

**TYPE N1 CARRIER TELEPHONE SYSTEM**

**GENERAL INFORMATION — DESCRIPTION — OVER-ALL SYSTEM**

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362-010-150 — Order Wire and Alarm Facilities

362-011-105 — Channel Units and Terminal Mounting

362-011-110 — Transmitting and Receiving Group Units

362-400-100 — Electron Tube Repeaters

362-400-120 — Low-High Transistorized Repeaters

362-400-121 — High-Low Transistorized Repeaters.

**1.03** The N1 carrier telephone system is a 12-channel system designed for short-haul use on toll and exchange plant cables. The system employs double sideband carrier transmission on nonloaded aerial or underground cable pairs. It operates on a 4-wire basis using two different frequency ranges and separate cable pairs for the two directions of transmission. Fig. 1 shows a simplified over-all schematic of the N1 system.

**1.04** Arrangements are provided for 13 channel frequencies. For most installations, 12 channels numbered 2 through 13 are used. These 12 channels use the low-frequency band of 36 to 132 kc with carriers at 8-kc intervals for one direction of transmission. For the other direction, the high-frequency band of 172 to 268 kc is used. Channel 1 is available for use in place of any other channel in the system which may be unsatisfactory due to radio or other interference. Channel 1 occupies the low-frequency band of 132 to 140 kc and the high-frequency band of 164 to 172 kc. However, channel 13 as compared to channel 1, provides better transmission performance, especially on long systems.

**1.05** The principal parts of the system are the channel units, the transmitting and receiving group units, and the repeaters. The channel units consist of the voice frequency terminal circuits, the signaling circuits, and the

**1. GENERAL**

**1.01** This section describes the general features of the Type N1 Carrier Telephone System. Issue 4 of this section replaces Issue 3 dated January 1961. Since this issue constitutes a general revision, arrows normally used to indicate changes have been omitted.

**1.02** Descriptive information on the various equipment components of the system is covered in the following Plant Series Sections:

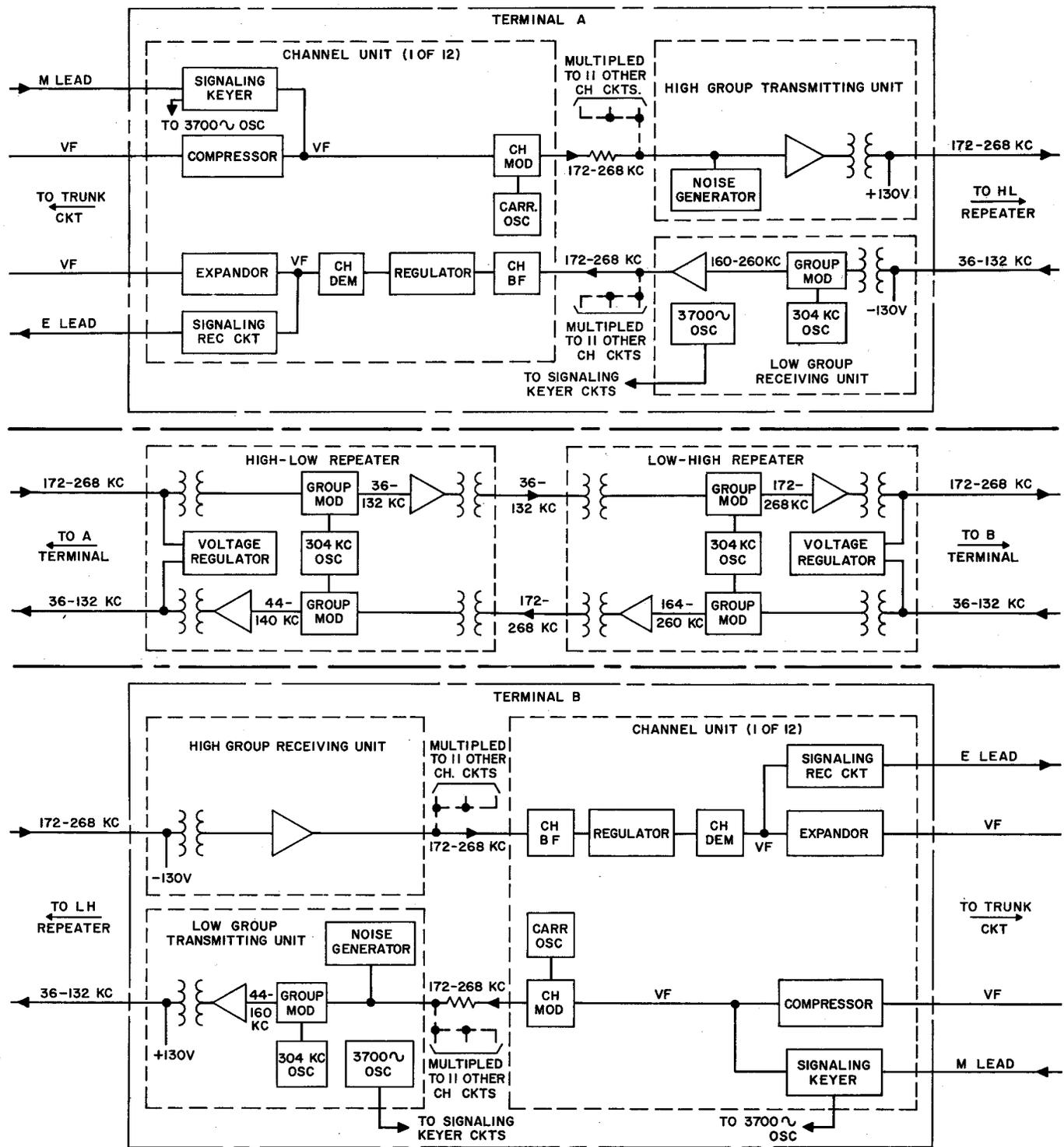


Fig. 1 - N1 Carrier System Schematic

modulating and demodulating circuits. The transmitting and receiving group units contain the transmitting and receiving amplifiers, the group modulator, the group oscillator, the signaling oscillator, the noise generator, and the carrier alarm detector. The repeaters include amplifiers, filters, a group modulator for each direction, and a common oscillator for both modulators.

**1.06** Signaling arrangements are built into the system as a component part of the basic channel unit for the transmission of supervisory signals and dial pulses. Connections from switchboard or trunk equipment to these signaling arrangements are similar to those used with present CX signaling circuits.

**1.07** Compandors are also provided in some of the channel units. Their use eliminates the need for crosstalk balancing and special noise treatment of the cable pairs, and leads to more lenient selectivity requirements for the receiving channel band filters. Most of the usual noise and crosstalk interferences encountered in carrier system operation are reduced by the compandor. In addition, double sideband transmission used with the compandors eliminates the need of a transmitting band filter.

**1.08** The use of different frequency bands in opposite directions of transmission reduces the effects of crosstalk sufficiently to permit the pairs for both directions to be in the same cable. The frequency bands assigned to the two directions of transmission are interchanged at each repeater. This is termed "frequency frogging" and is one of the salient features of the Type N1 System.

**1.09** Two types of repeaters designated as low-high (LH) and high-low (HL) are used alternately along the high-frequency line. Also, the repeater may be the electron tube type N1, or transistorized type N1A. As indicated in Fig. 2, the LH repeater receives at its input the low group of frequencies which are converted to the high group before amplification. For the HL repeater, the high group appears at the input and the low group at the output. The repeaters

