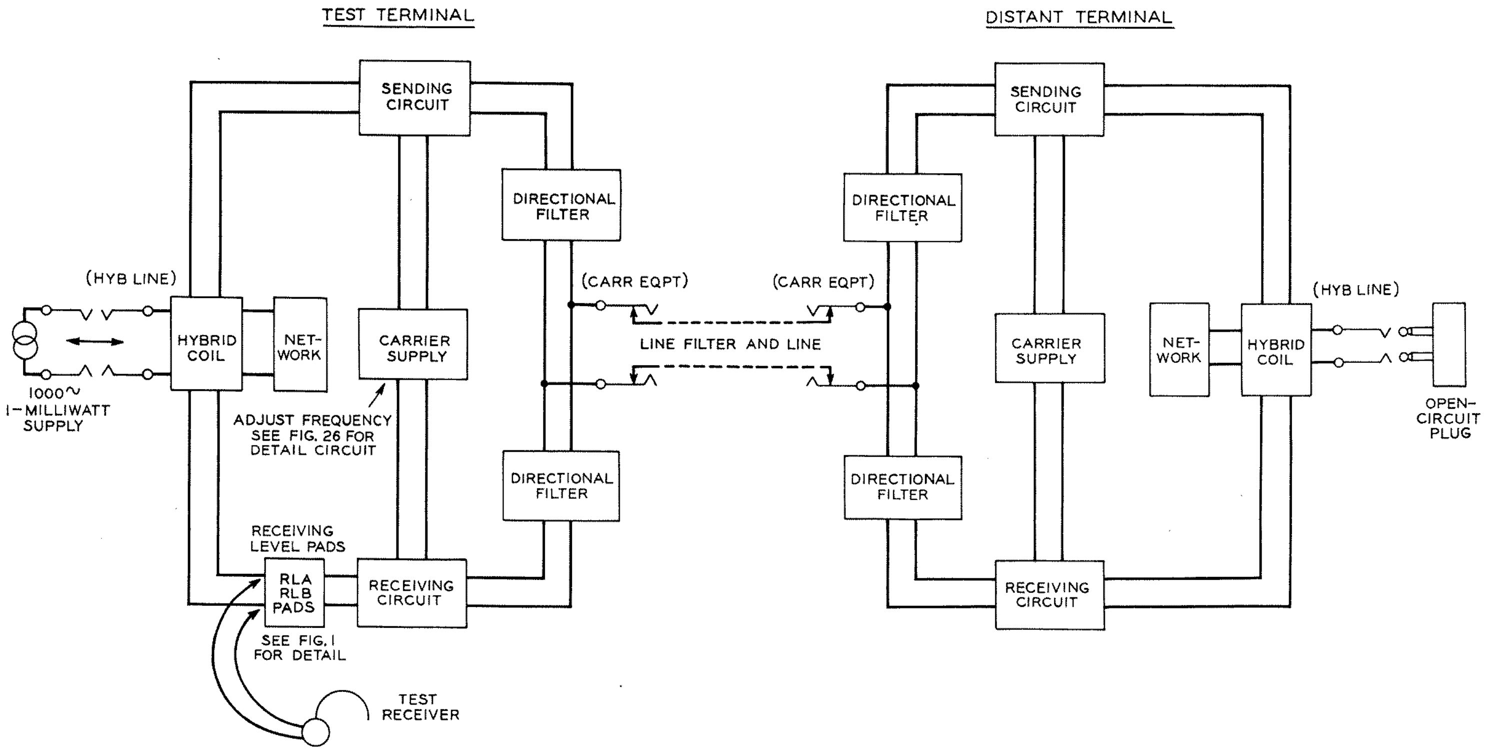


Fig. 24—Carrier Frequency Synchronization

8.23 *Procedure.* Patch the test power to the (HYB LINE) jacks at the sending terminal. If the oscillator does not have adequate means for adjusting the output, the oscillator may be connected through an attenuator. Patch the transmission measuring set to the (HYB LINE) jacks at the receiving terminal. Measure the net loss of the circuit at the frequencies given below, adjusting the test oscillator for 1 milliwatt at each frequency. The three 1000-cycle measurements are made for check purposes and the series of measurements should be repeated until the 1000-cycle measurements check within 1 db.

Frequency	*Frequency*
1000	2100
200	2600
500	2800
1000	3200
1600	1000

Plot the test results in order to obtain the general characteristics of the channel so that the requirements may be applied. At the extreme low and high frequency points it may be necessary to extend the trend of the curve beyond the test results.

8.24 *Adjustments and Requirements.* In the case of a system with no repeaters or with one repeater, the lower frequency at which the net loss is 10 db greater than that at the 1000-cycle point should not be above 300 cycles and the upper frequency at the 10-db point should not be less than 3000 cycles. In the case of a system with two repeaters the corresponding frequencies are 400 and 2800 cycles. Failure to meet the above requirements is probably due to line impedance conditions.

9. SERVICE ADJUSTMENTS

9.01 The only service adjustments required in operating the H1 carrier telephone system are setting of the key-controlled pads both in the terminals and repeaters. These adjustments are required to compensate for changes in attenuation of the line which will be caused by seasonal changes and changes in weather conditions. The total change in attenuation will, in general, be proportional to the length of the line, and the frequency with which pad adjustments will be required will be dependent upon the nature of the climate. Therefore, local experience with the performance of a system should determine the intervals at which adjustments will be required. It is recommended that the tests given in this section for determining service adjustments be performed at least once a week until sufficient experience has been acquired to determine the proper intervals.

9.02 One terminal of a system should be designated as control office, and no changes in the key-controlled pad settings at repeaters or terminals should be made without authorization from the control office. The non-control office should report to the control office, weather conditions which experience has indicated may affect the net loss of the system, such as temperature changes, heavy frost, wet snow, heavy rain, or a change from such conditions to clear dry weather. The control office should use such information as a guide for authorizing key-controlled pad changes. On line sections under 125 miles in length no adjustment should be necessary except under extreme changes in weather conditions.

Channel Net Loss Measurement

9.03 The purpose of this test is to measure the net loss of the carrier channel and to adjust the key-controlled pads for weather conditions differing from those obtained at the time of the system line-up. This test should be made in both directions of transmission. The net loss should be measured from the (LINE) jacks at the test board or at the switchboard. In the case of a circuit extending beyond the carrier terminal and which does not go through the test board the measurements should be made from the (HYB LINE) jacks of the carrier terminal.

9.04 *Procedure.* Connect 1,000-cycle, 1-milliwatt test power to circuit jacks at the test board or switchboard or to the (HYB LINE) jacks at the sending terminal. Connect the transmission measuring set to circuit jacks at the test board or switchboard or to the (HYB LINE) jacks at the receiving terminal. Measure the net loss on the transmission measuring set.

9.05 *Adjustments and Requirements.* The measured net loss should be as close as possible to and within 1 db of the specified circuit net loss. The key-controlled pads at the terminals and repeaters should be adjusted to meet the above requirement.

System Signaling Check

9.06 When the system is properly lined up a ringing test over the system should be a sufficient check of the signaling circuit. However, to provide additional signaling margin, the key-controlled pads at the receiving terminal should be included in the circuit when making this test. The signaling circuit should be tested in both directions of transmission.

9.07 *Procedure.* Operate the key-controlled pads to introduce the maximum loss of 6 db. Ring over the circuit from distant terminal switchboard or test board and make sure that ringing is received at the receiving switchboard or test board. Return the key-controlled pads to their normal operating position. If the ring is not received, proceed as follows:

(a) Replace the 328A Vacuum Tube of receiving signaling circuit.

(b) Make the transmitting signal output test, as described in paragraph 8.10.

(c) Check the adjustment of the receiving terminal as described in paragraph 8.16.

(d) Measure the rectified current in the receiving signaling circuit as follows:

At the sending terminal block the (OUT) relay in the operated position to produce an interrupted supply of signaling current in the carrier circuit. At the receiving terminal remove the power supply and connect a milliammeter in series with the operating winding of the (IN) relay of the signaling circuit. Replace power supply.

9.08 *Adjustments and Requirements.* The signaling current, as measured on the milliammeter, should not be less than 8 milliamperes. If this requirement is not met, the trouble probably is in the wiring or is due to defective varistor units.

10. TROUBLE LOCATION TESTS

10.01 This section describes tests which may be performed to locate trouble in the system. It is recommended that the plate voltage measurement described in paragraphs 10.04 and 10.05 be made at intervals of about three months. The other tests in this section may be made whenever it appears necessary.

A-c. Supply Voltages—Terminal and Repeater

10.02 When using an alternating-current source, all of the power required for the operation of the terminal or repeater is obtained from 50- to 60-cycle, 100- to 130-volt a-c. supply, and the connection to the proper step on the primary winding of the power transformer is made in accordance with the information on the circuit drawings. If at any time the supply voltage is changed by the power company or the average supply voltage as measured at intervals during a 24 hour period indicates a change in the operating range, the wiring of the power transformer should be changed to the proper tap as given on the circuit drawing.

