TYPE N1 CARRIER TELEPHONE SYSTEM

GENERAL INFORMATION - TERMINAL EQUIPMENT

DESCRIPTION - TRANSMITTING AND RECEIVING GROUP UNITS

CONTENTS

1. GENERAL

1.01 Issue 2 of this section describes the transmitting and receiving group units used for the N1 carrier telephone system. The system employs transmitted carrier, double sideband transmission with channels at 8 kc spacing. In a single cable, direction separation is obtained by using two cable pairs and, in addition, different frequency bands for the two directions of transmission. A low group range, 44-140 kc with carriers at 8 kc intervals from 48 to 136 kc, provides 12 channels in one direction. In the other direction, the frequency range is 164 to 260 kc with carriers at 8 kc interval from 168 to 256 kc.

1.02 The terminal group equipment consists of a transmitting group unit and an associated receiving group unit. These units provide the desired frequency conversion and required amplification for a group of 12 carriers and sidebands, between the terminal channel units and the cable pairs, in both the transmitting and receiving directions.

1.03 The transmitting group unit amplifies to the proper level and, if necessary, converts to the proper frequency group for transmission on a cable pair the group of 12 carriers and sidebands. These are generated in the channel units in the high group frequency range. In addition, each transmitting unit is equipped with a fixed 7 db slope equalizer to preequalize the slope of the transmission characteristic of approximately half a repeater section.

1.04 An adjustable noise source on the transmitting unit supplies noise to mask crosstalk in unusual cases such as in extremely short or quiet cables.

1.05 The receiving group unit provides a group frequency conversion when required and also provides gain in the receiving direction to compensate for the flat loss of one repeater section. A fixed 7 db slope equalizer compensates for the 7 db slope of the received level from the cable. In addition, a variable slope of zero, two or four db is obtained by means of the slope adjustment. There are no other optional adjustments in the receiving unit as normally used. Residual line equalization and the differences in repeater sections are compensated for by the slope adjustment setting in the receiving group unit and by fixed pads in the terminal frame.

1.06 The receiving group unit is provided with automatic gain regulation which keeps the power of all the carriers and sidebands at the receiving unit output nearly constant even though the input changes due to temperature changes in the cable.

1.07 The receiving unit is also provided with an alarm which operates on the total power of the received carriers so that a failure of the cable pair or the repeaters will be noted immediately.

1.08 There are four types of group units:

(1) The high group transmitting unit HGT.

(2) The low group transmitting unit LGT and associated oscillator subassembly.

(3) The high group receiving unit HGR.

(4) The low group receiving unit LGR and associated oscillator subassembly.

1.09 A terminal which transmits the high group of frequencies will be equipped with one high group transmitting unit HGT and one low group receiving unit LGR. A terminal which transmits the low group of frequencies will be equipped with one low group transmitting unit LGT and one high group receiving unit HGR.

1.10 The oscillator subassembly contains the 304 kc and the 3700-cycle oscillators. The oscillator subassembly is plugged into a low group transmitting or a low group receiving subassembly, and the combination equipped with a common can cover forms a low group transmitting LGT or a low group receiving LGR unit respectively.

1.11 The group units are arranged to receive power from a local -48 volt battery for heater supply and a +130 volt battery for plate supply. At terminals where power is supplied over the cable pairs to an adjacent repeater a +130 volt battery and a -130 volt battery supply the power to the cable pairs.

1.12 The group unit external connections terminate in a plug which is plugged into a jack in the terminal mounting.

2. CIRCUITS

(A) High Group Transmitting Unit HGT

2.01 A simplified schematic of the high group transmitting unit HGT is shown in Fig. 1.

2.02 The input to the unit consists of the 12 carriers and associated sidebands in the 164-260 kc range which are supplied by the channel units through the associated combining pads in the terminal mounting.

Noise Generator

2.03 The noise generator consists of a resistance of 75,000 ohms, the noise voltage from which is amplified by a vacuum tube and is then introduced into the low-level part

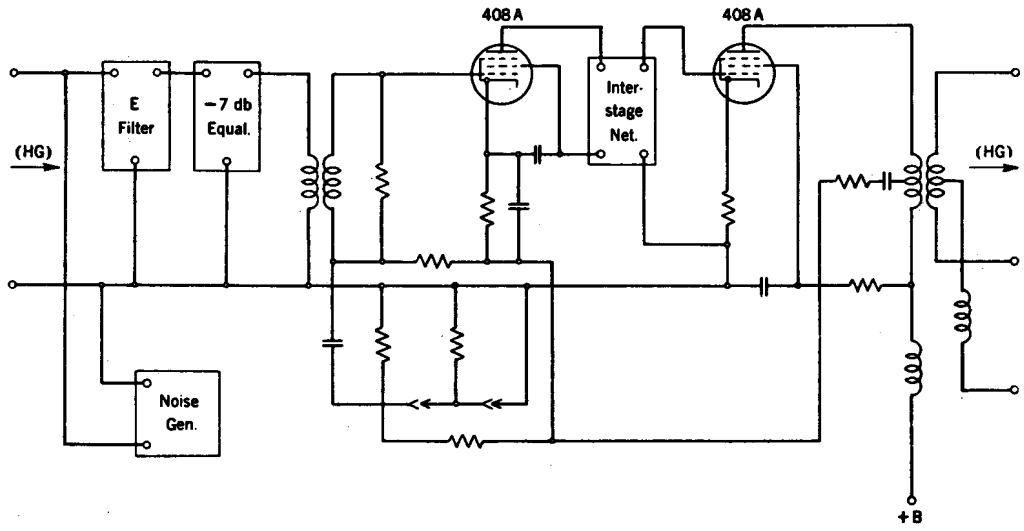

Fig. 1 - High Group Transmitting Unit

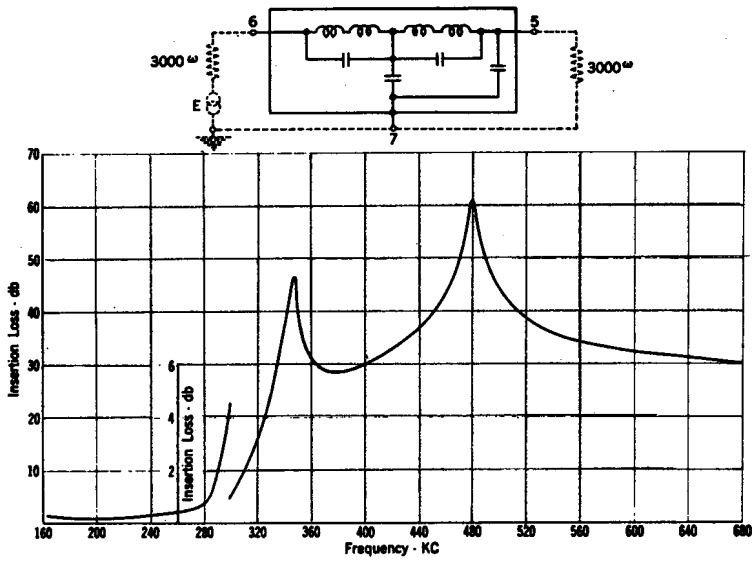

Fig. 2 - Schematic and Insertion Characteristic of "E" Filter

of the transmission circuit by means of a transformer. The amount of noise is adjustable by means of a potentiometer which varies the gain of the vacuum tube by changing its screen potential.

Low-Pass Filter

2.04 A low-pass filter designated E in Fig. 1 passes the high group frequencies 164 to 260 kc but attenuates the undesired modulation products above 260 kc produced in the channel units which would otherwise overload the amplifier of the transmitting unit. The configuration of the filter is shown in Fig. 2, together with the characteristic measured with a capacitance across terminals 6 and 7 equivalent to that of the noise generator transformer. The nominal input and output impedance of the filter is 3000 ohms.

-7 DB Slope Equalizer

2.05 The equalizer designated -7 DB EQL has a nominal slope of -7 db in its attenuation characteristic over the high group frequency band. This equalizer has a loss of approximately 1 db at 260 kc and a loss of approximately 8 db at 164 kc. Thus, the output of the transmitting unit is preequalized by 7 db with the highest output at the highest frequency. The nominal impedance of the equalizer is 3000 ohms. The characteristic and configuration are shown in Fig. 3.

Amplifier

2.06 A simplified schematic of the amplifier of the high group transmitting unit is shown in Fig. 1. It is a two tube, feedback-stabilized amplifier using 408A pentode tubes, impedance coupled. The feedback is obtained by means of a fixed resistance pad connected into the amplifier circuit by series feedback at the input and bridge type feedback at the output.