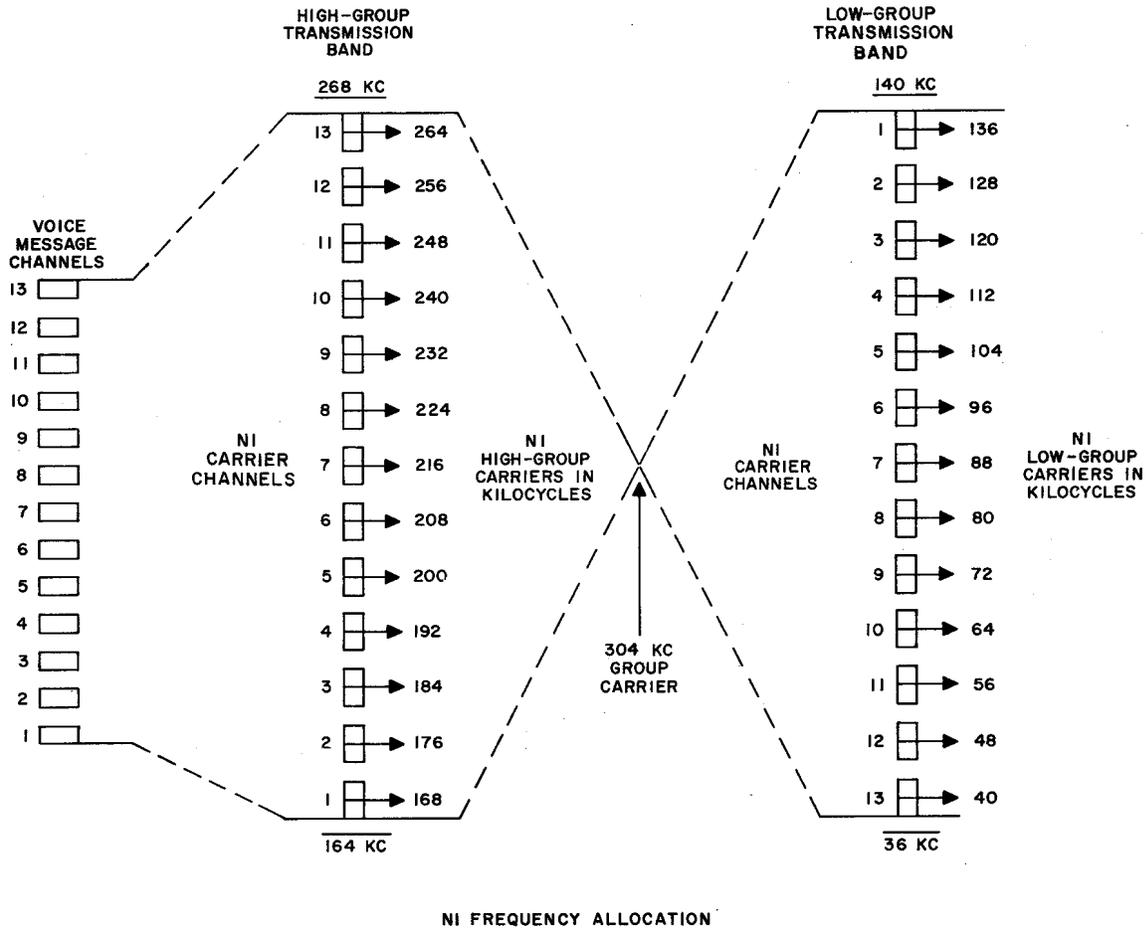
are spaced at intervals up to 8 miles for 19-gauge toll cable. For other types of cables the repeater spacing may be from 2.4 to 11 miles. Noise performance is normally the governing factor in determining the length of repeater sections.

**1.10** Power for the terminals is derived from standard  $-48$  volt and  $+130$  volt office power supplies. Local electron tube repeaters are powered from  $+130$  volt battery supplies; local transistorized repeaters may be fed from either  $+130$  or  $-48$  volt supplies. Power may be transmitted over the carrier pair simplex circuits from various combinations of  $+130$ ,  $-130$ , and  $-48$  volt supplies to power the N1 and N1A repeaters, the 240-type amplifiers, and to allow for sealing current. Fig. 3 shows several typical power connections for the repeaters with and without the 240-type amplifiers and/or sealing current.

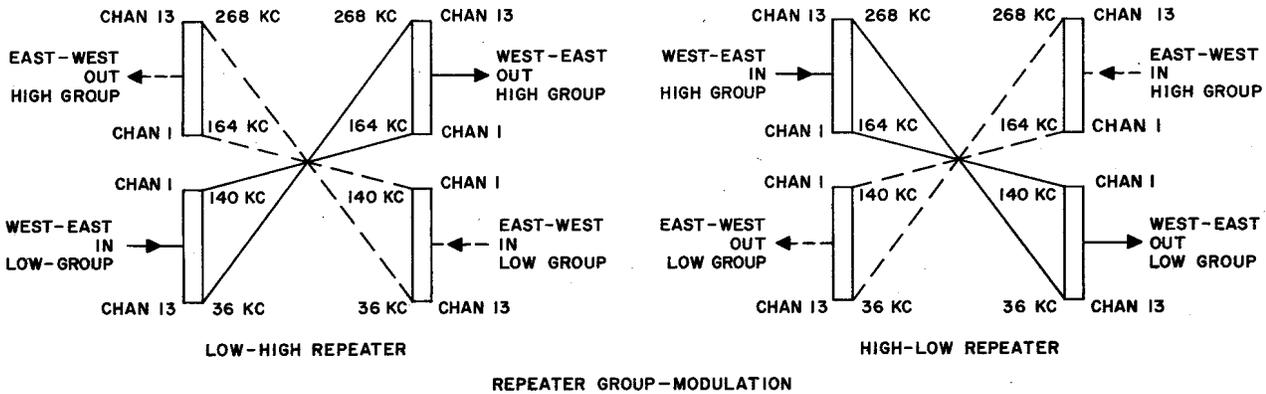
**1.11** Alarms are provided at the terminals for fuse failures, failures of carrier transmission, and failure of the 3700-cycle signal tone supply common to 12 channels. Fuse failure alarms are also provided at the main repeater stations which supply power to the other repeater points. A simple order wire and alarm circuit is used along each N1 system route to provide talking facilities and to relay alarms from unattended main repeater stations to attended offices. This order wire circuit also serves to supply power to the repeater switching set when used at a nonpower supply point.

**1.12** Facilities are provided for in-service switching of group equipment and repeaters for maintenance purposes. All equipment can be switched except the individual channel units which can only be replaced on a turn-down basis. The small size and plug-in feature of the group and repeater units make the complete removal and replacement of defective units practicable. The units, in turn, are comprised of easily separated subassemblies. This breakdown permits quick segregation of trouble and provides greater accessibility of the components. It also permits the combining of good subassemblies into working units; thus, materially reducing the requirement for system spares.

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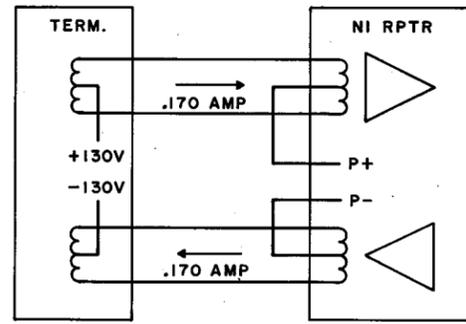


NI FREQUENCY ALLOCATION

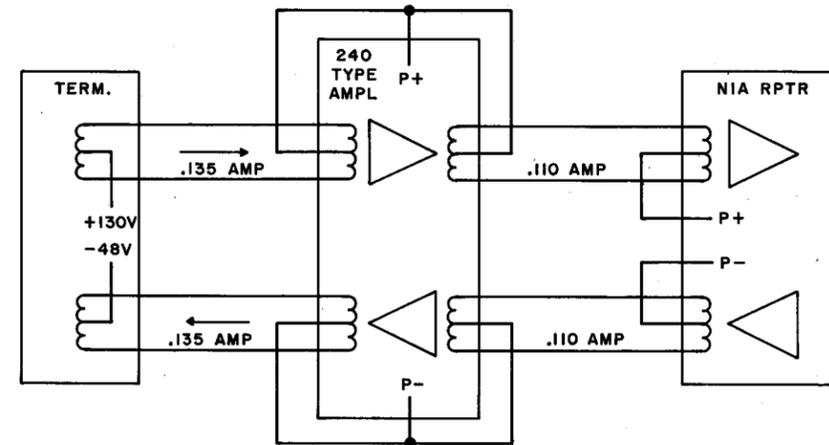


REPEATER GROUP-MODULATION

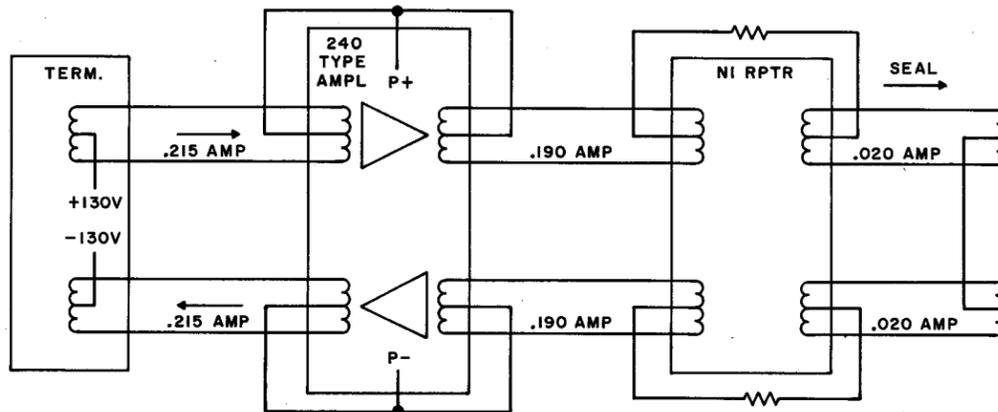
Fig. 2 - NI Carrier Frequency Allocation and Repeater Group Modulation