Caution: Under no circumstances should the a-c. power be connected to the power transformer of the type H terminal or repeater while the metal cover over the power supply unit is removed. This is important because of high voltages on the secondary of the power transformer.

D-c. Supply Voltages—Terminal and Repeater.

10.03. When the terminal or repeater is operated from central-office battery the power is obtained directly from the office 24-volt and 130-volt supplies and the 274A Vacuum Tube is not employed. For satisfactory operation the 24-volt supply should be maintained between 20 and 28 volts and the 130-volt supply between 125 and 135 volts at the terminal or repeater panel.

Plate-Voltage Measurement—Terminal and Repeater

10.04 This test provides a means of checking the 274A Vacuum Tube used for a-c. operation, for checking the operating voltage of the plate circuit, and will serve as a trouble location test. See Figure 25. Measure the voltage between terminals 1 and 5 of the (SB OUT) transformer of a terminal or of the (OUT WE) transformer of a repeater.

10.05 *Adjustments and Requirements.* The voltage should be between 147 and 171 volts. If this requirement is not met, check to see that the connections to the primary of the power transformer are correct for the power circuit supply voltage range as given on the circuit drawing. If this connection is satisfactory, replace the 274A tube.

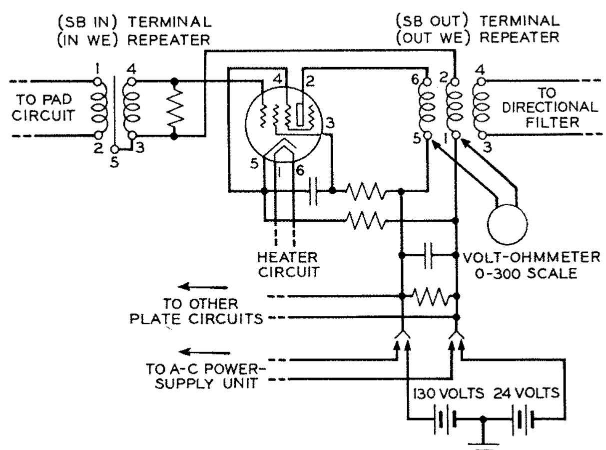


Fig. 25—Plate Voltage Measurement

Carrier Output Test

10.06 This procedure provides a means of checking the carrier-supply voltage, which is expressed in terms of one milliwatt as measured with the 600-ohm transmission measuring set bridged across the carrier supply to the modulator and demodulator circuit.

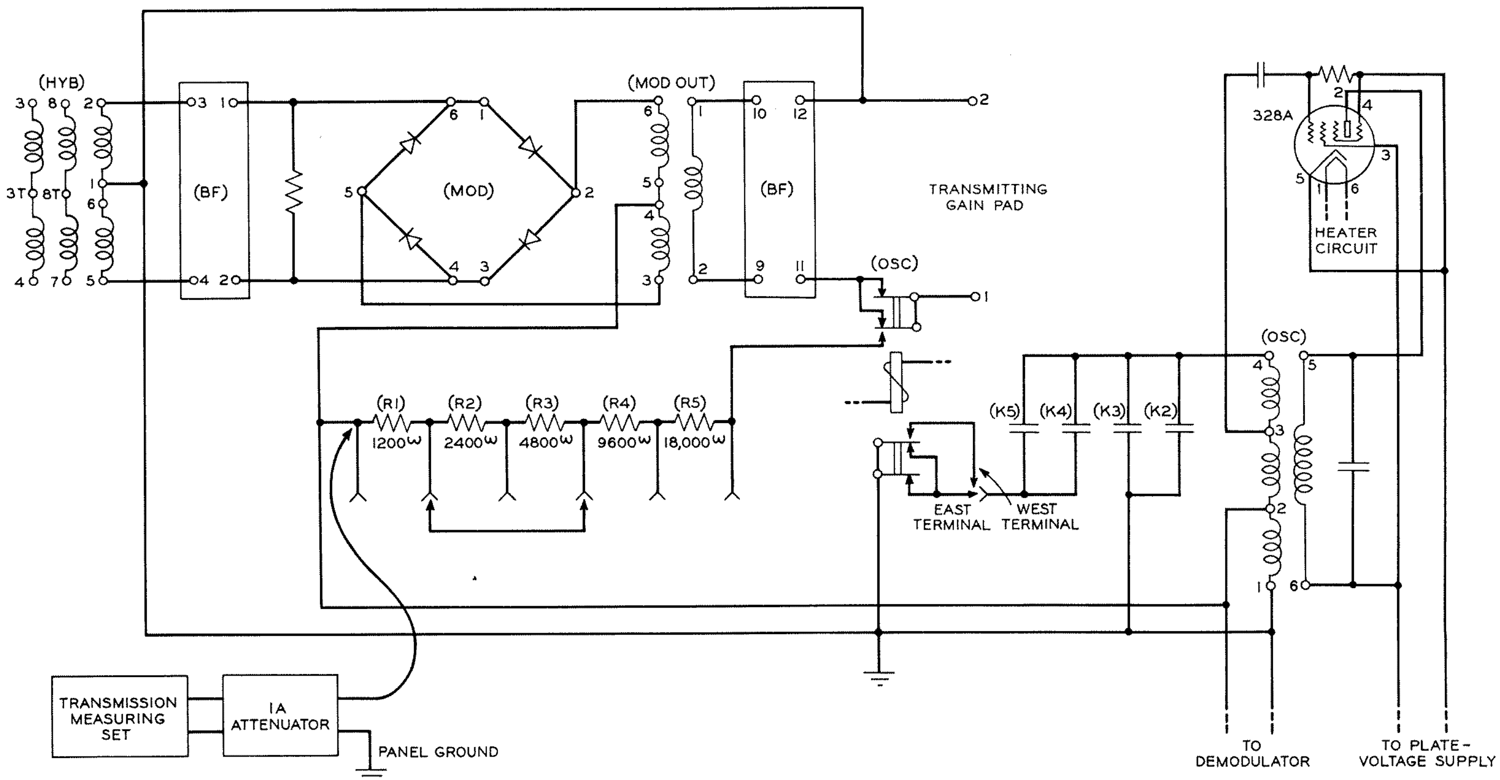


Fig. 26—Carrier Supply

10.07 *Procedure.* Connect the transmission measuring set to the output of the attenuator and connect one input terminal of the attenuator to ground and the other terminal of the attenuator to the (R1) resistance as shown in Figure 26. Adjust the attenuator initially to 20 db to protect the measuring set. Adjust the attenuator to give a reading on the portion of the transmission measuring set meter scale where the greatest accuracy is secured: that is, as close as possible to the zero or one milliwatt division of the meter. Correct the reading of the set for any error at a frequency of 7150 cycles. (See paragraph 1.17.) The carrier output referred to one milliwatt is the reading of the attenuator minus the corrected reading of the transmission measuring set if the corrected set reading is a loss, or plus the corrected reading if the corrected reading is a gain. For example, assume a transmission measuring set error of 0.8 db, meter reading of 1 db loss and attenuator setting of 12 db. Corrected meter reading is loss of 0.2 db and carrier output is 11.8 db above one milliwatt.

10.08 *Adjustments and Requirements.* The carrier output should not be less than 10 db above one milliwatt. If this requirement is not met, replace the (OSC) vacuum tube.

Terminal Transmitting Gain

10.09 The measurement of transmitting gain provides a means of checking the gain of the circuit including the hybrid coil, transmitting low-pass filter, modulator, modulator output filter, transmitting amplifier, and a section of the directional filter. The measurment is made by sending a milliwatt of 1,000-cycle test power into the hybrid line jacks and measuring the power at the carrier equipment jacks. If a network differing substantially from 600 ohms and 1 or 2 mf is employed to balance the hybrid coil, the receiving circuit should be disabled during this test to prevent singing around the terminal. This can be done by strapping terminals 3 and 4 of the (REC) pad.

10.10 *Procedure.* The strapping of the (TR) pad for the service condition should be recorded and the pad should then be restrapped for zero loss. Proceed as outlined in paragraph 8.07 under "Terminal Transmitting Level."

10.11 *Adjustments and Requirements.* The gain of the east terminal should be between 17.5 and 23 db; the transmitting gain of a west terminal should be between 17 and 22.5 db. If these requirements are not met, the trouble may be due to the adjustment for the voltage applied to the terminal, to defective transmitting amplifier tube (SB), or oscillator tube (OSC).

10.12 At the conclusion of the test the (TR) pad should be restored to the service condition as recorded at the beginning of the test.

Terminal Receiving Gain Test

10.13 The measurement of receiving gain provides a means of checking the gain of the receiving circuit including a section of the directional filter, the demodulator, low-pass filter, receiving amplifier, and hybrid coil. The measurement is made by sending into the carrier equipment jacks testing power at a frequency corresponding to the 1,000-cycle point of the channel and measuring the 1,000-cycle output power at the hybrid line jacks. If a network differing substantially from 600 ohms and 1 or 2 mf is employed to balance the hybrid coil, the transmitting circuit should be disabled during this test to prevent singing around the terminal. This can be done by strapping terminals 1 and 2 of the (TR) pad.