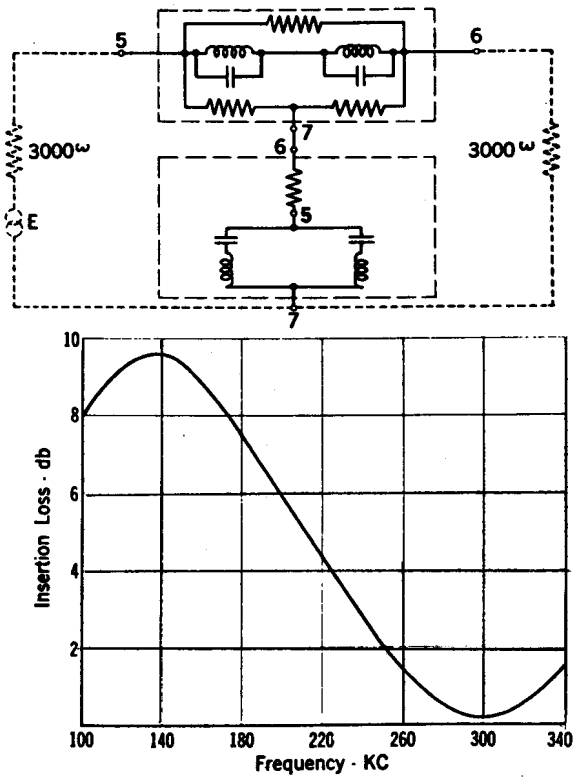

Fig. 3 - Schematic and Insertion Loss Characteristic of -7 db Slope Equalizer

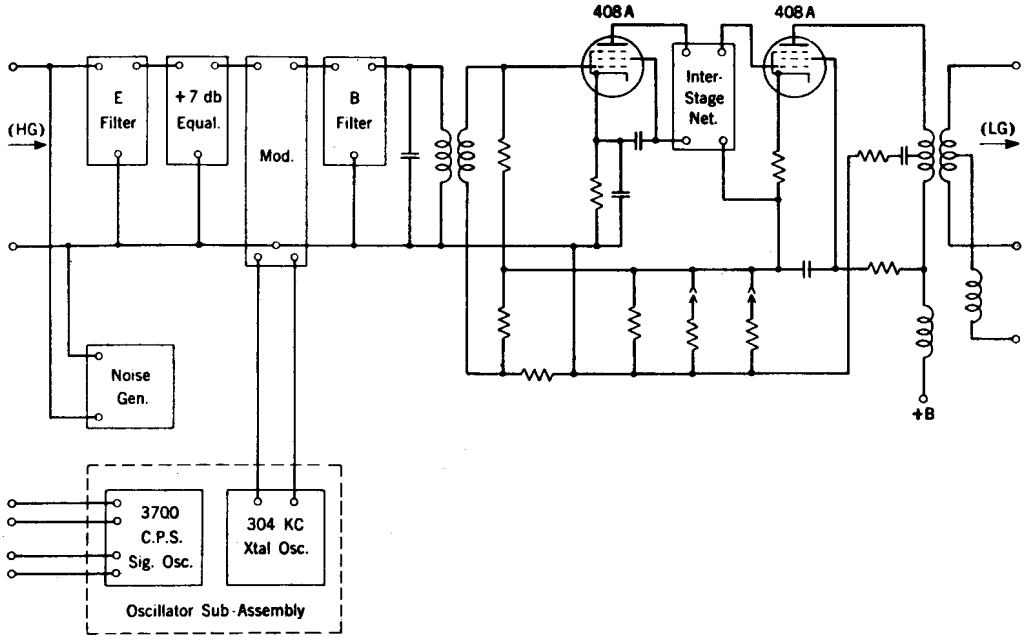

Fig. 4 - Low Group Transmitting Unit

2.07 An input transformer with an impedance ratio of 3000 ohms to 20,000 ohms, couples the 3000-ohm equalizer to the 20,000-ohm resistance in the grid circuit of the amplifier. This transformer provides as much voltage stepup as is practical for the band width and frequencies used in this system.

2.08 The interstage network is a simple impedance-coupled circuit consisting of an inductor in the plate circuit, a 330,000-ohm grid leak and a coupling capacitor between them. The inductance is anti-resonant with the tube and circuit capacitances in the high group frequency range.

2.09 The hybrid output transformer couples the amplifier output to the line and to the feedback circuit. The output impedance is 130 ohms to match the cable impedance. The circuit depends on feedback to obtain this impedance.

(B) Low Group Transmitting Unit LGT

2.10 A simplified schematic of the low group transmitting unit LGT is shown in Fig. 4. This unit is in general similar to the high group transmitting unit, and only the differences will be pointed out in the following description.

2.11 The added function of frequency transfer from the high group, 164-260 kc, received from the channel units to the low group, 44-140 kc, required for transmission over the line is provided by a group modulator with its associated carrier oscillator.

2.12 The equalizer designated +7 DB EQL is inserted ahead of the modulator and to obtain the highest output at the highest frequency in the low group, its slope is the reverse of that used in the high group transmitting unit previously described in Paragraph 2.05. The characteristics and configuration of the equalizer are shown in Fig. 5.

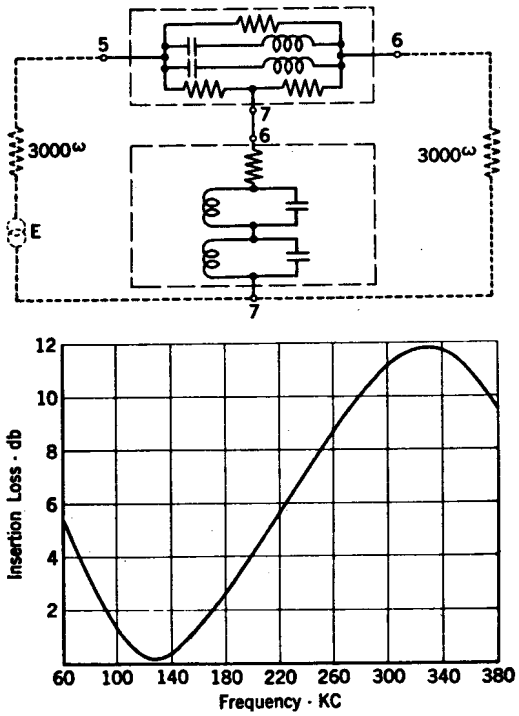

Fig. 5 - Schematic and Insertion Loss Characteristic of +7 DB Slope Equalizer

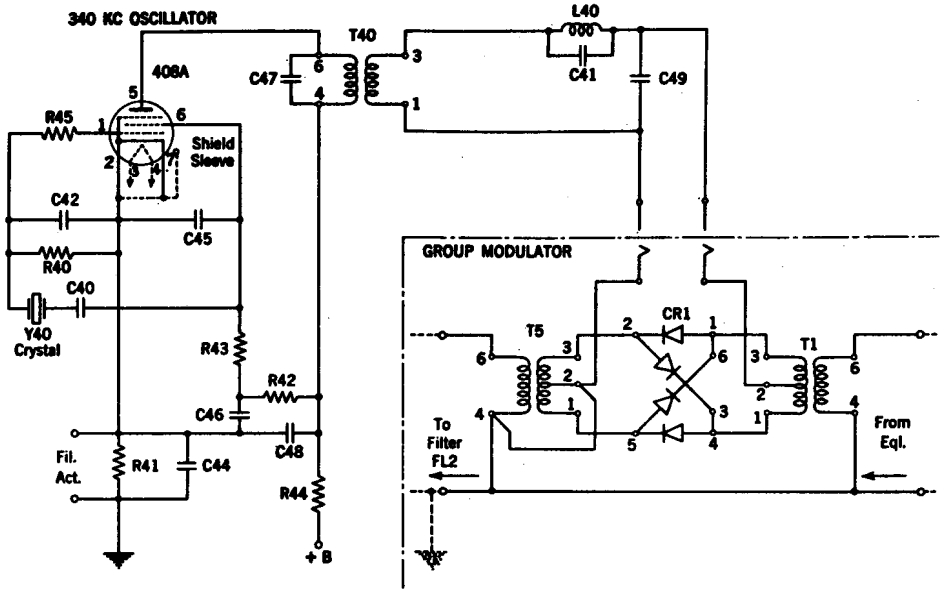

Fig. 6 - Group Modulator and 304 Kc Oscillator

2.13 The amplifier input circuit is bridge type instead of series type feedback. The output impedance of the amplifier is 135 ohms, instead of 130 ohms in the high group transmitting unit, to match the cable impedance at the low group frequencies.

Group Modulator

2.14 The group modulator within the low group transmitting unit receives a high frequency group, from the channel units, and modulates it with the group carrier (304 kc). The lower sideband is selected from the modulation products by the filter B. This selected sideband at the modulator output is the low group. A schematic of the modulator, together with the carrier frequency supply oscillator is shown on Fig. 6. The modulator used is of the double balanced type consisting of a copper-oxide varistor CR1 connected between two repeating coils T1 and T5.

2.15 The modulator action may be considered as a double-pole double-throw switch inserted in the signal path between the input and output coils, and activated by the plus and minus voltages of the carrier. When the carrier voltage is positive on the right and negative on the left side (Fig. 6) carrier current flows through the transformer windings in parallel opposing and through the two outer rectifying elements. Their impedance is then made low. A current present at the input will then flow directly through the modulator to the output transformer. During the next half cycle of carrier, the carrier potential is reversed and the current flows through the inner rectifying units making their impedance low. This is equivalent to reversing the path for signal voltages from the input to the output transformer at carrier frequency, resulting in the production of modulation products of various orders. With this configuration the input signal and the carrier do not appear at the modulator output terminals, being theoretically balanced out. While a perfect balance is not achieved practically, the input signal is suppressed about 20 db and the carrier about 40 db.

2.16 The T1 and T5 repeating coils have an impedance ratio of 3000 ohms to 130 ohms and serve to match the impedance of the filters to that of the modulator and also to change from an unbalanced filter and equalizer circuit to a balanced modulator circuit. To maintain the proper balance in this circuit it is important that the only ground connection to this modulator circuit be at the T5 transformer as indicated.