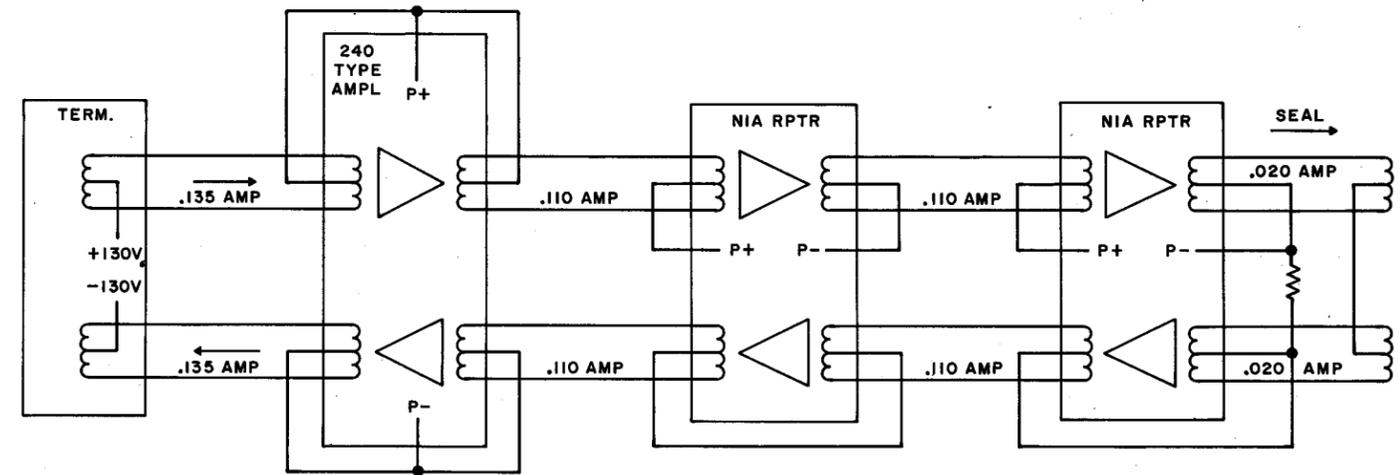
POWER TRANSMITTED TO ELECTRON TUBE REPEATER



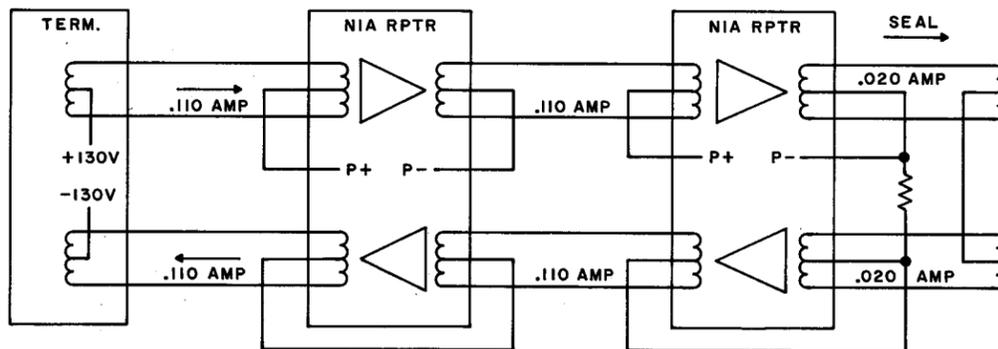
POWER TRANSMITTED TO NIA TRANSISTORIZED REPEATER AND 240-TYPE AMPLIFIER



POWER TRANSMITTED TO NI ELECTRON TUBE REPEATERS AND 240-TYPE AMPLIFIER WITH SEALING CURRENT



POWER TRANSMITTED TO NIA TRANSISTORIZED REPEATERS, 240-TYPE AMPLIFIER AND SEALING CURRENT



POWER TRANSMITTED TO TWO NIA TRANSISTORIZED REPEATERS PLUS SEALING CURRENT

Fig. 3—Typical Power Connections for the N1 and N1A Repeaters

## 2. TERMINAL TRANSMISSION FEATURES

### A. General

**2.01** A complete terminal consists of 12 channel units, a transmitting group unit, and a receiving group unit (see Fig. 1). The channel units modulate the channel voice frequencies to their respective place within the spectrum for transmission and demodulate the signals at the receiving end returning them to their original voice-frequency band.

**2.02** The transmitting group unit may be a high-group transmitting unit (HGT) or a low-group transmitting unit (LGT). When transmitting the high-group frequencies (172-268 kc), the HGT is used. This unit amplifies the high-group frequencies received from the channel units and applies them to the carrier line. When transmitting the low-group frequencies (36-132 kc), the LGT is used. The LGT first modulates the combined outputs of the channel units with a 304-kc carrier and selects the lower sideband of low-group frequencies (36-132 kc). This low-group frequency band is then amplified and applied to the carrier line.

**2.03** The receiving group unit may be low-group receiving (LGR) which is associated with a high-group transmitting unit or high-group receiving (HGR) associated with a low-group transmitting unit. The receiving group unit always sends high-group signals to the channel units; thus, when it receives high-group signals, only amplification is necessary. When it receives low-group signals, they are first modulated to the high frequency band, and then the signals are amplified and applied to the channel units.

### B. Channel Units

**2.04 General:** The standard message channel unit consists of the compressor subassembly, the expander and signaling subassembly, and the carrier-frequency subassembly. The compressor reduces the volume range of speech before it is applied to the line in order to obtain a better signal-to-noise ratio. At the receiving terminal the expander restores the signal to its original volume range. Signaling circuits are included in each standard message channel unit to permit the transmission of supervisory

signals and dial pulses over the N1 carrier system. The carrier-frequency subassembly contains circuits for modulating the outgoing voice frequencies with the carrier for each respective channel, and demodulating circuits for signals received from the low- or high-group receiving unit.

**2.05 Compandors:** The compressor, which is the transmitting portion of the compandor, contains a balanced diode type variollosser and an amplifier. The compandor does not alter the +5 dbm level of an input signal (referenced to zero system level), but signal inputs greater than +5 dbm are attenuated by an amount equal to 1/2 of the difference between the original signal level and +5 dbm. Signal inputs weaker than +5 dbm are amplified so that the signal, at the compressor output, equals the original level plus 1/2 of the difference between the original level and +5 dbm. This action is such that the weaker inputs receive more amplification than the stronger inputs, resulting in reduction in the volume range by one-half. Conversely, the expander, located in the expander and signaling subassembly at the far end of the transmission line, restores the signals to their original levels. This is accomplished by providing a variable loss such that the weaker inputs are reduced in strength and the stronger inputs undergo relatively little change. The loss ratio of the expander is identical to the gain ratio of the compressor. Thus, the original signal level is restored and the net result is an increased signal-to-noise and crosstalk ratio. Fig. 4 shows the effect that the compandor has on various input levels.

**2.06 Signaling:** Signaling over the N1 carrier system, where the built-in arrangement is used, is effected by means of a 3700-cycle tone. This tone, generated by an oscillator which is common to a 12-channel terminal, is transmitted over each channel during the idle condition. An off-hook signal over the M lead from the trunk circuit interrupts the tone. At the receiving end, the tone is detected and the dc indications are transmitted over the E lead to the trunk circuit. These indications correspond to the on-hook and off-hook signals initiated at the other end. Dial pulses can be transmitted similarly from the M lead at one end to the E lead at the other end. By suitable converters, ringdown signals also can be transmitted.