10.14 *Procedure.* Record the strapping of the (REC), (RLA), and (RLB) pads for the service condition and restrap them for zero loss. The setting of the key-controlled pads should also be recorded and they should be set in the zero db position. Adjust the oscillator to 1 milliwatt test power at 6150 cycles for an east terminal or 8150 cycles at a west terminal. Connect the oscillator to the attenuator and the attenuator to the carrier equipment jacks. Connect the transmission measuring set to the hybrid line jacks. Adjust the attenuator to give a reading on the portion of the transmission measuring set meter scale where the greatest accuracy is secured: that is, as close as possible to the zero or 1-milliwatt division of the meter. The receiving gain is the reading of the attenuator plus or minus the reading of the transmission measuring set depending on whether the set reading is a loss or a gain.

10.15 *Adjustments and Requirements.* The receiving gain of an east terminal should be within 11.5 to 17 db and the receiving gain of the west terminal should be within 12.5 to 18 db. If the requirements are not met the trouble may be due to the adjustment for the voltage applied to the terminal or to a defective receiving amplifier tube (V).

10.16 The (REC), (RLA), and (RLB) pads should be restored to the service condition and the key-controlled pads should be restored to their normal position as recorded at the beginning of the test.

Gain Test—Repeater

10.17 The measurement of repeater gain in each direction of transmission provides a means of checking the gain of the circuit including sections of the directional filters and amplifiers. The measurement is made by sending into the carrier equipment jack testing power at a frequency corresponding to the 1000-cycle point of the channel and measuring the output at the carrier equipment output jacks in the direction of transmission being tested. In order to prevent singing of the repeater the pads are set for 10 db loss in each direction of transmission.

10.18 *Procedure* (See Figure 23). The strapping of the EW and WE pads for the service condition should be recorded and the pads restrapped for a 10 db loss. The setting of the key-controlled pads should be recorded and they should be reset to the 0 db position. The oscillator should be adjusted to 1 milliwatt test power at 6150 cycles for the WE direction of transmission or 8150 cycles for the EW direction of transmission. Connect the oscillator to the attenuator and the attenuator to the (CARR EQPT) jacks (West) for testing the WE direction of transmission or to the (CARR EQPT) jacks (East) for testing the EW direction. Set the attentuator initially for 20 db loss to protect the measuring set. The transmission measuring set should be connected to the (CARR EQPT) jacks on the other side of the repeater in either case. The repeater gain is the reading of the attenuator minus the corrected reading of the transmission measuring set if the corrected set reading is a loss or plus the corrected set reading if it is a gain.

10.19 *Adjustments and Requirements.* The gain in either direction of transmission should be between 19 and 23 db. If this requirement is not met, the trouble may be due to the adjustment for the voltage applied to the repeater or to the amplifier tube (WE) or (EW) depending upon the direction of transmission in which the gain does not meet requirements.

10.20 At the conclusion of the test the (WE) and (EW) pads should be strapped for the service condition as recorded at the beginning of the test and the key-controlled pads should be restored to the position for normal operation.

Supplementary Tests

10.21 The following table gives information on the normal gain or loss in specific portions of the terminal and repeater circuits. This information may be useful in definitely locating a trouble condition when the requirements of one or more of the tests outlined above have not been met. This table shows the points at which the oscillator should be connected and the point at which the transmission measuring equipment should be connected. The output level for these measurements should be about 1 milliwatt except for the amplifier measurement, in which case the output level should be 10 to 16 db above 1 milliwatt. In making these tests, the connections shall be removed from the points to which the sending and receiving equipment is connected.

Circuit Element Under Test	*Measuring Equipment Connections* Send	Frequency	Receive	*db Loss (−) or Gain (+)*
	(Repeater and Terminal)			
85C Filter or (LF) part of 86A Filter	1-2 of (LF) Filter	7150	5-6 of (LF) Filter	−0.2 ± .2
85C Filter or (LF) part of 86A Filter	1-2 of (LF) Filter	1000	3-4 of (LF) Filter	−0.2 ± .2
85A Filter	1-2 of 85A Filter	6150	5-6 of 85A Filter	−1.2 ± .2
85A Filter	3-4 of 85A Filter	8150	1-2 of 85A Filter	−1.0 ± .3
85B Filter	3-4 of 85B Filter	6150	1-2 of 85B Filter	−0.8 ± .3
85B Filter	1-2 of 85B Filter	8150	5-6 of 85B Filter	−1.4 ± .3
Trans. Amp. East	1-2 of (SB IN) Transformer	8150	1-2 of (LF) Filter	+31.9 ±1.0
Trans. Amp. West	1-2 of (SB IN) Transformer	6150	1-2 of (LF) Filter	+32.2 ±1.0
Rec. Amp.* East or West	1-4 of (V IN) Transformer	1000	(HYB LINE) Jacks	+20.4 ±1.0
	(Repeater)			
Amplifier	1-2 of (IN WE) Transformer	6150	3-4 of (OUT WE) Transformer	+33.2 ±1.0
Amplifier	1-2 of (IN EW) Transformer	8150	3-4 of (OUT WE) Transformer	+33.2 ±1.0

*(RLA) and (RLB) pads strapped for 0 db loss.

11. APPARATUS REQUIREMENTS AND ADJUSTING PROCEDURES

General

11.01 This section includes information on the maintenance of the individual pieces of apparatus in the H1 carrier telephone system. It will not, in general, be found practicable to repair apparatus in the field except for the adjustment outlined herein for keys and relays. Other items of apparatus should be replaced when serious defects appear.

11.02 It is essential that parts and contacts be kept clean, since the failure of a circuit to function properly is often traced to dirty contacts or dirty or gummy parts. It is important that the inside of relay covers should be kept clean and should not be left off longer than absolutely necessary. Also, cabinet doors should not be kept open unnecessarily.

11.03 The *Test Requirements* listed herein are current maintenance tests. When it is found necessary to readjust the apparatus because it does not meet these *Test Requirements* the *Readjust Requirements* should be used.

11.04 If necessary to check for a reliable contact, this may be done by bridging a receiver across a made contact through which current is flowing. Absence of fluttering in the receiver is evidence of a reliable contact.

11.05 Carbon tetrachloride used in flushing relay contacts should be chemically pure to avoid leaving foreign material on the contacts after cleaning.

11.06 Unless otherwise specified, contact pressure shall be measured at the point of contact just as the contacts break. It shall be measured on normally closed contacts with the apparatus normal and on normally open contacts with the apparatus operated. Other spring tensions shall be measured at the points indicated.

Tools, Gauges, Meters, Etc.

11.07 The following tools, gauges, and test sets or the equivalent are recommended for the maintenance of the apparatus covered in this section.

Tools

Code	*Name*	*Used On*
259	Spring Adjuster	R & S type relays
265B	Contact Burnisher	Relays
340	Adjusting Key	206 type relays
*361B	Terminal Clip	R type relays
363	Spring Adjuster	S & 206 type relays
†373B	Contact Burnisher Holder	Keys
†374B	Contact Burnisher Blade	Keys
KS-6015	Duck-bill Pliers	Keys & relays

†If this contact burnisher holder and blade are not available the No. 265B burnisher can be used.

*An 893 cord equipped with 360A tools as listed in paragraph 1.20, should be available for use with the terminal clip in adjusting relays.

Gauges

Code	*Name*	*Used On*
70D	50-0-50 gram gauge	R & 206 type relays
70E	150-0-150 gram gauge	R type relays
70F	10-0-10 gram gauge	S type relays
74D	Thickness gauge (0.003-0.018 inch)	General
92A	Non-magnetic thickness gauge (0.010 inch)	206 type relays

Meters

The Western Electric 35C Test Set should be used for adjusting relays to meet their electrical requirements if it is available. If not, a milliammeter and a variable resistance can be used for this purpose.

Keys

Cleaning

11.08 The blades of contact burnishers and thickness gauges used on the contacts should be kept clean by wiping with a clean cloth dampened with carbon tetrachloride.

11.09 *Burnishing Contacts.* To burnish the contacts use a No. 265B Contact Burnisher or a No. 373B Contact Burnisher holder and a 374B Contact Burnisher blade or the equivalent. In burnishing normally open contacts, press the contacts together manually, or operate the key giving a slight pressure only on the blade of the burnisher. In the case of normally closed contacts, the tension of the springs themselves will usually furnish sufficient pressure against the burnisher. Usually rubbing the burnisher back and forth between the contacts two or three times is sufficient.

11.10 *Pitted Contacts.* Pitted contacts should be treated by burnishing until the pits are reduced. Abrasives other than contact burnishers should never be used.