2.17 The output filter designated B in Fig. 4 selects for transmission the lower sideband generated by the modulator and rejects the upper sideband, all other modulation products and the signals of the group applied at the input of the modulator. The output filter also includes a peak section to provide attenuation to the 304 kc carrier that is present

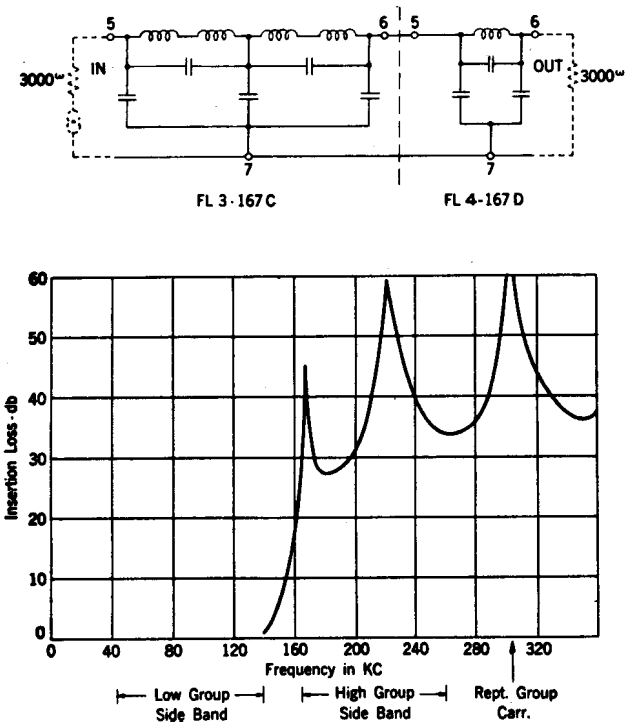

Fig. 7 - Schematic and Insertion Loss Characteristic of B Filter

due to imperfect modulator balance. It is a low-pass filter with characteristic and configuration shown in Fig. 7.

304 Kc Carrier Oscillator

2.18 The carrier frequency used with the group modulator is supplied by a 304 kc crystal oscillator. A schematic of this circuit is shown on Fig. 6. This oscillator employs the grid, screen and cathode of a 408A vacuum tube with a quartz crystal to form the oscillating circuit. The carrier power for the modulator is obtained from the plate of the vacuum tube through output transformer T40. By this means better stability of the output and frequency are obtained than if the plate of the vacuum tube and output transformer were connected directly in the oscillating circuit. The output transformer is tuned to provide discrimination against all but 304 kc. It also steps down the impedance to match that of the two CR1 varistors acting in parallel. Between the output transformer and the CR1 varistors there is a rejection filter L40-C41-C49 to further suppress all frequencies in this circuit above 304 kc and with a peak suppression at 608 kc.

2.19 The frequency of oscillation is controlled by the crystal Y40 and is 304,000 cycles ± 10 cycles within operating temperature ranges of 10°F. to 140°F.

(C) High Group Receiving Unit HGR

2.20 A simplified schematic of the high group receiving unit HGR is shown in Fig. 8.

2.21 The input consists of the high group of frequencies, 164 to 260 kc, received from the cable span pads in the terminal mounting which are connected to the incoming cable pair.

Input Coil

2.22 The input coil T1 serves to match the 3000-ohm impedance of the filters to the 130-ohm impedance of the incoming cable pair. It also provides the simplex connection to the line for the purpose of supplying power to an adjacent unattended repeater, and provides the means of maintaining line balance to suppress longitudinal noise.

Filter

2.23 The input filter designated A consists of two elements, FL1 and FL2. It passes the high group of frequencies and rejects the low

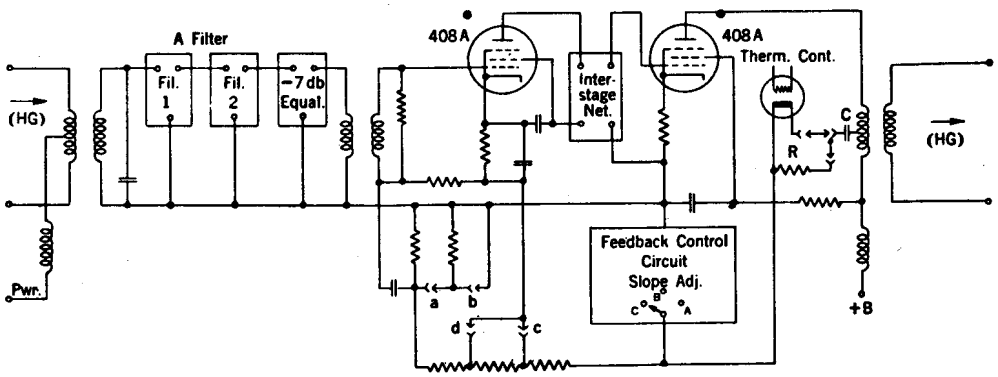

Fig. 8 - High Group Receiving Unit

group, thus attenuating the direct near-end crosstalk. It is a high-pass filter with characteristic and configuration as shown in Fig. 9.

-7 DB Slope Equalizer

2.24 The equalizer designated -7 DB EQL was described in Paragraph 2.05. It compensates for a 7 db slope of the received level from the cable and thus equalizes the input level to the amplifier which is nearly flat with respect to frequency.

Amplifier

2.25 A simplified schematic of the amplifier for the high group receiving unit is shown in Fig. 8. It is in general similar to the amplifier described in Paragraphs 2.06 to 2.09, with the addition of a thermistor flat gain adjustment and a slope control adjustment incorporated in the feedback circuit. Its output impedance, controlled by feedback, is 130 ohms to match that of the channel band filters.

Flat Gain Adjustments

2.26 A flat gain control of ± 1 db is obtained in each amplifier by the strapping options designated a and b which change the feedback. This control is used in manufacture to provide the proper gain for the channel 1 frequency.

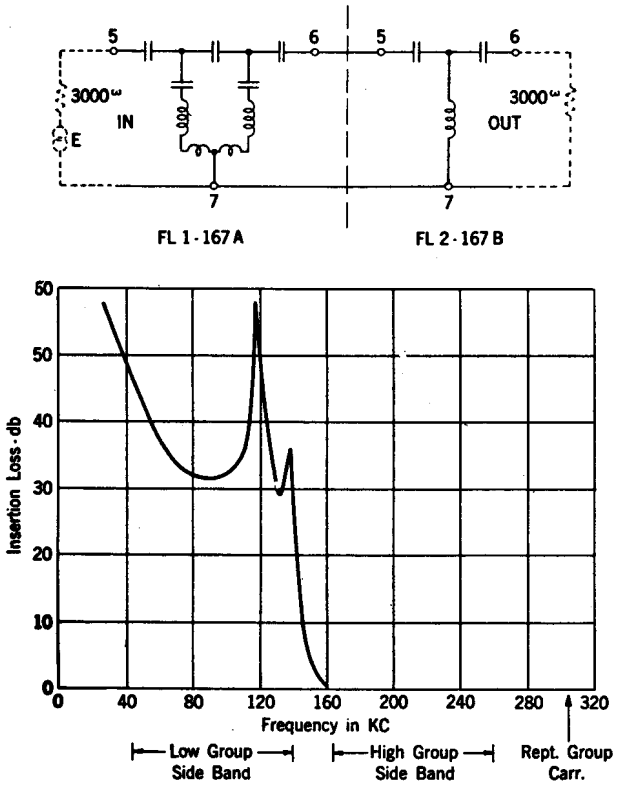

Fig. 9 - Schematic and Insertion Loss Characteristic of A Filter

2.27 A further flat gain adjustment of 6 db is available in the amplifier as a soldering adjustment by changing from c to d wiring. This increased gain is had at the cost of a reduction in feedback and an increase in modulation and noise equal to that of about four normal N1 repeaters. This special gain adjustment is not employed except for special cases to be considered on an individual basis and should not be used unless the inferior performance can be tolerated.

Fixed Gain

2.28 When the receiving group unit is used for switching purposes or during maintenance tests, a fixed gain without regulation is desired. This condition is obtained by using the resistor R shown in Fig. 8 in place of the thermistor regulator. This resistor provides about 6 db more gain than the average provided by the thermistor. The resistor is connected for manufacturing testing and will normally be replaced by the thermistor at the time of field installation. It will also be used when the receiving group unit is used in the switching equipment.

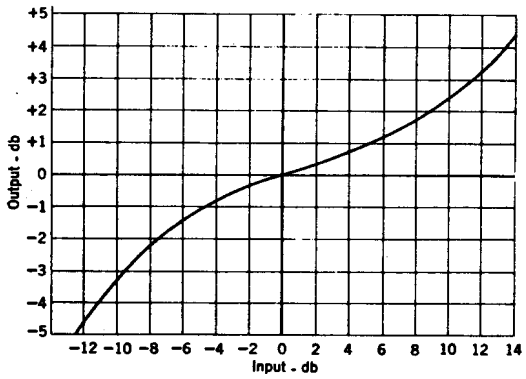

Fig. 10 - Regulating Characteristic

Regulation

2.29 The receiving group unit has a flat gain regulation control which operates about the "nominal" total output power of +5.5 dbm. This regulation is provided by a thermistor which varies the amount of feedback in the amplifier to control its gain. It is connected into the amplifier circuit as indicated in Fig. 8. The thermistor is activated by the total power at the output of the unit, practically all carrier, which is nominally +5.5 dbm. The thermistor holds the output power to within ± 2.0 db of the nominal value for a change in input level of ± 8 db. The regulating characteristic is shown in Fig. 10. The +5.5 dbm output power for the receiving unit is the summation of the 12 carriers each of which is nominally -5.5 dbm. Since the power of each 3700-cycle signaling sideband is 15 db below

the carrier power this signal does not add appreciably to the carrier power and since the thermistors have a time constant of the order of 8-10 minutes, the effects of the voice peaks of power are small. An average characteristic of the stabilization time and thermistor restoration time is shown in Figs. 11 and 12, respectively. The output increased curve (Fig. 11) applies to changes in output which the regulator restores to normal by decreasing the amplifier gain, while the output decreased curve (Fig. 11) applies to changes in output which the regulator restores to normal by increasing the gain.