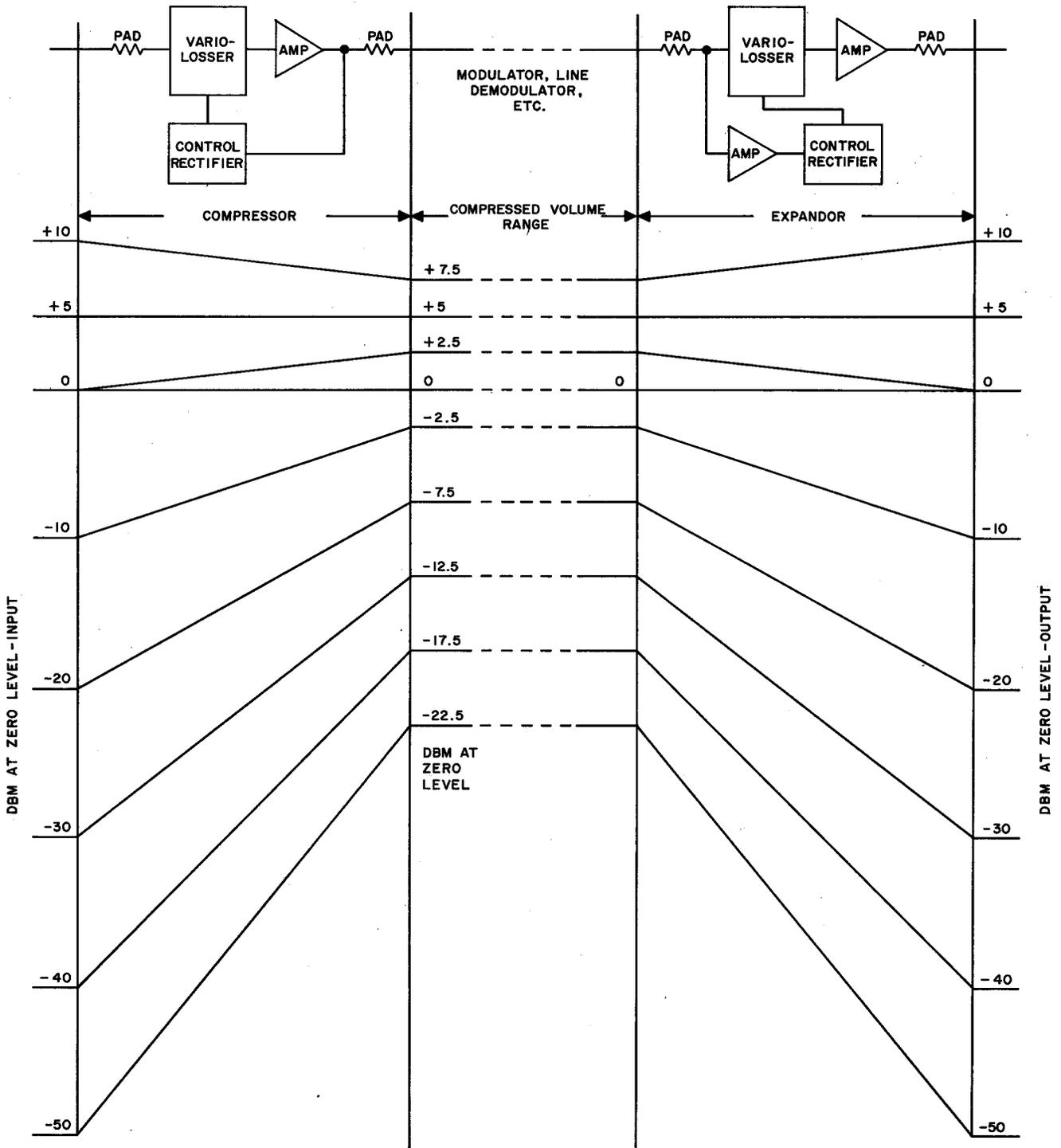


Fig. 4 - Compandor Action on Steady Tones of Different Levels

**2.07 Channel Modulator and Demodulator:**

The modulator and demodulator are part of the carrier-frequency subassembly. The modulator receives speech currents from the compressor and modulates them with the carrier generated by an oscillator in the carrier-frequency subassembly. The resulting products, which include the upper and lower sidebands of the modulated signal, are combined with similar outputs of the other 11 channels and are applied to the low or high-group transmitting circuit. The demodulator at the far end then receives the carrier and sidebands selected by the channel band filter, and produces speech currents which are applied to the expander. The channel regulator which precedes the demodulator is an automatic gain control circuit and serves to maintain an output at a nearly constant level for relatively large changes in its input.

**Types of Channel Units****2.08 J98703FA N1 Message Channel Unit:**

The N1 message channel unit is the standard channel unit which contains three complete subassemblies. The units for channels 1 to 13 differ only in the receiving band filters and in the crystal unit which determines the channel oscillator frequency.

**2.09 J98703AP Channel Unit Without Signaling:**

The channel unit without signaling is identical to the message unit except that the built-in signaling circuits have been omitted. It is intended for use where built-in signaling is not required or where external in-band signaling is to be provided.

**2.10 J98703BP Amplas Channel Unit:** The amplas channel unit has the same circuit as the J98703AP channel unit without signaling. The components and subassemblies of the J98703BP unit are arranged on two amplas (Apparatus Mounted in Plastic) boards. These boards are, in turn, mounted on a single die cast chassis. The unit will mount interchangeably with the J98703AP channel units and requires the same voltages and current requirements. However, certain restrictions on its use must apply with respect to operating temperatures, since the size and shape of the unit is such that it interferes with the flow of air from the bay temperature control equipment.

**2.11 J98703AH Thru Channel Unit:** Where type N carrier channels are connected or patched as through circuits to other type N, O, or ON carrier channels, it is advantageous, for transmission reasons, to omit the compressor and expander circuits from the channel units at the interconnection point. Under this condition, the signaling circuits are not required and considerable economy is realized by their omission. The J98703AH thru channel unit contains two subassemblies; the voice-frequency subassembly and the carrier-frequency subassembly. The carrier-frequency subassembly is identical to that used in the message channel unit.

**2.12 J98703AM Special Services Channel Unit:**

The special services channel unit, J98703AM, provides a 4-wire noncompandored circuit having level adjustment and amplification in each direction of transmission. It is a plug-in type unit used in place of an N message channel unit at each terminal where data transmission and voice-frequency carrier telegraph or telephoto is to be transmitted over the N carrier telephone system. The carrier frequency subassembly is identical to that used in the message channel unit.

**2.13 J98703W Schedule A and B Program Channel Unit:**

Channel 6 of an N-type system may be utilized for schedule A or B program transmission. When so utilized, it is necessary to remove message units from channels 5 and 7, as well as from channel 6, to provide the necessary 8-kc bandwidth. However, channel 1 or 13 (whichever is not normally provided in the system) may be substituted in the position of channel 7 for an additional message channel when a schedule A or B program channel is provided.

**2.14 J98703Y Schedule A and B Program Channel Reversing Unit:**

The reversing unit, J98703Y, is used in addition to the J98703W unit when remote control of the direction of program transmission is required. It consists of two plug-in subassemblies: a switching subassembly containing two relays, and a modified channel 5 carrier-frequency subassembly. The carrier-frequency subassembly provides a 200-kc narrow-band crystal filter and an amplifier-detector in the receiving direction. In the transmitting direction it provides a 200-kc crystal

oscillator. The reversing channel unit, under control of a dc signal from the program reversing panel J68617AW, controls the direction of transmission of the J98703W A and B program channel unit.

**2.15 J98703TA Schedule C and D Program Channel Unit:**

One or more channels of an N1 system may be utilized for schedule C or D program transmission. In order to accomplish this, it is necessary only to remove the N1 message channel unit from the channel position desired for program, replace it by a program channel unit J98703TA of the proper list, and make the proper cross connections. The program channel units are essentially the same as the corresponding message channel units without signaling and with different filters.

**C. Group Units**

**2.16 General:** The transmitting and receiving group units are each of two different types, handling either a high-group frequency or a low-group frequency; they are designated accordingly HGT, LGT, HGR, and LGR. The function of the transmitting group units is to receive the high-group band of frequencies from the channel units and amplify them suitably for transmission along the line. For transmission at high-group frequencies, only amplification is required, but for transmission at low-group frequencies, conversion from the high-frequency group to the low-frequency group is also required. The receiving group unit receives the low-level signal from the line, modulates it to the high-group band if received as low-group frequencies, and amplifies and regulates them suitably for application to the channel units.

**2.17 Transmitting Group Unit:**

(a) **High-Group Transmitting Unit:** The high-group signal outputs of the 12 channel units (combined in a multiple network) are applied to the input of the transmitting group unit. A noise generator, also connected to the input, provides an adjustable source of noise, and is used when specified to mask crosstalk in extremely short or quiet cables. The resulting signal is then applied through a low-pass filter and slope equalizer to the amplifier which raises the signal to the proper level for the transmission line.

(b) **Low-Group Transmitting Unit:** In addition to a noise generator and amplifier, the low-group transmitting unit (LGT) has an oscillator and modulator circuit. The group modulator in the low-group transmitting unit receives the high-frequency band (172-268 kc) from the channel units and modulates it with the 304-kc group carrier. The lower sideband, which is the low-frequency group (36-132 kc), is selected from the modulation products by a filter. This group is amplified and applied to the transmission line.

**2.18 Receiving Group Units:**

(a) **Low-Group Receiving Unit:** The low-group receiving unit provides group frequency conversion and gain to compensate for the flat loss of one repeater section. Frequency conversion from the low-frequency group (36-132 kc) to the high-frequency group (172-268 kc) takes place in the group modulator. A bandpass filter at the output of the modulator selects the lower sideband (high group), and after slope equalization, the signal is applied to the amplifier. A feedback circuit in the amplifier provides flat-gain regulation and maintains an output power of approximately 5.5 dbm after which the signal is applied to the 12 channel units.

(b) **High-Group Receiving Unit:** The high-group receiving unit serves only to amplify and equalize the slope of the incoming signals since they are already in the proper frequency range. A feedback circuit in the amplifier provides flat-gain regulation and maintains an output power of approximately 5.5 dbm after which the signal is applied to the 12 channel units.

**2.19 Oscillator Subassembly:** An oscillator subassembly is attached to the low group unit; whether it be a low group transmit or low group receive unit. This oscillator subassembly contains the 304-kc and 3700-cps oscillators.

**3. REPEATER TRANSMISSION FEATURES**

**A. General**

**3.01** N1 carrier repeaters are of two basic types: the high-low repeater (HL) electron tube or transistorized, and the low-high (LH) electron

tube or transistorized. The first type receives high-group frequencies from both directions and transmits low-group frequencies. The second receives low-group frequencies and transmits high-group frequencies. They are used alternately along the line. Each repeater includes amplifiers, filters, a group modulator for each direction, and a common oscillator. All amplifiers include automatic gain regulation.

### B. Frequency Frogging

**3.02** The repeaters, in addition to their amplification function, modulate the group received from the line with a 304-kc carrier to translate it to the other frequency group for transmission to the next cable section. Because of the use of different frequency groups at the inputs and outputs of the repeaters, signals crosstalking from high level points (repeater outputs) to low level points (repeater inputs) encounter the suppression provided by the repeater input filter and the balance of the modulator and thus do not affect system performance. Other advantages of "frequency frogging" are pointed out in 3.03 and 3.04.