11.11 *Flushing Contacts.* Clean and flush the contacts with carbon tetrachloride in the following manner. Dip the flat end of a clean toothpick in the carbon tetrachloride to a depth of about ¼ inch and deposit the liquid on the contacts (held slightly separated). Then rub the flat end of the toothpick back and forth two or three times between the contacts. Then with the contacts held slightly apart, flush them with the liquid taken up on the clean point of the toothpick. Be sure that sides as well as the tops of the contact points and discs are flushed. Following the use of carbon tetrachloride, burnish the contacts as outlined in 11.09.

Adjusting

11.12 The wiring to keys is left long enough to permit them to be pulled out in front of the panel for inspection and adjustment. Care should be exercised not to break off the skinners. While the key is removed, inspect the entire key for possible faults and make any adjustments that may appear necessary before it is remounted. In the event that troubles appear in a key, which prevent satisfactory operation, and which cannot be readily corrected, the key should be replaced.

Relays

General

11.13 The requirements on relays which are necessary for adjustment and maintenance are either mechanical or electrical. The mechanical requirements pertain to cleaning, contact alignment, contact separation and pressure, etc., and the electrical requirements are primarily direct-current flow values for operation or non-operation of the relay. Some of the requirements are given in this section and the remainder are covered in the circuit requirement tables on the individual circuit drawings, an explanation of which is given in Figure 27.

11.14 *Cleaning Non-Pitted Contacts*

(a) Burnish all contacts by using a No. 265B contact burnisher or the equivalent.

(b) In burnishing normally open contacts place the blade of the burnisher between the contacts, press them together manually, or operate the relay manually at the same time moving the blade back and forth. In the case of normally closed contacts, the tension of the springs themselves will usually furnish sufficient pressure against the burnisher.

(c) After burnishing make sure that the contact follow and contact separation requirements are still met.

(d) When unable to clear contact trouble by burnishing only, clean and flush the contacts with carbon tetrachloride. Dip the flat end of a clean toothpick into the carbon tetrachloride to a depth of about ½ inch and deposit the liquid on the contacts (held slightly separated). Where possible, rub the flat end of the toothpick back and forth two or three times between the contacts. Then with the contacts held slightly apart flush them with carbon tetrachloride taken up on the clean point of the toothpick. Be sure that the sides as well as the tops of the contact points and discs are flushed.

(e) Take care to keep the carbon tetrachloride from coming in contact with insulators or spoolheads.

(f) When the contacts are thoroughly dry burnish them to insure that no deposit or residue from the solution, or any foreign matter, remains.

11.15 *Cleaning Pitted Contacts*

Burnish pitted contacts but do not attempt to remove pits or build-ups unless it appears that their presence may cause the relay to fail in service.

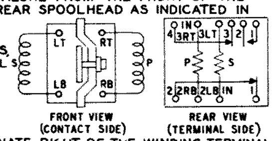
CIRCUIT REQUIREMENTS

TITLE

REMARKS	See notes below
DIRECT CURRENT FLOW REQ. — READJ. MA	MAGNITUDE OF TESTING CURRENT IN MILLIAMPERES
DIRECT CURRENT FLOW REQ. — TEST MA	MAGNITUDE OF TESTING CURRENT IN MILLIAMPERES
DIRECT CURRENT FLOW REQ. — AFTER SOAK MA	STRENGTH OF CURRENT TO BE PASSED THROUGH WINDING TO ESTABLISH DEFINITE MAGNETIC CONDITION IMMEDIATELY BEFORE TEST OR READJUST
DIRECT CURRENT FLOW REQ. — TEST FOR	FUNCTION OF RELAY TO BE TESTED. O=OPERATE; R=RELEASE; NO=NON-OPERATE
DIRECT CURRENT FLOW REQ. — TEST WDG.	NO INFORMATION REQUIRED IN THIS COLUMN FOR HI CARRIER EQUIPMENT
SEE TEST NOTE NO.	REFERENCE TO TEST NOTES AT BOTTOM OF THIS TABLE
TEST SET PREP	DESIGNATES WAY IN WHICH TEST SET IS TO BE APPLIED TO CIRCUIT. SEE NOTE 2 IN "REMARKS" COLUMN FOR EXPLANATION OF SYMBOLS
CIRCUIT PREPARATION — TEST CLIP DATA — CONN. GRD. / CONN. BAT.	THE POINT OR POINTS IN THE CIRCUIT UNDER TEST TO WHICH BATTERY OR GROUND IS TO BE CONNECTED IN MAKING THE SPECIFIED ELECTRICAL TESTS. THESE POINTS OF CONNECTION ARE USUALLY THE WINDINGS OF THE RELAYS. THE METHOD OF DESIGNATING THE WINDING TERMINALS AND CONTACTS IS EXPLAINED IN NOTE 1 UNDER "REMARKS" COLUMN. LETTERS IN PARENTHESES INDICATE APPARATUS TO WHICH CONNECTION IS REQUIRED.
CIRCUIT PREPARATION — BLOCK OR INSULATE	BLOCK THE ARMATURE OF DESIGNATED RELAYS IN THE CIRCUIT IN EITHER AN OPERATED (O) OR NON-OPERATED (NO) POSITION
MECH. REQ. — ARM. TRVL.	GAP BETWEEN CORE AND ARMATURE (OR NEAREST STOP PIN) GIVEN IN THOUSANDTHS OF AN INCH
MECH. REQ. — CONT. PRESS. / BSP FIG.	INFORMATION IN THESE COLUMNS MAY BE DISREGARDED SINCE THE INFORMATION IS GIVEN IN THE TEXT UNDER THE REQUIREMENTS FOR THE INDIVIDUAL RELAYS
APPARATUS — CODE	WESTERN ELECTRIC COMPANY CODE NUMBER OF RELAY
APPARATUS — DESIG.	FUNCTIONAL DESIGNATION OF APPARATUS

NOTES:

1. WINDING AND CONTACT TERMINALS ARE DESIGNATED SO THAT THEY MAY BE LOCATED WITHOUT USE OF A WIRING DIAGRAM. THE UPPER AND LOWER ROWS OF RELAY CONTACT AND WINDING TERMINALS ARE DESIGNATED T (TOP) AND B (BOTTOM). THE LETTERS L AND R, USED ONLY FOR DESIGNATING WINDING TERMINALS, INDICATE THE LEFT AND RIGHT SIDE RESPECTIVELY FACING THE CONTACT SIDE OF RELAY. CONNECTION MAY BE MADE TO TERMINALS DESIGNATED BY LETTERS ALONE FROM THE FRONT OF THE RELAY. THE TERMINALS ARE LOCATED ON THE REAR SPOOLHEAD AS INDICATED IN THE DIAGRAM AND MAY BE REACHED WITH A 361B TOOL. WHERE A TERMINAL IS DESIGNATED BY A NUMERAL OR A NUMERAL AND TWO LETTERS, CONNECTION MUST BE MADE FROM THE TERMINAL SIDE OF THE RELAY. CONTACT TERMINALS ARE NUMBERED FROM RIGHT TO LEFT FACING THE TERMINAL SIDE OF RELAY. WHERE A WINDING TERMINAL IS DESIGNATED BY A NUMERAL AND TWO LETTERS, THE NUMERAL IS THE SAME AS THAT OF THE CONTACT TERMINAL AT THE IMMEDIATE RIGHT OF THE WINDING TERMINAL. WHEN THE NUMERAL FOLLOWS THE LETTERS IT INDICATES THAT THE WINDING TERMINAL IS LOCATED AT THE EXTREME RIGHT END OF A ROW OF TERMINALS OR THAT IT IS IN A ROW OF WINDING TERMINALS ONLY. IN 206 TYPE RELAYS THE CONTACT AND WINDING TERMINALS ARE NUMBERED CONSECUTIVELY FROM RIGHT TO LEFT FACING THE TERMINAL SIDE OF RELAY.



2. "B/G" BATTERY AND GROUND BOTH HAVE TO BE FURNISHED OVER TESTING LEADS
"BAT" BATTERY ALONE MUST BE FURNISHED OVER TESTING LEADS
"GRD" GROUND ALONE MUST BE FURNISHED OVER TESTING LEADS
"NGB" NON-GROUNDED BATTERY REQUIRED TO REVERSE DIRECTION OF CURRENT FLOW

TEST NOTES:
THESE NOTES ARE REFERRED TO IN COLUMN HEADED "SEE TEST NOTE NO." THEY GIVE SPECIAL CONDITIONS FOR TESTING RELAYS OPPOSITE WHICH TEST NOTE NUMBER APPEARS.

Fig. 27—Explanation of Circuit Requirement Table

11.16 *Cleaning of Armatures, Cores, Stops or Pole-Pieces*

(a) To clean the armatures and cores of relays other than 206 type, insert heavy bond paper between the armature and the core, press the armature lightly toward the core and withdraw the paper. Repeat the operation until the paper shows no evidence of dirt. Use a clean piece of paper for each operation.