2.30 The thermistor unit consists of a thermistor bead and an associated temperature control for this bead. A schematic of this unit is shown in Fig. 13. The thermistor bead is a negative resistance unit, that varies over its normal operating range from about 1000 ohms to about 20,000 ohms. Under abnormal signal conditions, it may vary from a few hundred ohms to upwards of 40,000 ohms. For a receiving group unit having average gain it should be about 6000 ohms. This value is referred to as the "design" value. It is obtained by adjusting

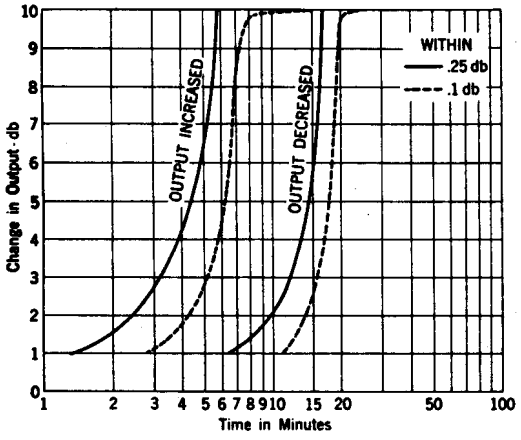

Fig. 11 - Stabilization Time

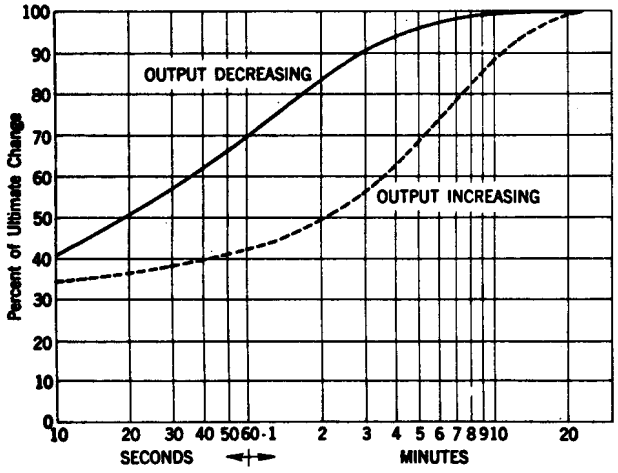

Fig. 12 - Thermistor Restoration Time

the temperature at which each individual bead operates so that for the mean value of signal power at the receiving group unit output (+5.5 dbm) the thermistor resistance will have the design resistance value. The thermistor operating temperatures used spread from about 125°F. to 180°F.

2.31 The temperature control for the regulating thermistor network is itself in turn thermistor controlled. This control permits the thermistor unit to be used with ambient temperatures between -20°F. and +130°F. without appreciable change in its operating performance. Thus, the temperature effect on regulation at attended stations, where the temperature range is much less, should be negligible. The thermistor bead is isolated by a blocking condenser C to exclude plate supply power.

Slope Adjustment

2.32 The receiving group unit slope adjustment provides the manual control of the frequency characteristic to obtain the desired slope across the band for system equalization. The adjustment is in three steps designated A, B, and C. The B setting is considered the nominal condition of the slope adjustment to equalize for the cable attenuation. Slope steps A, B and C provide a slope of 0, 2 db, or 4 db respectively. These settings are used as necessary to maintain adequate equalization of the system and permit a characteristic slope to be equalized to within ± 1 db. The change in gain frequency characteristics from slope A for the other two slope settings are given by Fig. 14.

2.33 The slope adjustments A, B and C are produced by varying the amplifier feedback with a slope network.

(D) Low Group Receiving Unit LGR

2.34 A simplified schematic of the low group receiving unit LGR is shown in Fig. 15. This circuit is in general similar to the high group receiving unit and only the differences will be pointed out in the following.

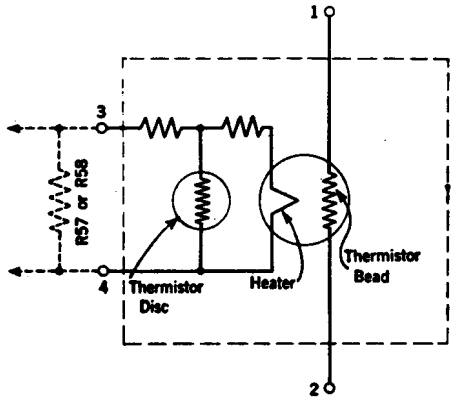

Fig. 13 - Thermistor Schematic

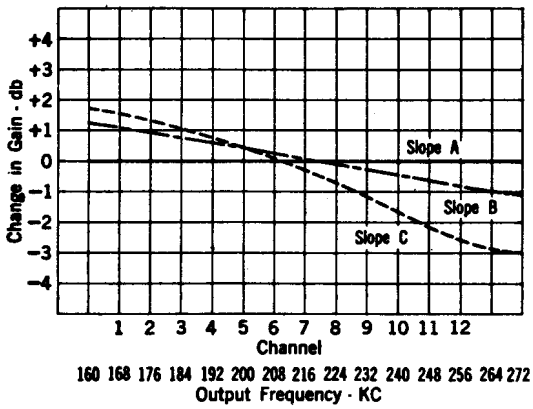

Fig. 14 - Change in Gain Vs. Frequency Characteristic from Slope A for B and C Setting of Receiving Group Unit

2.35 The added function of frequency conversion from the low frequency group, 44 to 140 kc received from the incoming cable pair, through the span pad mounted on the terminal frame, to the high frequency group 164-260 kc of the channel units is provided by a group modulator with its associated carrier oscillator. These have already been described in connection with the low group transmitting unit, Paragraphs 2.14 to 2.16 and 2.18.

2.36 The low-pass input filter designated C selects the low group signals, rejecting the unwanted group signals that are present at the input of the group unit owing to crosstalk between the cable pairs. Its characteristic and configuration are shown in Fig. 16.

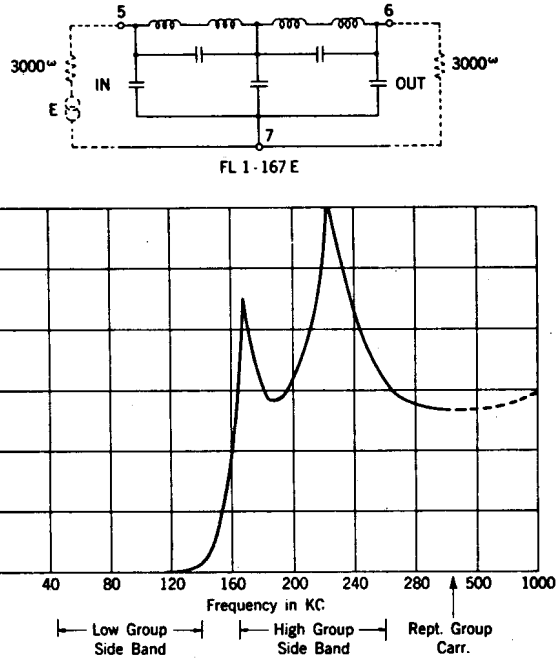

Fig. 16 - Schematic and Insertion Loss Characteristic of C Filter

2.37 The band-pass filter, D at the output of the modulator selects for transmission the lower sideband generated in the modulator and rejects the upper sideband, all other modulation products and the signals of the group applied at the input of the modulator. The output filter also includes a peak section to provide attenuation to the 304 kc carrier that is