### C. Equalization

**3.03** At the same time the group frequencies are interchanged by frequency frogging, the positions of the channels within the groups are also reversed, i.e., channel 13, the highest

(264 kc) in the high group allocation is the lowest (40 kc) in the low group allocation. This transfer results in a total loss that is approximately the same across the 12-channel group for two adjacent line sections, thus, the line slope is very nearly equalized. This is indicated in Table A which shows the equalization of equal length adjacent cable sections (for 45°F) and the gains of the associated LH and HL repeaters (with B slope settings) for channels 2, 7, and 13 carrier frequencies. Both the LH and HL repeaters with B slope settings have essentially flat-gain characteristics with only a slight amount of slope. Accumulated slope, including uncompensated slope due to unequal lengths of cable sections, is corrected by selection of appropriate slope settings for the repeaters when a route is engineered.

**3.04 Slope Adjustment:** When shorter spans or cables with different slope characteristics are used, slope equalization is obtained by use of the A or C slope adjustments located on the repeater which provide a nominal slope change of  $\pm 2$  db from the B adjustment. Transistorized repeaters have a nominal slope change of somewhat less than 2 db.

**3.05 Span Pads:** Flat loss adjusting span pads are normally introduced at the receiving end of the cable pairs, and may be located in high-frequency cross-connect cabinets or in repeaters or terminals. These pads serve to build

**TABLE A**  
**TRANSMISSION THROUGH TWO REPEATER SECTIONS**

	CHANNEL 1	CHANNEL 6	CHANNEL 12
LG Cable Transmission	-44.3	-36.9	-27.4
HG Cable Transmission	-49.8	-56.0	-63.0
	-94.1	-92.9	-90.4
LH Repeater Gain	+48.0	+46.9	+46.5
HL Repeater Gain	+47.0	+47.7	+46.0
	+95.0	+94.6	+92.5
Over-all Transmission Net Gain	+0.9	+1.7	+2.1

out the cable loss to normal values for the system, which are 46 db for low-group transmission and 50 db for high-group transmission. Losses are calculated at channel 2 carrier frequencies of 128 kc for the low group and 176 kc for the high group to determine the pad values required. The pads are available in steps of 2 db. Other build out units are available for those cases where flat loss units are not required.

**3.06 Deviation Equalizers:** These equalizers are required with the older J98703L and M repeaters. They correct small amounts of transmission distortion not covered at each repeater point. The deviation equalizers operate in the low-group frequency range and are placed either at the input of LH repeaters or the output of HL repeaters.

**3.07 Deviation Regulators:** A deviation regulator is used in conjunction with a low-high repeater and provides regulation in one direction of transmission. The regulator corrects deviations in relative levels of individual channels.

**3.08 Adjustable Deviation Equalizer:** This circuit is intended for use in equalizing N and ON carrier systems where the amount of artificial lines and nonideal repeater characteristics cause transmission level deviations to become excessive. The equalizer operates in the high-group frequency band and is installed at the output of an N carrier LH repeater.

**3.09 240-Type Amplifiers:** These amplifiers are used to improve the signal-to-impulse noise ratio in N, O, and ON carrier systems. The amplifier may also be used to improve regulations on long repeater spans by raising the average carrier level at the input of a repeater or terminal to the center of its regulation range.

## 4. SYSTEM TRANSMISSION FEATURES

### A. Attenuation

**4.01** The 4-wire voice frequency input and output levels, relative to the transmitting switchboard are  $-16$  dbm and  $+7$  dbm, respectively. A 0- to 26-db variable loss attenuator is provided in the output to adjust the  $+7$  dbm level

from the  $+10$  dbm expander output level and to make output level adjustment on 2-wire channels.

**4.02** A 2-wire to 4-wire resistance hybrid network was also provided in the message channel units of older manufacture. The network has a 16-db loss on the input side and a 3-db loss on the output side. It is suitable for use at 2-wire nongain switching centers, but not with 2-wire extensions or at 2-wire gain switching centers. Although formerly furnished, its use is optional.

### B. Levels

**4.03** The system carrier levels on the high-frequency line are shown in the carrier level diagram (Fig. 5) which is for a typical system. In the diagram, the levels shown are in terms of the powers of the transmitted carriers, which are 12.5 db above the single sideband compandored message power for a 0 dbm zero system level input voice-frequency signal. The top half of the figure shows the levels for the A to B direction of transmission, and the B to A direction is represented in the bottom half of the diagram.

**4.04** The channel carriers each have a power of  $-53$  dbm at the inputs to the transmitting group units. They are then predistorted to provide a 7-db slope across the band and amplified for transmission at the normal carrier levels for high- or low-group transmission on the line. At the receiving group unit, the signal levels are equalized by 7 db. This amount of equalization, together with the 7-db predistortion at the transmitting end, approximately corrects the line transmission slope of half of the first cable span, and half of the last span.

**4.05** The normal power level of the 12-channel carriers within each group, measured at the output of the transmitting group units and repeaters, is illustrated in Fig. 6. The total power for each channel is indicated, together with the net power for all 12 carriers in each group.

**4.06** The channel carriers at the outputs of the receiving group units are all equal, with a value of  $-5.5$  dbm for each channel, and a power summation of  $+5.3$  dbm for a perfectly equalized system.

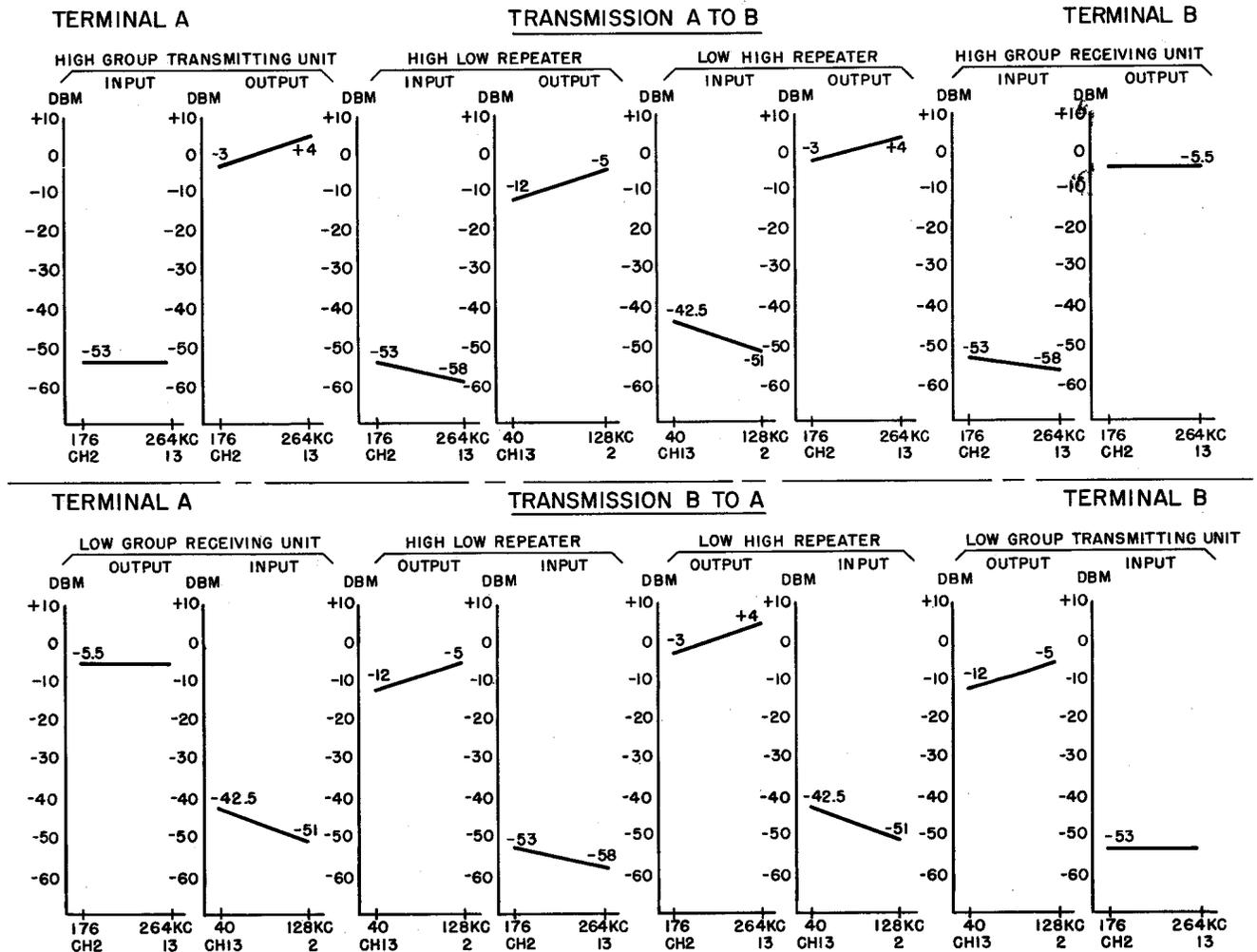


Fig. 5 - N1 Carrier Level Diagram

**C. Regulation**

**4.07** For line transmission, flat-gain regulation is required to compensate for changes in the cable loss with varying temperature, whereas slope changes are almost completely compensated by "frequency frogging". The flat-gain regulation provided in each repeater and receiving group unit holds the average power output within approximately 1 db of its nominal value for temperature changes from  $-15^{\circ}\text{F}$  to  $+110^{\circ}\text{F}$ . For greater temperature changes the regulator functions less efficiently.