(b) Clean the pole-pieces of 206 type relays when necessary in accordance with the following procedures. Back off the pole-piece screws as far as possible from the armature. Also back off the contact screws. If the pole-pieces are dirty clean them with carbon tetrachloride. To remove metallic particles from the pole-pieces clean them with a tool made out of a piece of thin stiff metal (preferably non-magnetic) over which is wrapped a layer of friction tape with the stickier side toward the blade. *Press, do not rub,* the taped portion of the tool against the pole-pieces and the armature so as to cause any particles that may be present to adhere to the tape. Do not rub the tape over the pole-pieces as this tends to leave a residue from the tape on the pole-pieces. Do not use the tape for more than one cleaning operation.

Requirements for R Type Relays

11.17 *Contact and Spring Alignment*

(a) The point of contact should fall wholly within the boundary of the opposing contact except for opposing contacts having the same diameter, in which case their centers shall not be out of alignment more than 25 per cent of the diameter of the contact points. Springs should not touch the relay cover.

(b) If the contacts do not line up properly, or if the tang does not overlap the spoolhead sufficiently, or the stud rubs on the spring, attempt to correct the trouble by applying pressure to the end of the springs using a No. 259 spring adjuster and exercising care not to distort or otherwise damage the springs. If the springs cannot be shifted, remove the relay from the mounting plate and loosen the spring assembly clamping screws sufficiently to shift the springs so as to correct the fault.

11.18 *Armature Travel*

(a) The armature travel should be in accordance with the value specified in the "ARM TRVL" column on the circuit requirement table. Use the 74D gauge.

(b) To adjust the armature travel insert the proper thickness gauge between the armature and the core and turn the adjusting nut until the gauge fits snugly.

11.19 *Contact Pressure*

(a) The contact pressure should be in accordance with the information in the following table. Use the 70D gauge. T indicates test and R indicates readjust, minimum allowable values in grams. See Figure 18 for numbering of contacts. Where the relay has top and bottom spring combination the values given apply to each of them, unless specified separately.

Relay	*Spring Pressure in Grams*									
	1		*2*		*3*		*4*		*5*	
	T	*R*	*T*	*R*	*T*	*R*	*T*	*R*	*T*	*R*
R422*†	15	17	25	27	15	17	15	17	25	27
R1510†										
Top	15	17	15	17	25	27				
Bottom	15	17	A	A						
R1002	15	17	A	A						
R721										
Top	15	17	A	A	15	17	A	A		
Bottom	15	17	A	A						

*Spring 4 shall break from 5 before it makes with 3.

†There shall be a slight clearance between the stud or bushing and the springs. This clearance shall be checked when the armature is resting against the adjusting nut. Gauge by eye.

"A" appearing in the spring tension column designates springs which should be tensioned against the armature stud. The tension of such a spring together with the tensions of all other springs on the relay that rest against the armature studs should be sufficient to hold the armature against the adjusting nut.

(b) To adjust the springs place the 259 spring adjuster about ¼ inch from where the spring leaves the clamping plates of the spring assembly and twist the spring slightly to the left or right as required, exercising care not to disturb adjacent springs.

11.20 *Contact Separation and Follow*

(a) The separation between any pair of contacts normally open or between any pair of contacts that are opened when the relay is operated should be

Min. 0.005 inch

(b) The contact follow on all normally open contacts should be approximately 0.005 inch.

(c) If necessary adjust the springs as outlined in paragraph 11.18.

11.21 *Electrical Requirements*

(a) The relay shall meet the electrical requirements specified on the circuit requirement table. These requirements should be met with the cover off the relay unless otherwise specified.

(b) If necessary to meet the operate or hold requirement decrease the spring tension towards the minimum, reduce the contact follow towards the minimum or increase the stud gap.

(c) If necessary to meet the non-operate or release requirement, increase the spring tension or the follow or decrease the stud gap.

Requirements for S Type Relays

11.22 *Contact Alignment*

(a) The point of contact should fall wholly within the circumference of the opposing contact disc except for opposing contacts having the same diameter, in which case the centers shall not be out of alignment more than 25 per cent of the diameter of the contact points.

(b) If the contacts are out of alignment vertically make sure that the studs on the contact screw brackets rest in the slots in the spoolhead. To do this, apply pressure to the front end of the contact screw bracket and attempt to move it up and down with the fingers. If the contact screw bracket cannot be shifted, loosen the vertical hinge screws slightly and shift the armature as required. Tighten the hinge screws.

(c) If the contacts are out of line horizontally examine the armature to determine whether it is in an approximately vertical position. If the armature is moved in a horizontal direction either toward or away from the front spoolhead so that it no longer assumes a vertical position, it may result in the contacts being off center. If necessary correct for this condition as outlined in (b).

(d) If the armature is in an approximately vertical position and the contacts are out of line horizontally, or if the contact spring or contact spring support touches the side of the slot in the retractile spring, loosen the contact retaining screw slightly and shift the spring and support to the desired position. While tightening the screw hold the spring and support in alignment with a gem clip in order to prevent the spring from twisting in such a way that it will not rest against its support and the contacts be misaligned.

11.23 *Contact Screw Bracket Pressure.* The contact screw brackets should press firmly against the front spoolhead. If necessary adjust the brackets by lifting them enough to clear the spoolhead and bending to secure the desired pressure.

11.24 *Armature Travel.* The armature travel should be

Min. 0.009 inch Max. 0.011 inch

It is adjusted by means of the back contact screw.

11.25 *Contact Separation.* The separation between contacts normally open or between contacts that are opened when the relay is operated should be

Min. 0.003 inch Max. 0.005 inch

It is adjusted by means of the front contact screw, after the armature travel has been correctly adjusted.

11.26 *Contact Spring Pressure*

(a) The pressure of the spring on the spring support shall be

Min. 3 grams Max. 7 grams

and shall be as near the minimum as possible when meeting the electrical requirements. Use the 70F gauge.

(b) If necessary to check for contact spring pressure insert a toothpick between the front contact screw bracket and the front spoolhead so that with the armature in its fully operated position, the front contact will not make. Then with the armature held in the operated position apply the gram gauge at the center of the contact and note the reading of the gauge just as the spring breaks from its support.

(c) If the spring fails to rest on its support or if it fails to meet the contact pressure requirements, adjust it by slightly loosening the contact spring retaining screw, turning the flexible contact spring out toward the front until it is in a horizontal position and adjusting it with the 363 spring adjuster applied near the offset portion of the spring. If after resetting the contact spring it should be found that the pressure of the spring is too great, force the back contact screw bracket slightly away from the contact spring by inserting a toothpick between the back contact screw bracket and the front spoolhead. Then hold the armature manually operated and force the contact spring back toward the back contact screw with the flat end of a toothpick. Repeat this operation until the required tension is obtained. After making this adjustment, adjust for contact separation and recheck to determine whether the relay will meet its contact alignment requirement.

11.27 *Electrical Requirements*

(a) The relay should meet the electrical requirements specified on the circuit requirements table. The cover should be on but the cover cap may be either on or off when applying the electrical requirements.

(b) Failure to meet an operate or hold requirement indicates that the tension of the retractile spring is excessive. Failure to meet the non-operate or release requirements indicates insufficient tension of the retractile spring. The tension is increased when the adjusting screw is turned clockwise.

(c) If the relay meets all its electrical and mechanical requirements but fails to function satisfactorily in service, the the tension of the contact spring against its support is probably at fault. Due to the fact that it is difficult to gauge the tension of the spring and since it is adjusted carefully initially, it should not be changed until with all other requirements met, the relay has failed in a service test, due to speed limitations.

Requirements for 206BR Relays

11.28 *Armature and Spool Clearance*

(a) The armature should not touch the inside of the spool in any operated position. If the armature does not clear the inside of the spool, correct as follows:

(b) Back off the contact screws on each side sufficiently to give the armature free play between the pole-piece screws.

(c) Loosen the pole-piece clamping screws on each side and back off both pole-piece screws as far as possible.

(d) To center the armature horizontally, back off the contact and pole-piece screws sufficiently to allow the armature to assume its normal mechanical position. Loosen the two front coil support screws on the under side of the relay base with an offset screwdriver and move the winding coil to the right or left as required to bring the armature into an approximate central position with respect to the opening in the coil and spoolhead.

(e) To center the armature vertically and to obtain contact alignment, remove the relay from the panel and then slightly loosen the screws holding the armature to its support. Then move the armature up or down as may be required to bring it into an approximate central position with respect to the coil, noting that the contacts are in alignment vertically.

11.29 *Contact Alignment*

(a) The contacts shall line up so that the point of contact falls wholly within the boundary of the opposing contact.

(b) To align contacts vertically, move the armature up or down as required.

(c) To align the contacts from front to rear, loosen the screws holding the contact screw bracket to the base of the relay. Then move the bracket until the contacts line up properly. In making this adjustment it is desirable to set the contact screw brackets so that the contact screws strike the contacts on the armature as near the center as possible.

11.30 *Flexible Contact Spring Alignment (Readjust Only)*

(a) The tips of the flexible contact springs should be approximately flat, should bear upon each other at the top and bottom edges and should make at least a line contact for at least 25 per cent of the distance across their $\frac{3}{16}$ inch width.