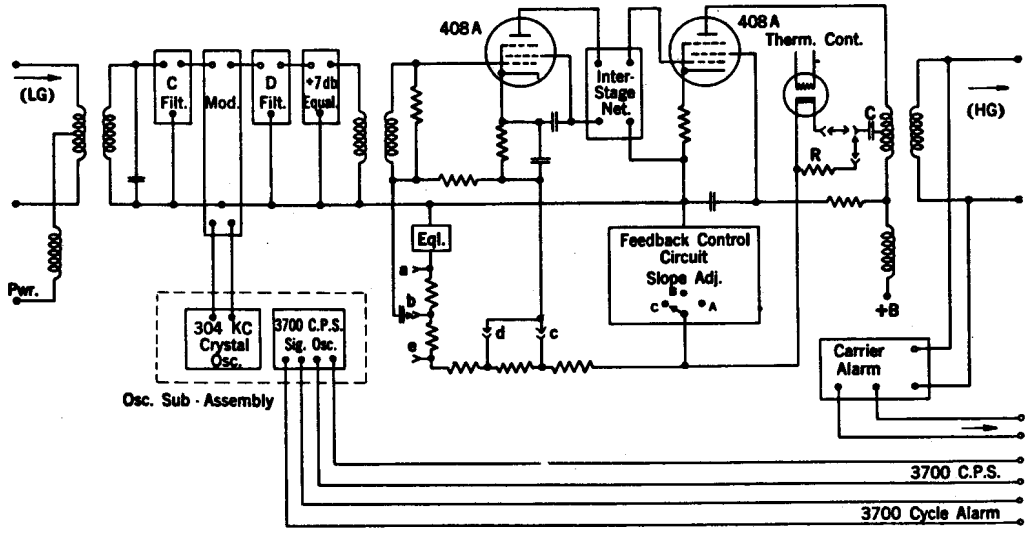

Fig. 15 - Low Group Receiving Unit

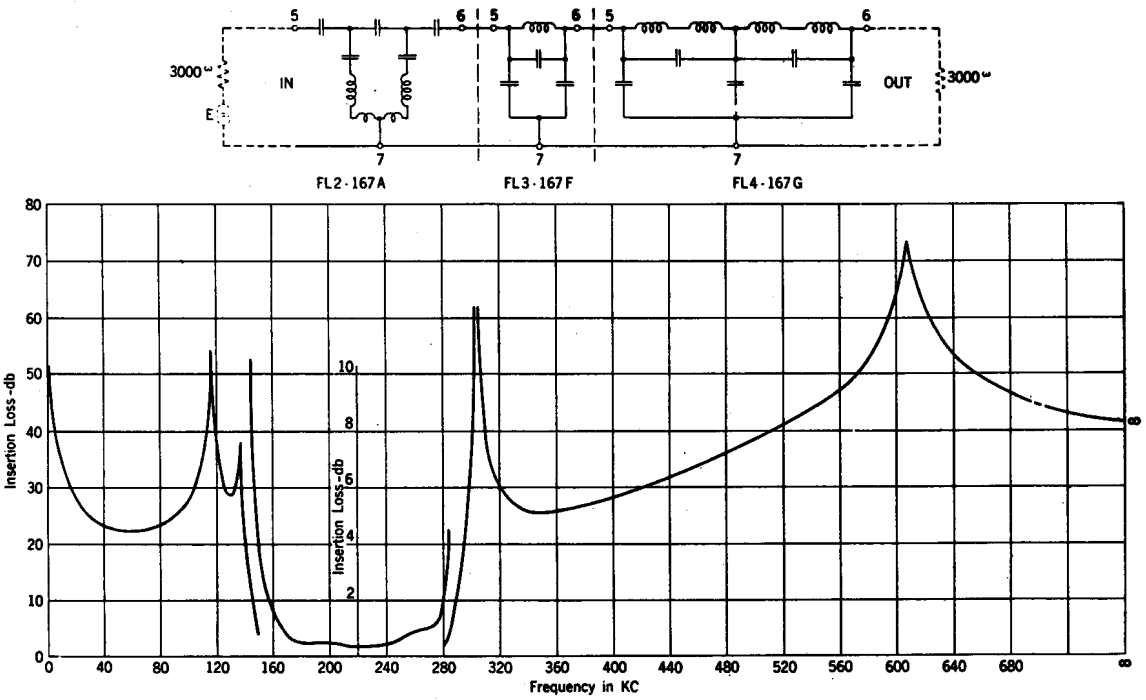

Fig. 17 - Schematic and Insertion Loss Characteristic of D Filter

present due to imperfect modulator balance. The characteristic and configuration of this filter are shown in Fig. 17.

2.38 The +7 DB EQL equalizer following filter D compensates for a 7 db slope of the received level from the cable and thus equalizes the input to the amplifier which is nearly flat. It was described in Paragraph 2.12.

2.39 An amplifier deviation equalizer designated EQL equalizes the small deviations produced in both the low group receiving unit and the preceding high-low repeater. Strapping to a, b or e vary gain in 1 db steps for factory adjustments.

(E) 3700-Cycle Signal Oscillator

2.40 A 3700-cycle signaling oscillator with a low output impedance supplies signaling tone to the 12 channel units. Its schematic is shown in Fig. 18. The oscillator is a bridge

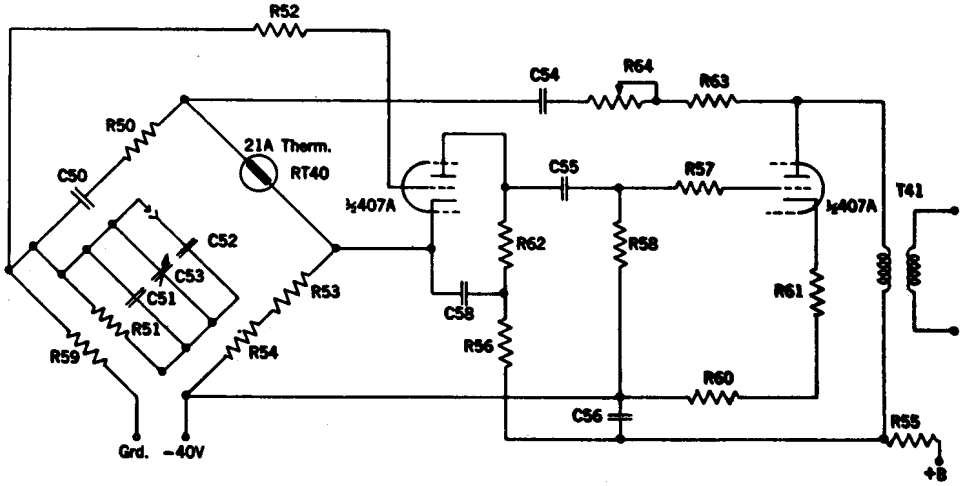

Fig. 18 - 3700-Cycle Signaling Oscillator

type feedback oscillator. It is tuned to its resonant frequency by means of a resistance-capacitance bridge. One arm of the bridge is composed of capacitors C51, C52 and C53 and resistors R51 and R59, capacitor C53 being the variable tuning element. The second arm of the bridge is made up of capacitor C50 and resistor R50. These two arms provide the positive feedback. The thermistor RT40 is the third arm of the bridge. The action of this thermistor makes the amplifier independent of voltage variations and at the same time affords a method of stabilizing the amplitude of oscillation. The resistors R54 and R53 are in the fourth arm and provide d-c feedback to stabilize the space current of the left-hand triode of the double triode vacuum tube. The control grid of the first triode is connected to the junction of the first two bridge arms through grid suppressor resistance R52 to prevent singing. The first stage is resistance coupled to the second stage by means of capacitor C55 and resistor R58. A grid suppressor resistance R57 is provided for anti-sing purpose. Capacitor C54, potentiometer R64 and resistor R63 couple the plate of the second stage to the input of the bridge and also insulates the bridge circuit from the d-c plate voltage. Potentiometer R64 adjusts the output power of the oscillator. The output of the oscillator is very low impedance by virtue of feedback. A transformer T41 couples the plate circuit of the oscillator to the output leads which are connected to the 12 channel units in the terminal mounting.

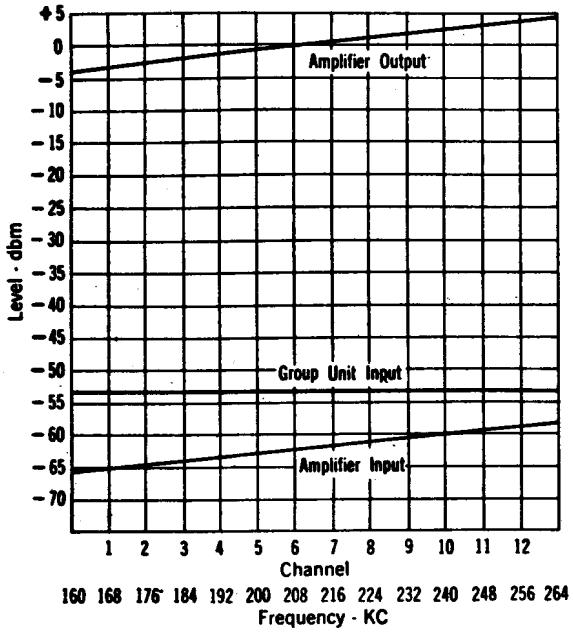

Fig. 19 - Typical HGT Unit Operating Level Diagram

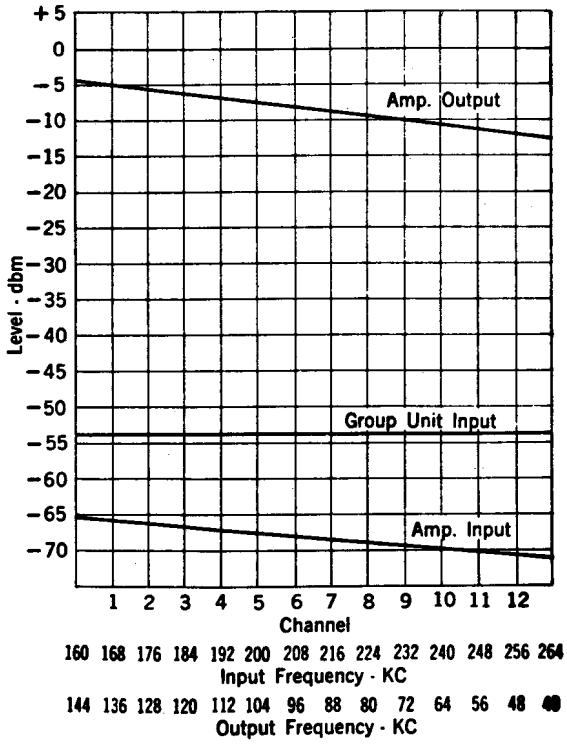

Fig. 20 - Typical LGT Unit Operating Level Diagram

3. TRANSMISSION PERFORMANCE

(A) Transmitting Units HGT and LGT

Levels

3.01 The output power at which the two types of transmitting units operate is substantially different. For mean circuit conditions the low group transmitting unit LGT operates with a total output power of about +3 dbm and the high group transmitting unit HGT with about +12 dbm. These values may vary about ± 1.5 db. The output power is composed of the twelve channel carriers and their associated sidebands. The level of the carriers has a nominal slope of 7 db over the band for each unit. For the low group transmitting unit LGT the channel 1 (136 kc) carrier level is -5 dbm, the channel 12 (48 kc) carrier level is -12 dbm and the other channel carrier levels are uniformly spaced between. For the high group transmitting unit HGT the channel 1 (168 kc) carrier level is -3 dbm, the channel 12 (256 kc) carrier level is +4 dbm and the other channel carrier levels are uniformly spaced between them. These carrier levels and levels at other points in the two types of transmitting units are shown on Figs. 19 and 20 (curves labeled group unit output). The sideband energy associated with

each of these channel carriers is considerably weaker than the carriers except for instantaneous peaks of voice energy so that the power contributed by them is unimportant. The gain vs. frequency characteristics are shown in Figs. 21 and 22 for the HGT, and LGT units, respectively. With the potentiometer of the noise generator at the "Minimum noise setting", which is normally used, the plate impedance of