**4.08** The line regulation is obtained by means of thermistors which vary the feedback of the amplifiers. The thermistor resistance is deter-

mined by the total power of all the carriers at the amplifier outputs. Higher than nominal output heats the thermistor reducing its resistance. This produces more negative feedback which reduces the amplifier gain, restoring the output to normal. The line regulation characteristic is shown in Fig. 7. The receiving group unit changes are the resultant of the preceding cable span loss variations plus the unregulated residues of preceding repeater regulators. Arrows "a" and "b" indicate the expected input variations for 8 miles of 19-gauge toll aerial cable at high-group frequencies for a temperature range of  $-15^{\circ}\text{F}$  to  $+110^{\circ}\text{F}$  and  $-30^{\circ}\text{F}$  to  $+130^{\circ}\text{F}$ , respectively. Within the range indicated by arrows "a", the unregulated residue of preceding

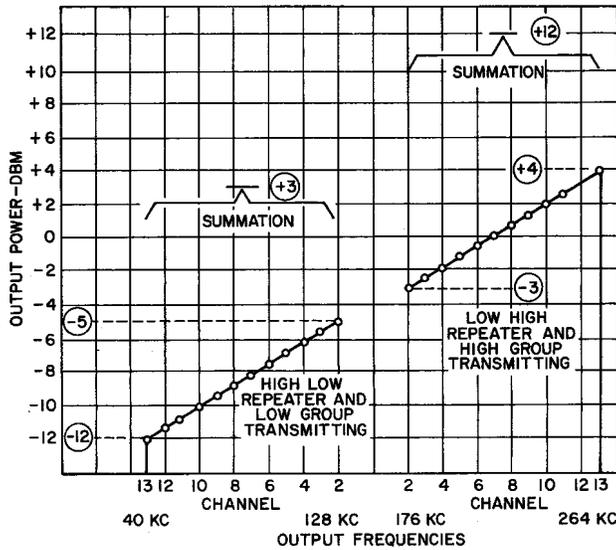


Fig. 6 – Transmitting Group Unit and Repeater Carrier Output Power

repeaters is negligible, but for greater temperature variations, the accumulating residues cause an increasing degradation of regulation. This line regulation is somewhat poorer when receiving low-group frequencies because of the greater departure from perfect regulation of the preceding high-low repeater. This is shown in the individual repeater regulating characteristics (solid curves) of Fig. 8. The dotted curves of this figure show the effect of accumulated residues approached asymptotically for a large number

of repeaters. The circled numbers on these dotted curves indicate the number of repeaters which, for the span loss variations given as abscissas, will give practically the residue given by the curves. When underground cable or shorter aerial spans are used, the temperature effects are, of course, reduced and the line regulation correspondingly improved.

4.09 Because of the frequency characteristic of the line transmission variations, individual channels may depart by as much as 8 db from the nominal value as measured at the output of the receiving group unit. This is corrected by the regulator contained in each channel unit which maintains the received channel carrier applied to the demodulator to within 0.5 db of its nominal value.

4.10 The thermistor regulator has a sufficiently long reaction time so that channel voice current peaks do not alter the system regulation. For a decreasing output regulator action with time, this reaction time is three to five times as great as for an increasing output with time. This effect materially affects the waiting period required after any transmission change, before the circuit will stabilize within the desired measuring accuracy. With a change in LH repeater slope step from B to A (Fig. 8) the waiting period for a single regulator section is 2 to 4 minutes, depending upon the accuracy desired as shown in Fig. 9. For a change in slope step from B to C (output decreased) the

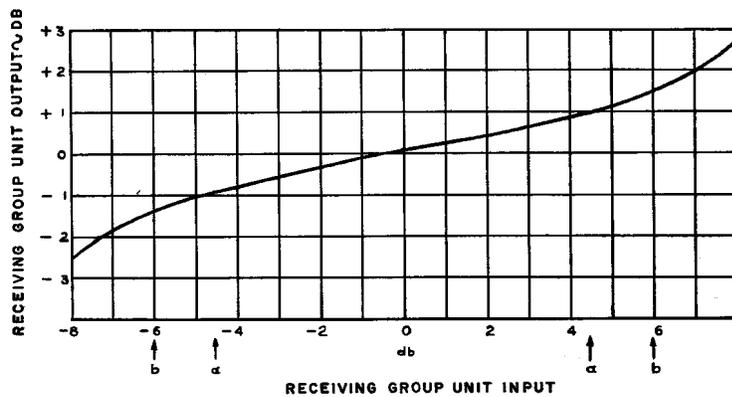


Fig. 7 – N1 System Line Regulation Characteristic

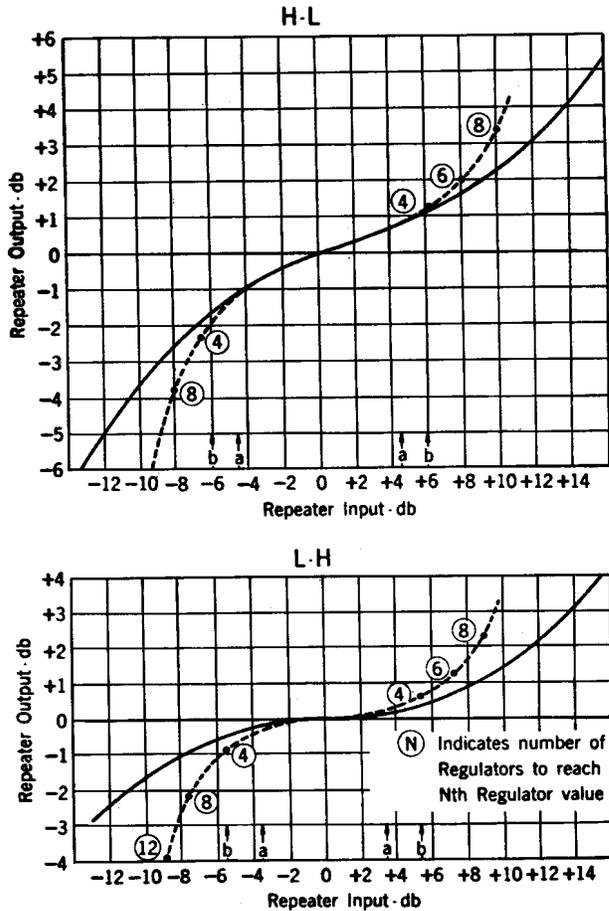


Fig. 8 — Repeater Regulation Characteristics

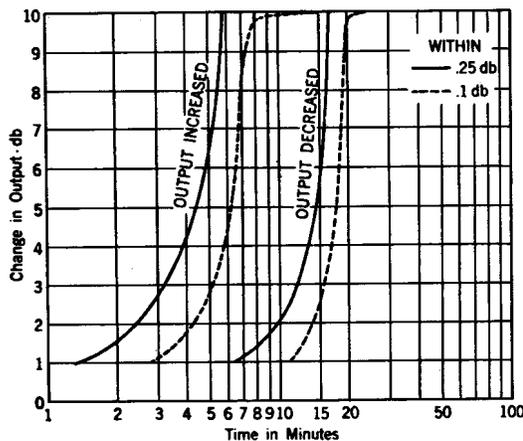


Fig. 9 — Regulator Stabilization Time

wait is from 9 to 12 minutes for corresponding accuracies.

4.11 When there are a number of repeaters between the point of circuit change and the point of observation, the tandem action of the regulators results in a shortening of the over-all restoration time. This shortening, however, is no indication that, in the intervening portion of the circuit, the levels have already restored to their normal values and there is no possibility of overload. The tandem action may cause the output to overshoot by 10 per cent of the original change before settling to its stabilized value.

4.12 The sideband speech power on the line on a long-time average and the signaling tones are 12.5 db or more below their respective channel carriers, so they do not appreciably affect the system regulation.

**D. Transmission Performance**

4.13 The nominal over-all frequency characteristic of a type N1 channel measured 4-wire is essentially flat between 250 and 3000 cycles, with the 3-db points occurring at approximately 200 and 3100 cycles. The 10-db points occur at approximately 150 and 3200 cycles. A circuit composed of four type N1 channels, patched 4-wire in tandem, is expected to give a bandwidth of about 2900 cycles with the 10-db points at approximately 200 and 3100 cycles, respectively. Fig. 10 shows a typical over-all channel frequency characteristic, measured from compressor-in to expander-out.