(b) They may be adjusted by backing off the contact screws and using the 363 spring adjuster.

(c) Check that the flexible springs rest against each other in line with the armature with a pressure of 20 to 50 grams (use the 70D gauge) measured at the contact of one spring with the other spring held so that it cannot follow its mate. Hold the other spring with the flat end of an orange stick. If necessary, back off the contact screws and adjust the tension by applying the 363 spring adjuster to the spring as close as practicable to the point where it is riveted to the armature. Adjust the spring toward or away from the other contact spring as required, at the same time keeping the contact springs in alignment with the armature and with each other. Reset the contact screws and adjust for bias and sensitivity.

11.31 *Contact Travel*

(a) The contact travel—that is, the distance the armature can travel in passing from a position against one contact screw to a position against the opposite contact screw—should be

Min. 0.002 inch Max. 0.005 inch

(b) Use the 74D gauge and check the travel with the armature resting against each contact screw. If there is a difference between the measured travel on opposite sides of the armature it is an indication that the contacts on the side of the armature having the smaller travel are pitted.

(c) To establish the total contact travel, back off the pole piece screws. Also back off the contact screws so that the armature will assume its normal mechanical position. Advance one contact screw until it just touches the armature and then back it off approximately 0.002 inch. (Approximately $\frac{1}{12}$ of a turn on the contact screw.) Repeat this operation on the other contact screw. With the contacts adjusted to meet the total contact travel, the armature should stand midway between the contact points. Then set the pole-piece screws as described below.

11.32 *Magnetic Air-Gap.* The magnetic air-gap—that is, the clearance between the armature and either pole-piece screw—with the armature against the opposite pole-piece screw shall be a maximum of 0.010 inch. Use the 92A gauge.

If the relay does not meet its electrical requirements, readjust the magnetic air-gaps on each side. Back off the pole-piece screws. Note that the armature stands approximately midway between the contacts, and if necessary set the contact screws as outlined above. Readjust the magnetic air-gaps on each side by turning in the pole-piece screws gradually and equally until the magnetic air-gap is of the specified maximum value. Apply the electrical requirements and if the relay fails to meet them with the magnetic air-gaps set at the maximum value reduce the air-gaps on each side gradually and equally by turning in the pole-piece screws. If the contact closure is not steady, it is an indication that either the pressure between the flexible contact springs is excessive or insufficient or the contacts are dirty.

11.33 *Electrical Requirements.* The relay shall meet the electrical requirements specified on the circuit requirement table, with the cover and cover cap in place.

Vacuum Tubes

11.34 Vacuum tubes must be replaced with new ones when the filament emission becomes too low to permit the tubes to give satisfactory service. A tube needs replacing when substitution of a new tube in the socket gives marked improvement in operation. In general, 328A Vacuum Tubes should be replaced semi-annually, and the 274A Vacuum Tubes should be replaced annually.

NOTES:
1. WIRES NOT OTHERWISE SPECIFIED ARE 20ESCB.
2. FOR METHOD OF OPERATION SEE CD-64082-01.
3. "J" TOP OR LEFT SIDE OF KEY LOOKING AT TERMINAL SIDE.
4. "P" DENOTES PAIR.
5. LEADS DESIGNATED "D" ARE RUN IN THE SHORTEST POSSIBLE MANNER.
6. LEADS DESIGNATED "U" ARE 20ESCB SHIELDED PAIRS PER M19069.
7. "X" WIRING IS FURNISHED WHEN 115V. A.C. POWER SUPPLY IS USED.
8. "Y" WIRING IS FURNISHED WHEN OFFICE BATTERY IS USED.

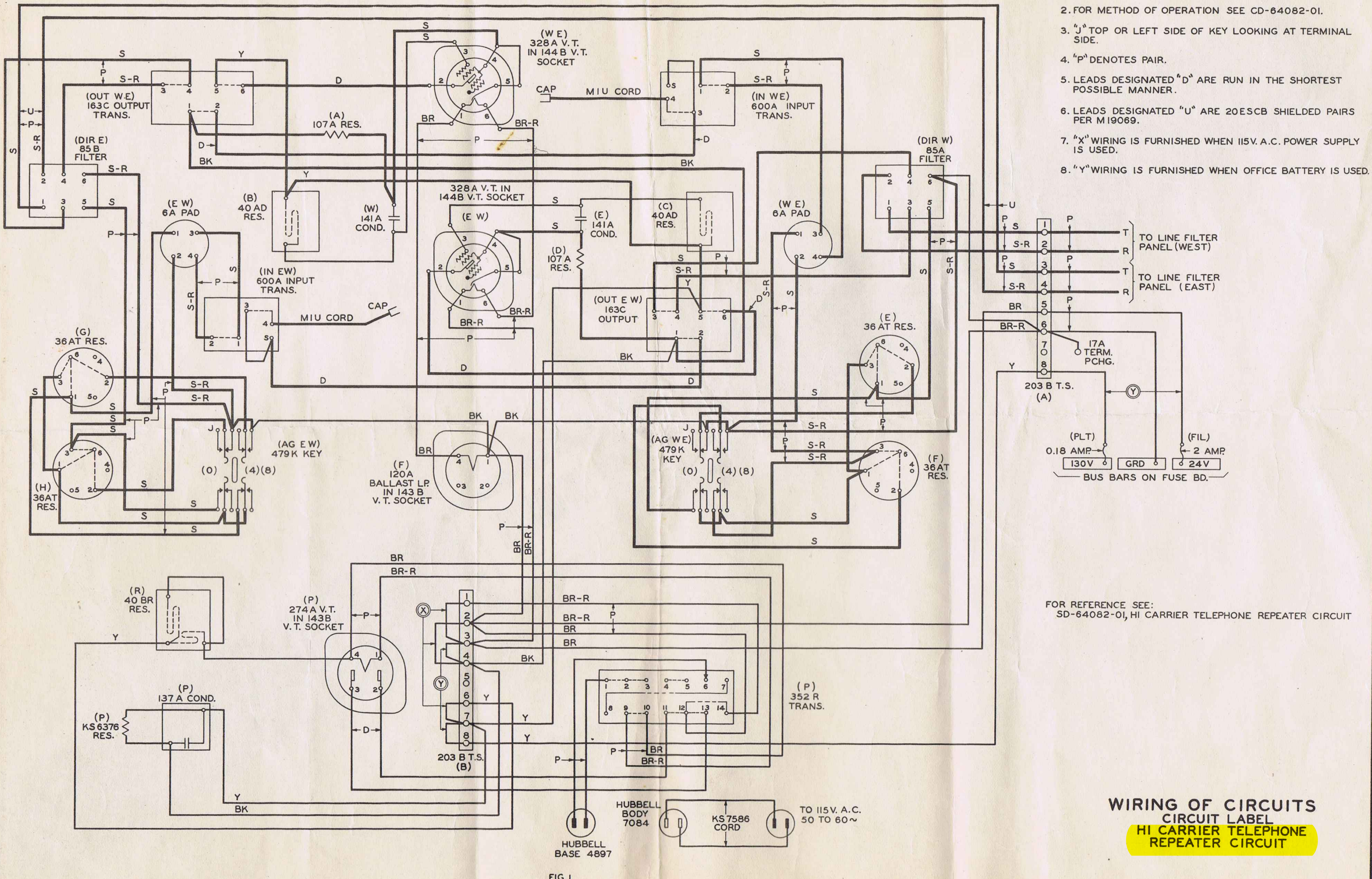


FIG. 1

FOR REFERENCE SEE:
SD-64082-01, HI CARRIER TELEPHONE REPEATER CIRCUIT

WIRING OF CIRCUITS

CIRCUIT LABEL
HI CARRIER TELEPHONE REPEATER CIRCUIT

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SD-64082-81, ISS.3

P-412130

21 - "DD" WIRING SHALL BE FURNISHED BY THE SHOP IN ALL CASES FOR USE WHEN THE PADS ARE REQUIRED AND RAPID COMPENSATION FOR CHANGE IN CIRCUIT EQUIVALENT DUE TO TEMPERATURE AND HUMIDITY IS NECESSARY. THE INSTALLER SHALL REMOVE "DD" WIRING AND ADD "CC" WIRING WHEN THE ABOVE FEATURE IS NOT REQ.

22 - "PT" DENOTES LEADS PART OF APP. LEADS OF INSUFFICIENT LENGTH SHALL BE SPLICED WITH NO.18 STRAP WIRE

23 - "B2" DENOTES TERM NEAREST MTG BRKT.

24 - THESE LEADS TO BE SHORT ENOUGH SO THAT CAN COVER CANNOT BE REMOVED SUFFICIENTLY FOR MAINTENANCE WITHOUT FIRST DISCONNECTING LEADS FROM HUBBELL BASE.