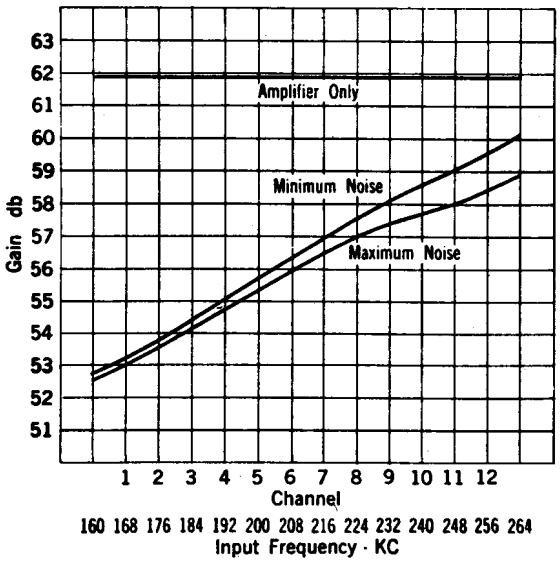

Fig. 21 - HGT Unit - Gain Versus Frequency

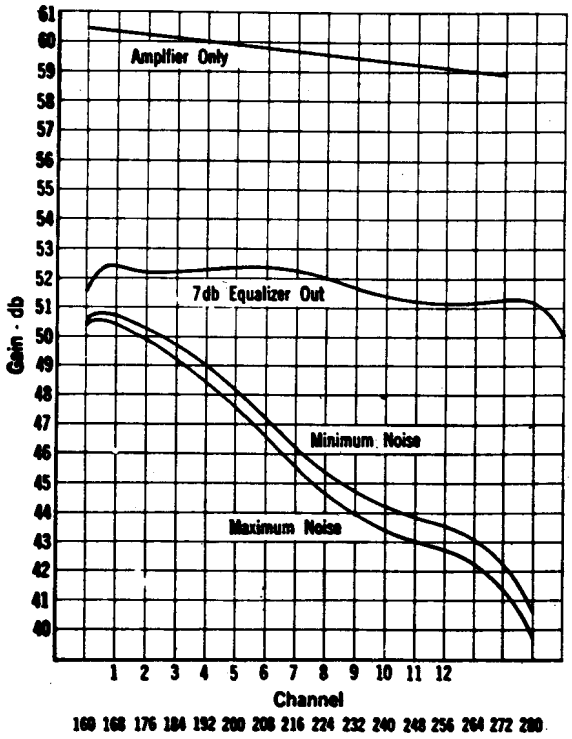

Fig. 22 - LGT Unit - Gain Versus Frequency

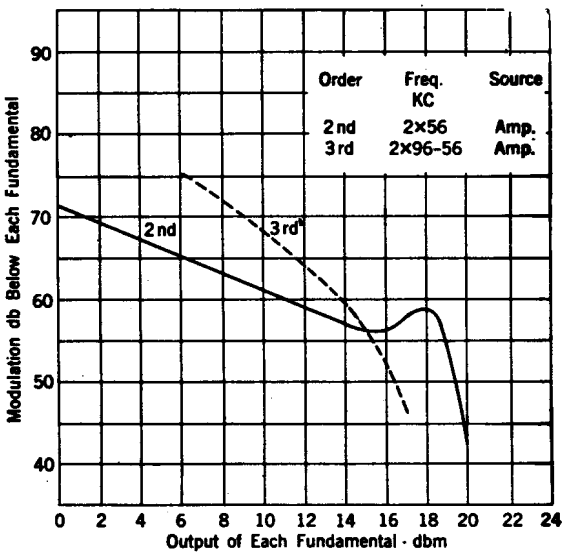

Fig. 23 - Modulation for Low Group Transmitting Unit

the noise generator tube is very high. However, with the "Maximum noise setting" the plate impedance is reduced, causing a small shunt loss as shown by the over-all gain curves.

Load Capacity

3.02 The amplifier of the two types of transmitting units is capable of a single frequency output of about +23 dbm. The load characteristic is similar to that given below for the receiving units. The maximum output for the high group transmitting unit HGT is about one db more than for the low group transmitting unit LGT because of the difference in output transformer impedance. The output transformer for the high group transmitting unit HGT presents a load impedance to the vacuum tube of approximately 18,000 ohms. This value of load impedance is a little above the optimum but provides increased gain with sufficient power to handle the required load. The output transformer for the low group transmitting unit LGT presents a nominal load impedance of 6100 ohms. The same output transformer is used for both the low group transmitting unit LGT and the high-low repeater H-L. The value of load impedance, which is low, is dictated by the regulating level used with the H-L repeater and the power required to operate the H-L repeater thermistor regulator.

Modulation

3.03 The modulation products formed in the low group transmitting unit and in the high group transmitting unit originate mainly in the amplifier. Typical characteristics are given in Fig. 23 for a representative case of both second and third order products for the low group transmitting unit.

3.04 In the high group transmitting unit the third order modulation products will be essentially the same as the third order products in the low group receiving unit shown in Fig. 29. The second order products will be at a much lower level than indicated in the same figure because of the absence of a group modulator in the high group transmitting unit.

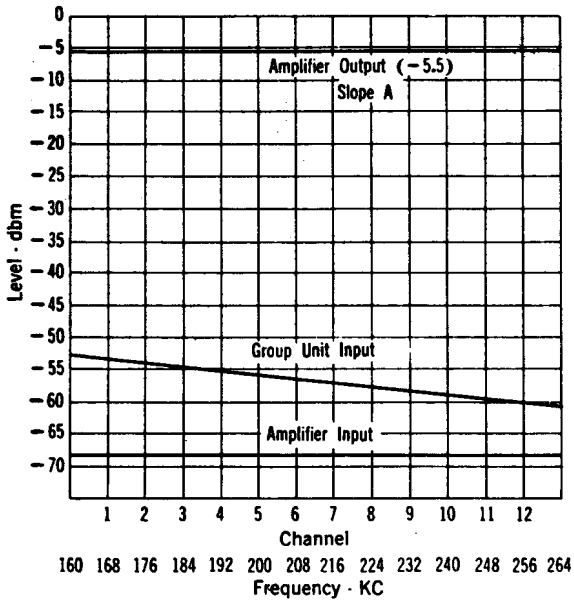

Fig. 24 - Typical HGR Unit Operating Level Diagram

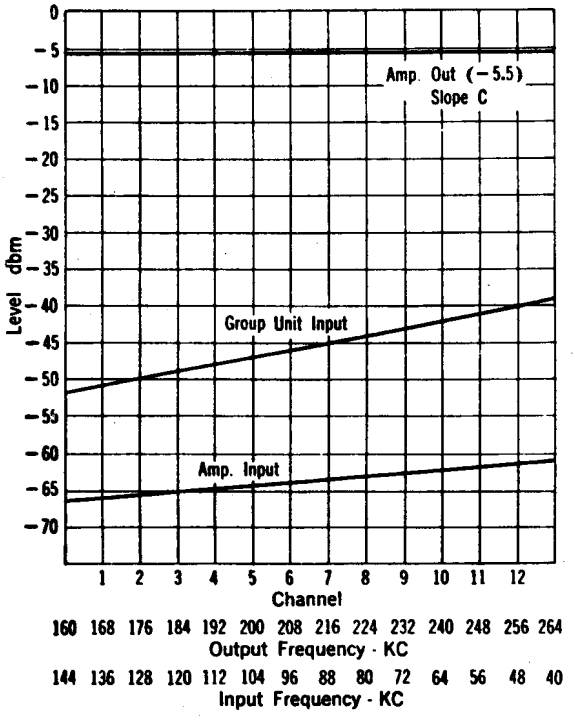

Fig. 25 - Typical IGR Unit Operating Level Diagram

(B) Receiving Units HGR and LGR

Levels

3.05 Both types of receiving units operate at about the same output power. For mean circuit conditions the total output power for both of the receiving units is about +5.5 dbm, the level of the carrier of each of the 12 channels being approximately -5.5 dbm. These values may vary by ± 1.5 db over the normal range of system regulation. Under abnormal circuit operation greater departure from normal output results. The output power is composed of the 12 channel carriers and their associated sidebands. The levels of the 12 carriers received from the cable pair have a slope over the band of approximately 7 db. For the low group receiving unit the 136 kc channel 1 carrier received from the cable is 7 db lower than the 48 kc channel 12 carrier and the other channel carriers are uniformly spaced between. For the high group receiving unit the 256 kc channel 12 carrier received from the cable is 7 db lower than the 168 kc channel 1 carrier. These carrier levels are shown by the curves labeled group unit input on Figs. 25 and 26. The gain vs. frequency characteristics are shown in Figs. 27 and 28 for the HGR and LGR units, respectively.