4.14 The nominal 1000-cycle transmission variation of any length of N1 carrier link is normally within  $\pm 0.8$  db.

**5. POWER SUPPLY**

5.01 The power at terminal stations for both the channel and group units is obtained from standard -48, +130, and -130 volt power supplies. Local electron tube repeaters use only +130 volts and ground. Where electron tube repeaters at an adjacent nonpowered station are to be supplied over the simplex transmission pairs, +130 volt and -130 volt potentials

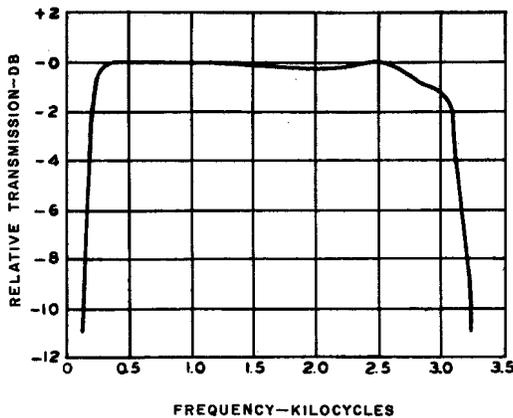


Fig. 10 — Typical Channel Frequency Characteristic

are required. Optional arrangements for transistorized repeater applications permit using either  $-48$  volt or  $+130$  volt supplies for local repeaters, and combinations of;  $-48$  volts and ground (sealing current only),  $+130$  volts and ground,  $-48$  volts and  $+130$  volts, or  $+130$  volts and  $-130$  volts, as required, to feed remote repeaters.

**5.02** Repeaters at powered stations depend upon battery regulation for voltage control. With power supplied over the simplex pairs to nonpowered repeater stations, a gas tube voltage regulator is used in each electron tube repeater and one or two avalanche diodes are used in transistorized repeaters for voltage control. In addition, an adjustable resistor in the  $-130$  volt lead at the dc power supply point controls the current fed over the simplex line.

**5.03** In the case of exchange area applications where the cable splices are usually not soldered, it is desirable to use a dc sealing current over the transmission wires to insure low splice contact resistance to the signal. Arrangements are provided to procure this current flow in line spans which would not otherwise be required to carry power to a distant repeater. This is done by inserting at repeater stations, when required, special "bleeder" resistances between the input and output simplex leads. The spans normally carrying power will then, in addition, transmit the "bleeder" power to the nonpowered spans, and the adjustable resistor mentioned in the preceding paragraph will be set accordingly.

## 6. SYSTEM EQUIPMENT FEATURES

**6.01** The N1 carrier system is designed on a unit basis, each unit having all external connections terminated in a plug so that it may be plugged into a jack in an associated mounting framework. The three types of plug-in units required are channel, group, and repeater. Miniature components, compactly assembled and wired in aluminum die castings, are employed to permit sufficiently small and light units for this method of construction.

**6.02** A complete terminal primarily consists of 12 channel units, a transmitting group unit, and a receiving group unit. These units plug into jacks in a terminal mounting (Fig. 11) which can be mounted on any relay rack or cabinet which will mount 19-inch panels. This mounting contains terminal strips and interconnecting wiring as well as power supply fuses and alarm equipment not only for the terminal but also for an adjacent nonpower supply repeater. Also, switching jacks are provided for the group units so that these units may be replaced without service interruption. The terminal framework is 40-1/4 inches high (23, 1-3/4 inch mounting plate positions) and three such terminals may be mounted in a standard 11-foot 6-inch channel or duct type relay rack. All framework parts are made of natural finish aluminum.

**6.03** The N1 carrier system terminals may also be mounted in shop-wired bays. Two of these bays are available; an 11-foot 6-inch channel-type bay which is completely wired and contains mounting facilities for three N1 carrier system terminals, and an 8-foot 8-inch bay which contains facilities for two terminals.

**6.04** Repeater units are plugged into jacks on a repeater mounting bracket which in turn is assembled on a repeater mounting shelf. The repeater mounting bracket consists of a die cast frame which mounts span adjustment pads, when required, and switching jacks to permit repeater testing or replacement without service interruption. Each repeater mounting shelf mounts four repeaters and brackets as shown in Fig. 12. A group of four repeaters requires 14 inches of vertical space or eight 1-3/4 inch mounting plate positions. The repeater mounting framework is also made of natural finish aluminum.

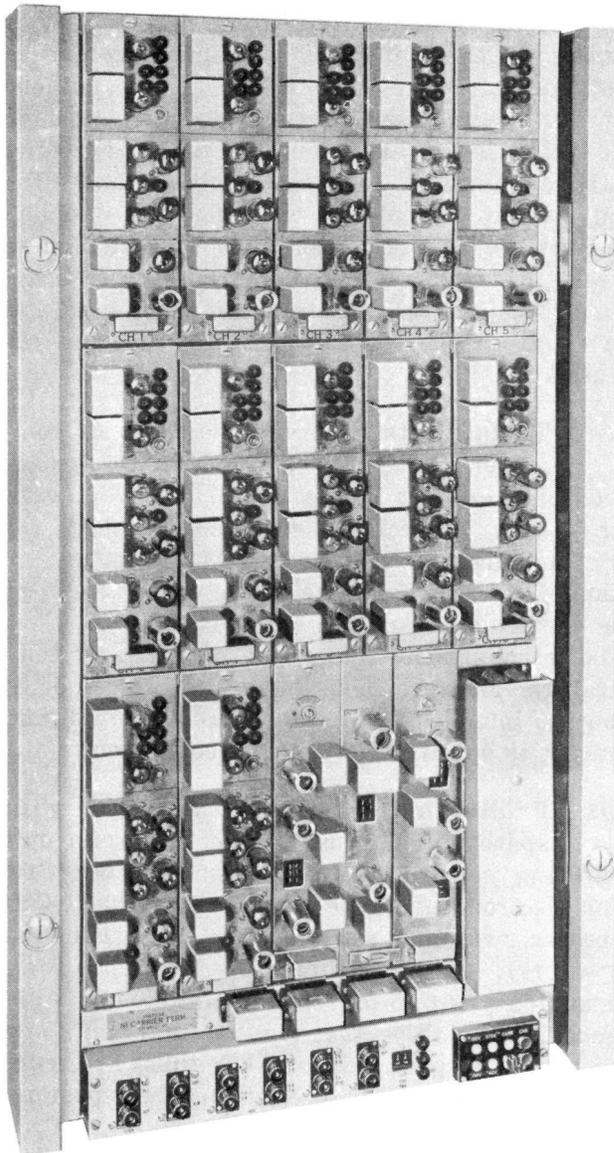


Fig. 11 - N1 Terminal - Front View

**6.05** When repeaters are mounted on standard relay racks at power supply points, a power distribution panel is required for each four repeaters. This panel includes the fuse, fuse alarms, and power supply resistors for the four local repeaters and for the four adjacent repeaters in each direction.

**6.06** Repeaters may be mounted in pole-mounted cabinets at nonpower supply points as shown in Fig. 13 or on standard

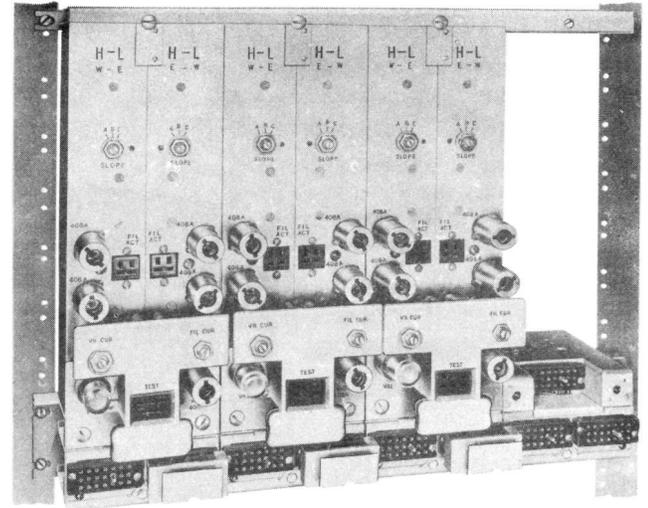


Fig. 12 - Relay Rack Mounting for Four N1 Repeaters

19-inch relay racks at offices or other locations not suitable for the cabinets. The cabinet, which is approximately 6 feet high, provides sufficient space for the protected cable terminal and a maximum of 12 repeaters. It is made of sheet steel, white enameled on the outside with insulated walls. It has ventilating openings at the top and bottom with a thermostatically controlled shutter at the top.