25 - COLORS IN BRKTS [ ] NOT TO BE USED AFTER ISS 2. (CONTINUED BELOW NOTE 17)

19 - AT THE EAST TERMINAL CONDENSER (K3) SHALL BE ADJUSTED BY THE SHOP TO PRODUCE AN OSC. FREQUENCY OF 8150 ∿ AND (K4) & (K5) CONDENSERS SHALL THEN BE ADJUSTED TO PRODUCE 7150 ∿.

AT THE WEST TERMINAL CONDENSERS (K2) & (K3) SHALL BE ADJUSTED BY THE SHOP TO PRODUCE 7150∿ & (K4) CONDENSER SHALL THEN BE ADJUSTED TO PRODUCE 6150∿.

" 20 - "MM" WIRING SHALL BE CONNECTED BY THE SHOP, ARRANGING FOR AC POWER SUPPLY. WHEN CENTRAL OFFICE BATTERY SUPPLY IS REQUIRED THE INSTALLER SHALL DISCONNECT "MM" WIRING AND ADD "NN" STRAPS.

" 28 - WHEN THIS CKT. IS USED ON A MOISTURE PROOF JOB THESE LEADS SHALL BE 22 EDSCL

" 29 - WHEN THIS CKT. IS USED ON A MOISTURE PROOF JOB THESE LEADS SHALL BE 20 ESCB

6-B & 6-C PAD·(RLA) OR (RLB)			
6B FRONT TOP: oA oE oJ oN / oC oH oL 1/2 1 2 / oD oI oM / oB oF oK oP	0.5 DB	IN	C TO D
		OUT	D TO E & B TO F
	1 DB	IN	H TO I
		OUT	E TO J & F TO K
	2 DB	IN	L TO M
		OUT	J TO N & K TO P
6C FRONT TOP: oA oE oJ oN / oC oH oL 4 8 16 / oD oI oM / oB oF oK oP	4 DB	IN	C TO D
		OUT	D TO E & B TO F
	8 DB	IN	H TO I
		OUT	E TO J & F TO K
	16 DB	IN	L TO M
		OUT	J TO N & K TO P

" 18 - THE LETTERED DESIGNATIONS EXCEPT "G" SHOWN ON THE (TR), (REC), (RLA) AND (RLB) PADS DO NOT APPEAR ON THE APPARATUS. TO CONNECT PADS IN OR OUT OF CIRCUIT THE SHOP SHALL STRAP THE TERMS. OF THE PADS AS REQ'D AND THE TEL. CO. SHALL RESTRAP AS REQD. IN ACCORDANCE WITH THE FOLLOWING TABLE

6-A PAD (TR) OR (REC)			
FRONT TOP	ATTENUATION	CONDITION	STRAP
A C E H / 1/2 1 2 / oB oD oF G / oJ oL oN 4 8 16 / oI oK oM oP	0.5 DB	IN	B TO G
		OUT	A TO C
	1 DB	IN	D TO G
		OUT	C TO E
	2 DB	IN	F TO G
		OUT	E TO H
	4 DB	IN	J TO G
		OUT	I TO K
	8 DB	IN	L TO G
		OUT	K TO M
	16 DB	IN	N TO G
		OUT	M TO P

" 11 - THE TOTAL FILAMENT CURRENT FOR THIS CIRCUIT WHEN OPERATED FROM 20-28V FIL. BAT. IS 0.853 ± 0.108 AMP. WITH THE PLATE BAT. DISCONNECTED.

" 12 - "ZZ" WRG. & "VV" STRAP TO BE FURN. IN ALL CASES BY THE SHOP AND "ZZ" WRG. LEFT DISCONN. THE INSTALLER SHALL CONNECT "ZZ" WRG. & REMOVE "VV" STRAP WHEN THE RING. FREQUENCY USED AT THE DISTANT TERMINAL IS 16 2/3 ∿. THE INSTALLER SHALL LEAVE "VV" STRAP CONN. AND "ZZ" WIRING DISCONNECTED WHEN 20∿ RINGING IS USED AT THE DISTANT TERMINAL.

" 13 - COND.(M1) TO (M4) SHALL BE CONN. TO PRODUCE EQUAL REL. CURRENTS AT 18.3∿ & 20∿.

" 14 - "LL" WRG. SHALL BE FURN. IN ALL CASES BY THE SHOP WHEN 20∿ LOW VOLTAGE IS USED FOR SIG. THE INST. SHALL CHANGE FROM "LL" TO "KK" WRG. WHEN DC SIG. IS USED INST. SHALL REMOVE "LL" WRG. WITHOUT CHANGING TO "KK" WRG. WHEN 20∿ HIGH VOLTAGE IS USED THE "LL" WRG. SHALL BE LEFT INTACT & THE INST. SHALL STRAP RES (T) & (S) AS REQ. IN ORDER TO LIMIT THE RING. CURRENT FLOWING INTO THE DROP

" 15 - RESISTANCES (R1) TO (R5) SHALL BE STRAPPED BY THE SHOP & RESTRAPPED BY THE TEL. CO TO OBTAIN DESIRED SIGNALING VOLTAGE.

" 16 - PAD (TR) SHALL BE READJUSTED FOR DESIRED TRANSMITTING LEVEL BY THE TEL CO.

" 17 - PADS (RLA), (RLB) AND (REC) SHALL BE READJUSTED BY THE TEL. CO. TO SECURE THE DESIRED SIGNALING VOLTAGE AT THE INPUT TO TRANSFORMER (SIG IN) AND THE DESIRED OVERALL NET LOSS BETWEEN THE TERMINALS.

" 26 - DIR. FILTERS USED BEFORE 2-1-38 OF THIS DWG. WERE MADE WITHOUT TERMINALS 7 & 8

" 27 - "DI" LEADS TO BE BK ~~20 ESCB~~ 22 DSSBL NOT INCLUDED IN THE LOCAL CABLE BUT RUN DIRECT FROM TERM. TO TERM. IN THE SHORTEST MANNER POSSIBLE AND SHALL BE KEPT SEPARATE FROM OTHER "D" WIRING. ON A MOISTURE PROOF JOB, THESE LEADS SHALL BE 20 ESCB.

(CONT'D UNDER NOTE 20)

MANUFACTURING NOTES

NOTES 1 - WIRES NOT OTHERWISE SPECIFIED TO BE 22 DSCL.

" 2 - "P" DENOTES PAIR.

" 3 - "C" WIRING TO BE SEPARATE CABLE SEWED TO OUTSIDE OF REGULAR LOCAL CABLE.

" 4 - "K1" DENOTES TOP OR LEFT TERMINAL ON STRIP.

" 5 - "F" BRING FROM CABLE FORM AT SEPARATE STITCH.

" 6 - "J" TOP OR LEFT SIDE OF KEY LOOKING AT TERM. SIDE.

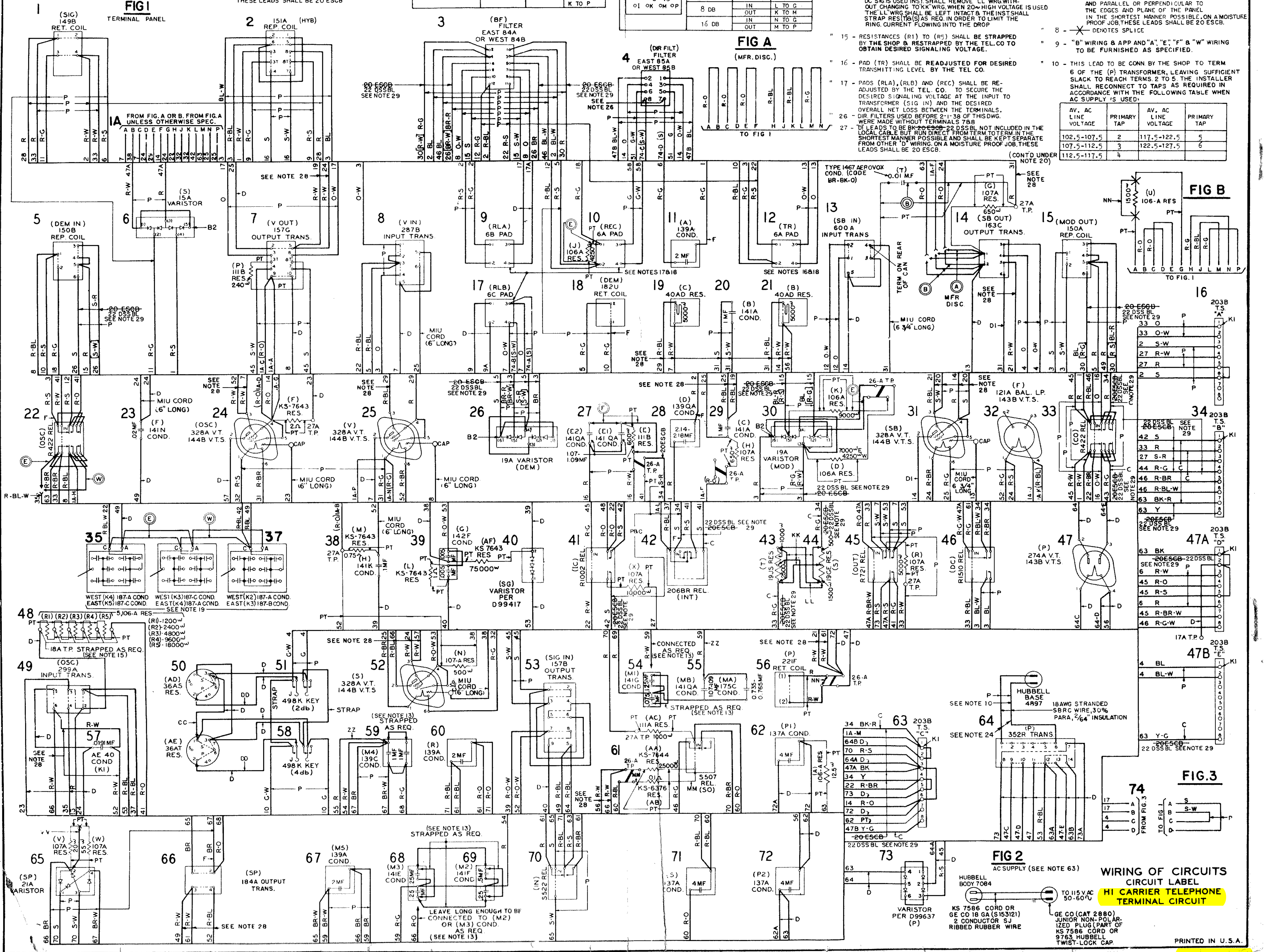
" 7 - "D" LEADS SHALL BE BLACK ~~20 ESCB~~ 22 DSSBL AND RUN BY WIRING DEPT. UNDER LOCAL CABLE AND PARALLEL OR PERPENDICULAR TO THE EDGES AND PLANE OF THE PANEL IN THE SHORTEST MANNER POSSIBLE. ON A MOISTURE PROOF JOB, THESE LEADS SHALL BE 20 ESCB.