3.06 An equalizer with -7 db slope in the high group receiving unit, and an equalizer with +7 db slope in the low group receiving unit equalize for most of this 7 db slope

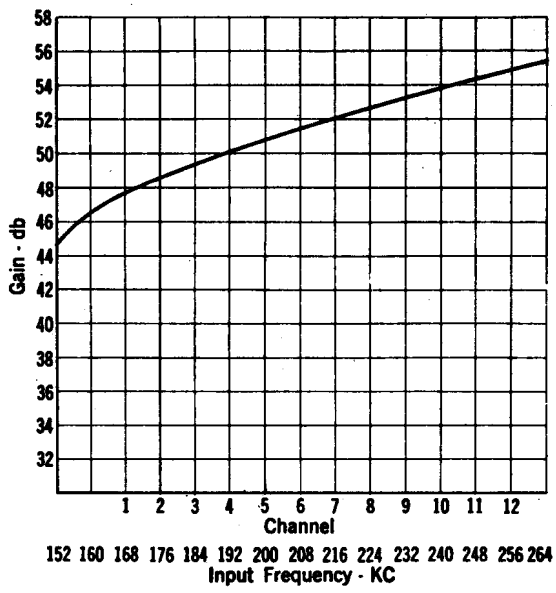

Fig. 26 - HGR Unit - Gain Vs. Frequency

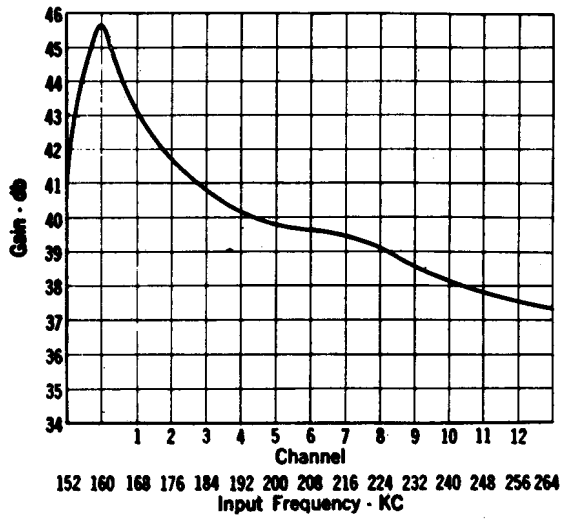

Fig. 27 - LGR Unit - Gain Vs. Frequency

in the levels received from the cable. Thus, the input to the amplifier is essentially flat which in turn results in nearly a flat amplifier output level for each of the 12 channels.

Load Capacity

3.07 Both types of receiving units are capable of a single frequency output of about +23 dbm. The load characteristic is shown in Fig. 28. The output transformer for the receiving units presents a load impedance to the vacuum tube of approximately 20,000 ohms. This value varies a little as the thermistor resistance changes over its range. This value of load impedance is a little above the optimum but provides increased gain with sufficient power to handle the required load.

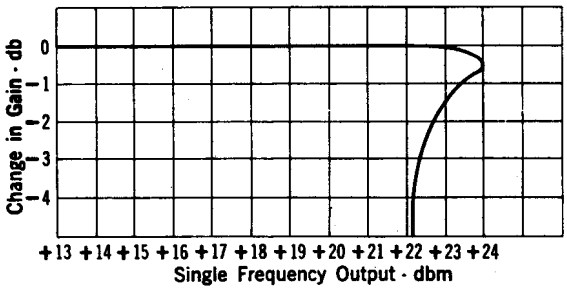

Fig. 28 - Gain Load Characteristic of Receiving Group Units

Modulation

3.08 Typical characteristics are given in Fig. 29 for a representative case of both second and third order products in the low group receiving unit. The second order products that

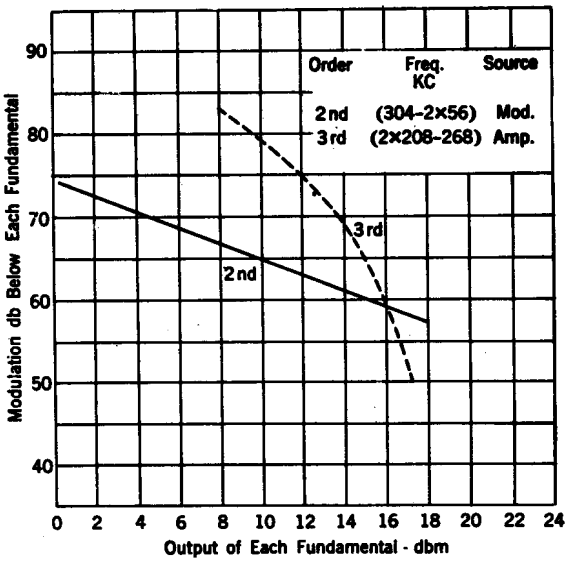

Fig. 29 - Modulation for Low Group Receiving Unit

occur within the transmitted band originate in the modulator. The third order modulation products that are transmitted are formed in the amplifier. These modulation products follow closely the normal performance of 2 db increase in second order and 3 db increase in third order products for each db increase in fundamental power. The level of modulation at a given output varies inversely as the amplifier gain changes with regulation.

3.09 In the high group receiving unit, which does not have a modulator, the second order products will be at a lower level. The third order products, however, will be essentially the same as for the low group receiving unit.

(C) 3700-Cycle Signal Oscillator

3.10 The oscillator output is designed to give a very constant output with a very low impedance and with harmonic distortion at a low level.

3.11 The output is adjusted at the factory to 2.4 volts RMS into a 200-ohm load. This voltage should not vary more than ± 10% due to changes in office ambient temperature.

3.12 The output impedance is approximately 5 ohms which results in good voltage regulation with the changes in load from approximately 1400 ohms with one channel signal circuit keyed to approximately 120 ohms with all 12 channels keyed.

3.13 The 2nd and 3rd harmonic distortion levels are approximately 40 and 45 db respectively, below the level of the fundamental frequency of 3700 cycles.

4. POWER SUPPLY

(A) General

4.01 The power circuit of the group units (and the channel units) is designed to be operated from the office battery supply. When required, battery power may be supplied over the cable to an adjacent unattended repeater.

(B) -48 and +130 Volt Battery for Terminal

4.02 The -40 volt heater supply and negative voltage for the 3700-cycle oscillator of the group unit are obtained from the -48 volt office signaling battery through a group of parallel dropping resistors and a series rheostat connected between the -48 volt bus and the fuses for the group and channel units in the terminal frame assembly. The proper voltage is obtained by strapping resistors in or out and adjusting the rheostat as required. One 1-1/3 ampere fuse serves both the transmitting group unit and the receiving group unit. The current drain from the -48 volt supply for both group units is 0.3 ampere. (In addition, the -48 volt bus supplies the 12 channel units.)

4.03 The +130 volt plate supply is obtained from the +130 volt battery through a built-in filter circuit consisting of a series retard coil and shunt capacitor between the +130 volt fuse and the channel units in the terminal frame assembly. One 2.0-ampere fuse serves both group units and also the 12 channel units. The current drain from the +130 volt supply for both group units is 0.1 ampere.

(C) -130 Volt and +130 Volt Battery for Adjacent Repeater

4.04 When an adjacent unattended repeater requires power supplied over the cable one 1/4 amp. fuse connected to the +130 volt battery supplies the required current of 150 milliamperes to 170 milliamperes.

4.05 An additional -130 volt battery is also required which supplies the required current of 150-170 milliamperes, through one 1/4 amp. fuse.

4.06 The power connections to the simplexes are made at the center tap of the transmitting group unit output transformer and the receiving group unit input coil through the longitudinal choke coils L_1 and L_3, Fig. 30. These leads are connected to terminals in the terminal mounting for the power supply cross-connections. In each battery lead there is at the power supply panel a 130-ohm current limiting resistor and in addition in the minus voltage lead a 150-ohm variable resistor. This variable resistor compensates for different line resistances to provide 140 volts at the non-powered repeater point for the normal adjustment condition.