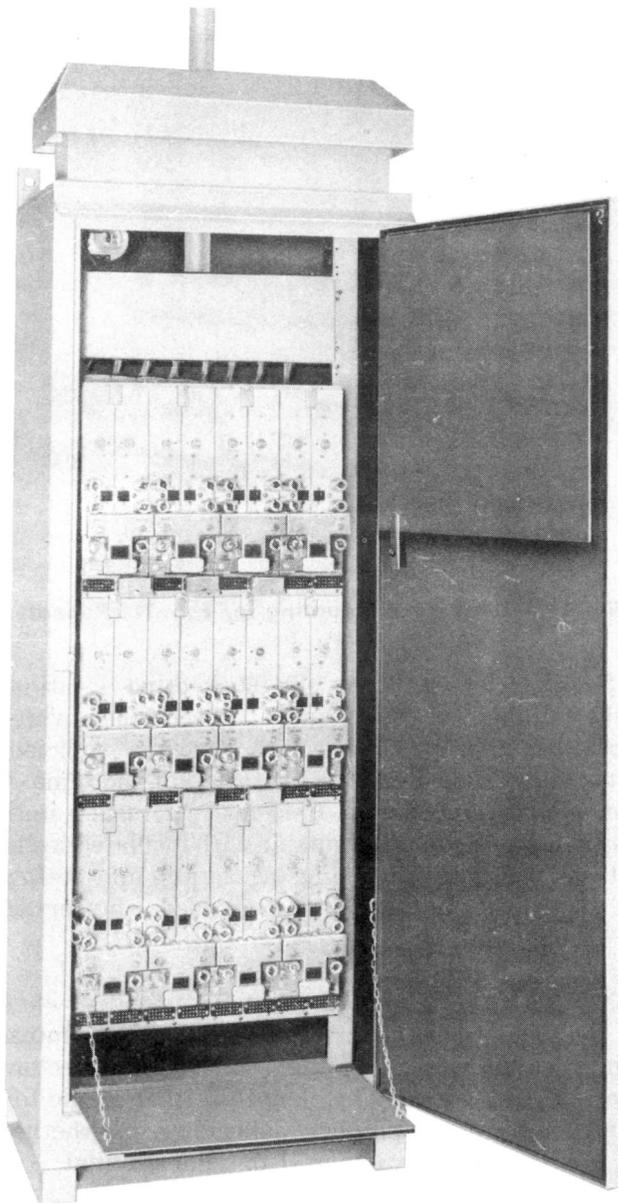
**6.07** A cable terminal must be provided when using pole-mounted cabinets. The terminal includes a 19-gauge cable stub with protectors for 54 pairs. It may be mounted either at the top or bottom of the cabinet, depending on whether the entrance cable is aerial or underground.

## 7. MAINTENANCE FEATURES

### A. Testing Arrangements

**7.01** The testing and maintenance arrangements for the type N system provide for out-of-service maintenance for single channel components and for in-service maintenance of all multichannel components.

**7.02** The single channel components are the channel units. A channel unit is tested on an interrupted or out-of-service basis by first



**Fig. 13 — N1 Repeaters in Pole-Mounted Cabinets**

removing it completely from the terminal mounting so that its component parts are more readily accessible. The unit is then mounted in the J98705M channel unit test stand and reconnected into the circuit by means of a special W18B test cord so that it can operate and be tested as when in its normal circuit position. In case of trouble, the whole channel unit or the subassembly found defective may be replaced.

**7.03** The multichannel components include the group units and repeaters. The in-service testing of these includes the servicing checks and the exchange of complete units without service interruption. Servicing checks include the measuring of carrier output power, checking cathode activity of the tubes, and for nonpowered repeaters, checking the applied line voltage and regulator tube current. These checks are made with the 2J repeater test set. For group units, the 2K tube test set is used and for electron tube repeaters, the 2P tube test set is used.

**7.04** To facilitate in-service detection of component variations on the N1A transistorized repeater, test points are provided on each subassembly which allow measurement of emitter currents with a KS-14150 meter. A change indicates a change in the current gain of the particular transistor or a change in other biasing component values due to aging or temperature. Measurements during in-service operation are intended to indicate a trouble condition, and not to specify the defective component.

**7.05** Faulty units may be replaced with spare units by use of the 2N group unit switching set, the 2M repeater switching set (for electron tube repeaters) or the J98703BD repeater switching set (for N1A transistorized repeaters). These switching sets each utilize an auxiliary group or repeater unit to maintain transmission while the regular unit is being replaced by a spare unit, or while tubes are being changed in group units or electron tube repeaters.

#### **B. Order Wire and Alarm Circuit**

**7.06** To aid in the testing and maintenance of the type N system, a special order wire and alarm circuit has been developed which utilizes two pairs along each system route. It provides complete talking service, transmission of alarms from unattended power supply stations to attended stations, and power for the repeater switching set. A simplified schematic of these facilities is shown in Fig. 14.

**7.07** The order wire arrangements are designed to use a 16- or 19-gauge pair with H88 or H172 loading. Signaling is provided by sending an uninterrupted 1900-cycle signal. Standard

1000-20-cycle signaling may also be used but the 1900-cycle system provides simpler arrangements. At pole-mounted repeater points calling-in signals are generated by an appropriate whistle.

**7.08** The alarm circuit uses the second pair mentioned above. It provides for alarms to be brought into the attended points from unattended main repeater stations by means of voice-frequency tones spaced 400 cycles apart at 700, 1100, 1500, and 1900 cycles. These tones are generated at the unattended stations and are steadily applied to the line during normal operation. Under control of relays at these stations, a trouble condition removes the tone from the line which then causes an alarm indication at the attended station. Each tone is capable of one alarm indication and the four tones can therefore provide a single alarm, each from

four unattended stations. This single alarm can be a general alarm for any station in which there is more than one alarm condition.

**7.09** A control is provided for silencing the audible alarm at the attended station. In this condition, when the trouble has been cleared at the unattended station, the audible alarm will again sound at the attended point until the control is set back to normal. The alarm has a 5-second delay interval to guard against false operation from static or maintenance hits.

**7.10** The order wire and alarm pairs have dc power simplexed onto them from all the powered repeater stations. This provides the power supply required for a repeater switching set at each nonpowered repeater station.

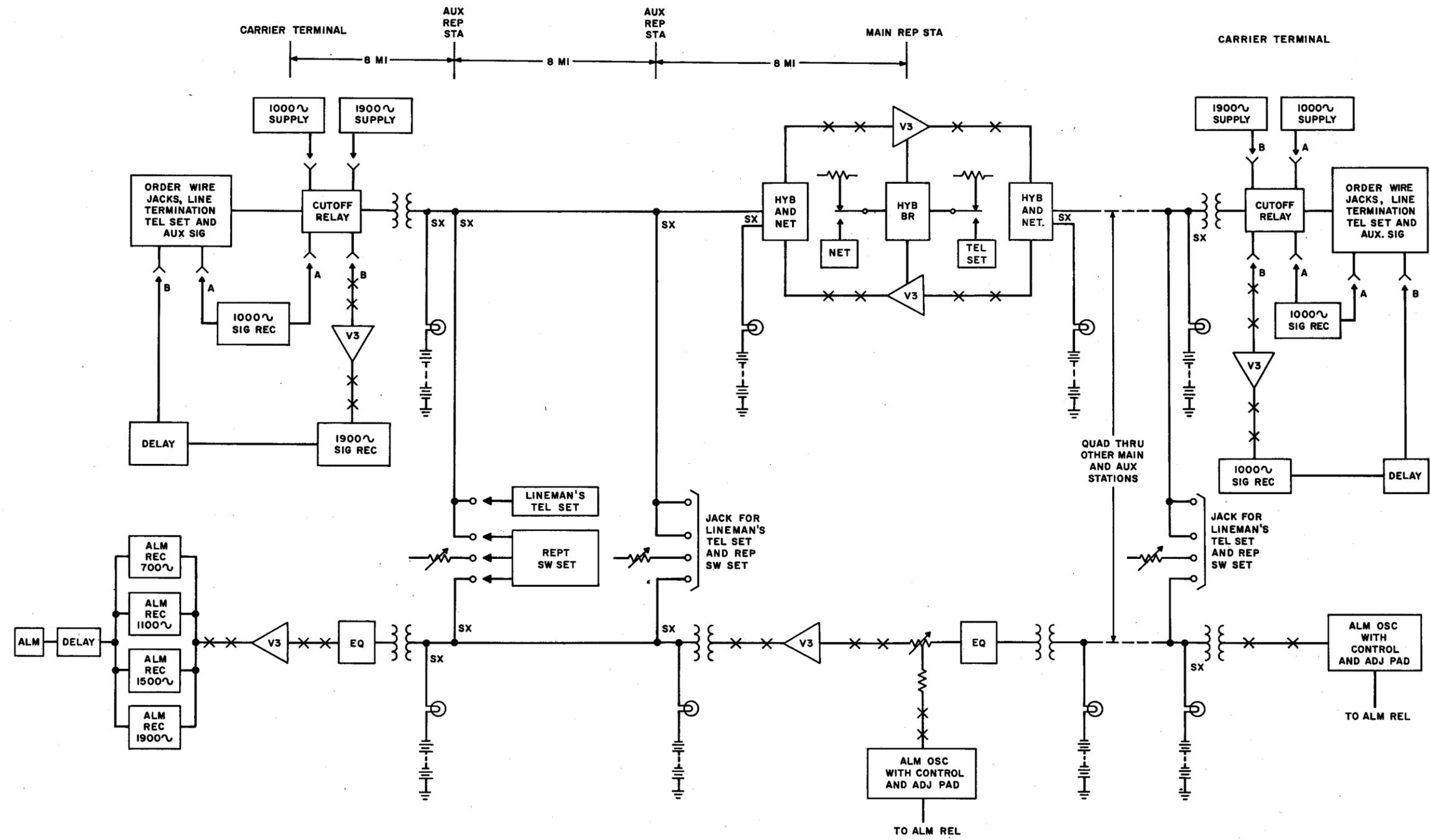


Fig. 14—Order Wire and Alarm Circuit, Simplified Schematic