" 8 - ✕ DENOTES SPLICE

" 9 - "B" WIRING & APP AND "A", "E", "F" & "W" WIRING TO BE FURNISHED AS SPECIFIED.

" 10 - THIS LEAD TO BE CONN. BY THE SHOP TO TERM 6 OF THE (P) TRANSFORMER, LEAVING SUFFICIENT SLACK TO REACH TERMS. 2 TO 5. THE INSTALLER SHALL RECONNECT TO TAPS AS REQUIRED IN ACCORDANCE WITH THE FOLLOWING TABLE WHEN AC SUPPLY IS USED:

AV. AC LINE VOLTAGE	PRIMARY TAP	AV. AC LINE VOLTAGE	PRIMARY TAP
102.5-107.5	2	117.5-122.5	5
107.5-112.5	3	122.5-127.5	6
112.5-117.5	4		



WIRING OF CIRCUITS
CIRCUIT LABEL
H1 CARRIER TELEPHONE TERMINAL CIRCUIT

PRINTED IN U.S.A.

T-66081-70 ISS 14

San Francisco, July 6, 1948

Managers, Telegraph Offices
All District Linemen

The following is a list of the more common types of troubles experienced in single channel telephone and telegraph carriers and procedures which should be followed to locate and clear such troubles:

CARRIER MAINTENANCE

TYPICAL CASES OF TROUBLE AND CAUSES

H-1 SYSTEMS WITHOUT VOICE PLUS TELEGRAPH

Ringing fails in one direction:

1. Operate ring button at board and check operation "OUT", "IC", "OSC" and "INT" relays at home terminal. ("INT" relay tongue should vibrate at 20 cycles).

2. Ask distant terminal to test or swap "S" tube in his terminal if his "IN" relay does on operate on incoming ring.

3. Measure level of carrier with 1000 cycles and adjust level to normal. (Adjust pads at terminals and repeaters). Normal level is minus 5 to 8 DB as measured in top jack of switchboard jack strip.

Voice and ringing fails in one direction:

1. Change "OSC" tube in home terminal.

2. Change "SB" tube in home terminal.

3. Change one tube in intermediate repeaters. (If failure is east to west, have rptr attendant change east west tube in rptr or vice versa if failure is in opposite direction.

4. Ask distant terminal swap his "V" tube.

Voice and ringing fail in both directions.

1. Test or have proper wire chiefs test physical circuits (repeaters and terminals).

2. Change the "P" tube in home terminal and then ask distant terminal to change his "P" tube.

3. Check to see if power failure at any repeater.

4. Have repeaters (one at a time) change power tube.

5. Change "OSC" tube in home terminal and then ask distant terminal change his "OSC" tube.

H-1 SYSTEMS EQUIPPED WITH VOICE PLUS TELEGRAPH SYSTEMS.

Ringing fails in one direction:

1. Operate ring button at board at home terminal and check operation of "OUT" relay.

2. If "OUT" relay functions change tube in 2A ringer oscillator.

3. Ask distant terminal to change his "S" tube in his terminal

4. Measure level of carrier and regulate per item 3 under ringing failures H-1 systems without telegraph.

Voice fails in one direction, ringing still okay.

1. Change 51C limiter amplifier tube in home terminal.

Voice, ringing and telegraph fails in one direction.

1. Follow same procedure outline under "H-1 systems without voice plus telegraph".

Voice, ringing and telegraph fails in both directions.

1. Follow same porcedure outline under "H-1 systems without voice plus telegraph".

Telegraph only fails in one direction (signal level meter zero).

1. Test tubes in telegraph transmitter unti at home terminal.

2. Have distant terminal test his No. 1 tube in his telegraph receiver unit.

Level above normal on signal level meter.

1. Regulate switch pads at home terminal and at repeaters if necessary. (Signal level meters shoul be checked for correct calibration at least one each week, procedure described below).

2. Test number one tube in home telegraph receiver.

Level below normal on signal level meter:

1. Follow same procedure as for above normal signal level.

The procedure for checking calibration of signal level meters is as follows:

1. Ask distant terminal to run 1000 cycles on top jack of jackstrip of his voice channel

2. Measure level of carrier with DB meter in top jack of home terminal jack strip of voice channel and regulate level of carrier with switch pads at home terminal and repeaters until reads minus 5 to minus 8 DB.

3. Ask distant terminal to stop the 1000 cycles and note reading of signal level meter or meters.

4. Report any off calibration to manager, or travelling wire chief.

LENKHURT TYPE 12 OR 17 VOICE CARRIERS WITH VOICE PLUS TELEGRAPH CHANNELS.

Voice, ringing and telegraph channels fail one direction:

1. Test or change number one-tube in ringing 2A unit, at carrier bay, at home terminal.

2. Test or change number one tube in carrier telephone terminal bay at home terminal

Voice and ringing fail in one direction but telegraph channels still okay.

1. Test or change tube in limiter amplifier at home term.

2. Plug left in main switchboard drop jack at home term.

Ringing fails in one direction but voice and telegraph okay.

1. Test or change tubes 3, 4 and 5 at home terminal ringing unit at bay. (Terminal not getting ring)

2. Have distant terminal operate PR 2 ringing relay in his ringing by hand.

   "A" If ring comes thru trouble is on drop, at distant terminal, or defective PR 2 relay.

"B" If ring does not come through but relay operates when PBX or WC rings trouble is not on drop.

3. Have distant terminal check or change No. 2 tube in his ringing unit at bay.

Voice and telegraph channels fail in one direction but ringing still okay:

1. Check or change No. 1 and 2 tube in carrier telephone terminal at bay (Terminal not noting failure).

2. Check or change No. 3, 4 and 5 tube in distant terminal carrier telephone terminal at bay.

LENKHURT TYPE 212 TELEGRAPH CHANNELS.

Current in "R" jack above normal. (Normal 50 to 60):

1. Change (do not test) tubes 4 and 5 (tubes 3 and 4 in new type terminals) in telegraph receiver. If this corrects trouble throw these tubes away and do not use in any other circuit even though they may test okay after they cool off.

Current in "R" jack below normal:

1. Check or change 5Z4 rectifier in telegraph receiver.

2. Check or change tubes 4 and 5 in telegraph receiver. (tubes 3 and 4 in new type terminals).

3. Check or change 5U4G tube in telegraph receiver.

4. Check or change tube No. 2 in telegraph receiver.

Open and closed key current in "R" jack not normal. (Normal for most terminals is 15 open and 55 closed key from distant terminal):

1. If the ratio of open to closed key current in "R" jack is below 3 to one, notify manager and travelling wire chief.

(This current should be checked as often as possible and recorded twice each week).

Signal level meter drops to zero:

1. Check phone channel if both signal level meters drop to zero in cases when 2 meters are used.

2. If only one channel used, check phone channel first.

3. Then check or change number 1 tube in telegraph receiver.

4. Ask distant terminal to change or check all tubes in his telegraph transmitter, one at a time.

A. W. Flanagan

JWB/os

cc - General Foremen