5. TESTING ARRANGEMENTS AND FACILITIES

5.01 The testing facilities for the type N1 terminal group units are arranged so that all tests may be made on an in-service basis. The tests include (1) the customary vacuum tube activity tests, (2) measurements of the heater voltages for each group unit, (3) measurement of the total power at the output of a transmitting group unit, and (4) means of switching a standby transmitting or

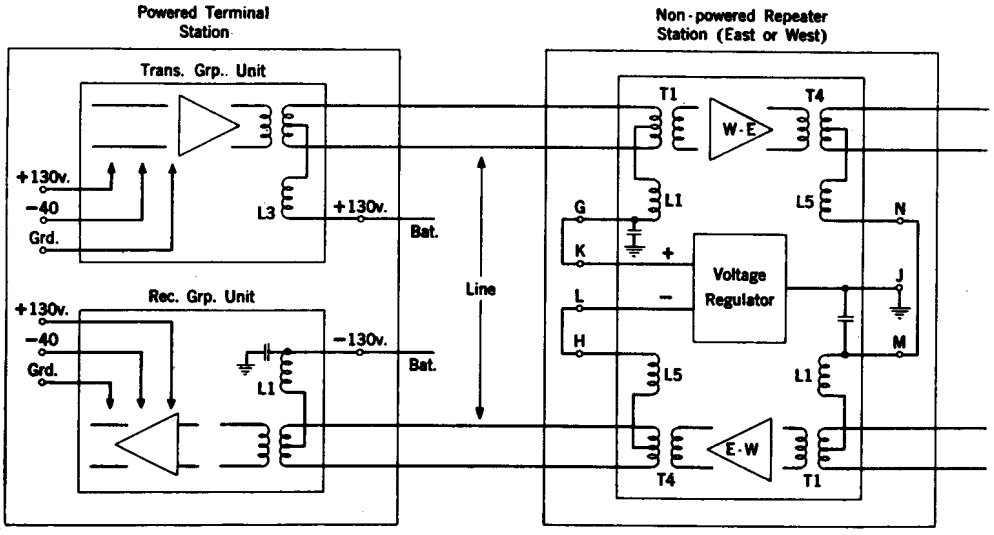

Fig. 30 - Power Connections for Power Supply Over the Cable

receiving group unit into the circuit without service interruption to make the regular transmitting or receiving group unit available for out-of-service maintenance or adjustment. The tests can be performed with three of the test sets for the type N system, the 2J Repeater Test Set, the 2N Group Unit Switching Set and the 2K Tube Test Set.

(A) Testing

5.02 The FIL ACT and TEST jacks, which appear on the front panels of the group units as seen on Fig. 31, provide the necessary access points in the circuits for the tube tests. The tube activity test is made with the 2K Tube Test Set in the usual manner by observing the change in tube space current for a ten per cent. reduction in the heater current. The heaters of approximately one-half of the tubes in the group units are connected in parallel, and the remaining half, also connected in parallel are connected in series with the first half. The tube space currents are measured by means of jack connections across the cathode resistors, and the change in heater current is obtained by connecting an adjustable resistance across the groups of paralleled tubes, one group at a time, to provide the desired change in voltage.

5.03 The measurement of the transmitting group unit or receiving group unit output power is made with the 2J Repeater Test Set. This test is made by plugging the Test Set connector in one of the switching jacks, appearing on the terminal mounting, through which the units are connected to the other terminal equipment. A meter in the test set is thus bridged across the output circuit of the unit under test. The meter measures the total power present, which for normal operation is about +12 dbm for the high group transmitting unit, about +3 dbm for the low group transmitting unit and about +5.5 dbm for the high group receiving unit or the low group receiving unit. This power is the summation of the 12 channel carriers plus a small augmentation by the signal powers. In case of failure of the repeaters or line, the power of the channel carriers is absent, and the repeaters endeavor to increase their gain until the noise output is enough to provide the normal output power. To prevent such noise power from being mistaken for the normal power of the channel carriers the test set includes a receiver which permits the output power to be monitored audibly. The normal carrier power will be heard as an 8000-cycle tone in the absence of which the system can be assumed to be in trouble. Owing to the operation of the dynamic regulators, a few minutes after a transmission failure the gain may have been raised enough to cause reappearance of the 8000-cycle tone but in this case the tone would be heard through loud noise. By use of this test set, a quick check can be made to determine proper system operation or to locate a circuit failure.

(B) Switching

5.04 When the replacement of a group unit is indicated it may be accomplished without interruption of service on the system by use of the 2N Group Unit Switching Set. A test cord connects this switching set to one of the group unit switching jacks in the terminal mounting and provides the necessary switches and gain adjustment so that an alternate group unit may be switched into the circuit in place of the regular group unit. The regular group unit may then be removed for out-of-service repair or replacement. The alternate group unit is connected by means of another test cord to the switching set, of which it is a component, and must be of the same type as the unit in the terminal that is being replaced. It is a standard group unit with the flat gain regulating thermistor replaced by the 20,000-ohm resistor, R in Figs. 8 and 15 to provide a fixed gain. The power for this set is derived from the regular office battery.

(C) Alarm Circuits

5.05 Alarms for +130, -130 and -48 volt battery supply failure are incorporated in the terminal mounting.

5.06 The output of the receiving group unit is rectified and the d-c output is connected to a relay which releases when the received carriers disappear, thus resulting in an alarm of any transmission failure of the system.

5.07 The 3700-cycle signal oscillator output also is rectified and is connected to a relay in the terminal mounting to bring about an alarm upon failure of this oscillator.

6. EQUIPMENT ARRANGEMENTS

6.01 A plug-in unit method of construction is employed for the N1 high and low group transmitting unit and the high and low group receiving unit. The external connections of each unit terminate in a plug which is inserted into a jack in the terminal mounting. This method permits the testing of the units without jack fields and allows the removal of a group unit in trouble to a convenient location for maintenance and its replacement by a spare group unit. Access for wiring maintenance is required only at the front of the rack which permits back-to-back relay rack mounting or mounting against a wall.

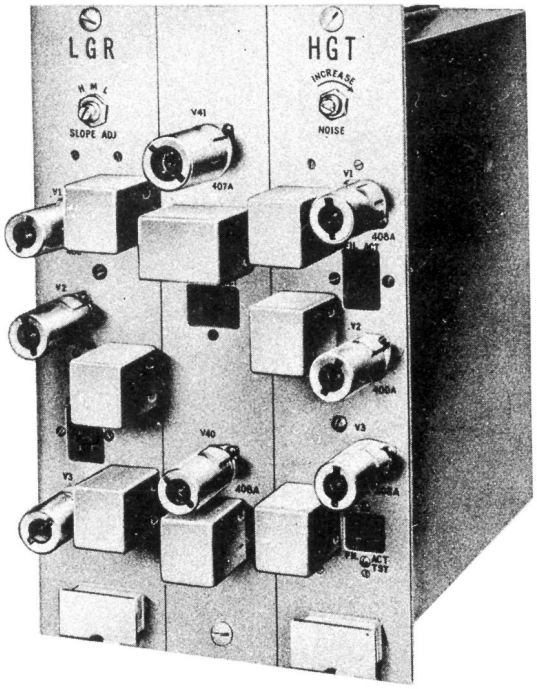

Fig. 31 - Front View of High Group Transmitting and Low Group Receiving Units

6.02 The transmitting group unit and the receiving group unit are separate plug-in units. A front view of the group units for a terminal transmitting high group and receiving low group is shown in Fig. 31. For the low group units, either transmitting or receiving, an oscillator subassembly for the carrier and the signaling oscillator plugs in a transmitter or receiver subassembly. The arrangement is shown in Fig. 32 where the two subassemblies are separated. When the cover is removed from a unit and the subassemblies are separated, all apparatus and wiring is accessible for maintenance. Pigtail apparatus, so far as electrical requirements permit, is mounted on two parallel thermoplastic strips by setting their terminal wires into the edges of the strips. An individual component can be removed readily by applying heat to its leads by means of a soldering iron.

6.03 Span adjustment pads when required mount in the terminal mounting.

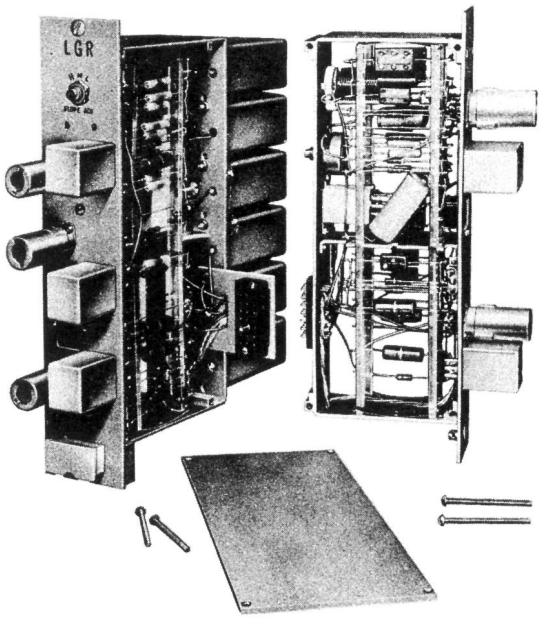

Fig. 32 - Low Group Receiving Subassemblies - Receiver at Left and Oscillator at Right

6.04 The power distribution panel contains the power resistors, fuses and fuse alarms and is mounted on the terminal mounting.

7. LIST OF DRAWINGS (Not Attached)

(A) SD Drawings

SD-95119-01	High Group Transmitting Circuit HGT
SD-95120-01	Low Group Receiving Circuit LGR
SD-95121-01	Terminal Application Schematic
SD-95129-01	Low Group Transmitting Circuit LGT
SD-95130-01	High Group Receiving Circuit HGR

(B) ED Drawings

ED-92290-01	Terminal Mounting
ED-92293-01	Span Adjustment Pads
ED-92300-01	High Group Transmitting Unit
ED-92301-01	Low Group Transmitting Unit
ED-92302-01	High Group Receiving Unit
ED-92303-01	Low Group Receiving Unit
ED-92304-01	Low Group Receiving Subassembly
ED-92305-01	Low Group Transmitting Subassembly
ED-92306-01	Oscillator Subassembly