V4 TELEPHONE REPEATER

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1. GENERAL

1.01 This section covers the V4 telephone repeater which consists of two 227-type transistorized voice-frequency amplifiers and their associated equipment. The repeaters have been designed primarily for use between 600- or 900-ohm central office equipment and H88 loaded exchange cable, 600-ohm equipment, or nonloaded cable by utilizing miniature repeating coils.

1.02 The description and operating principles of the 227-type amplifiers are covered in Section 332-104-101. The 1-type terminating sets, 359-type equalizers, 849-type networks, and various power supplies described later in this section, make up the associated equipment for the 24V4 and 44V4 repeaters. The various equipments have been designed as plug-in units to facilitate field maintenance, line-up and monitor procedures, and unit replacement as the demand for a particular circuit arrangement changes.

1.03 The V4 telephone repeater, which is adapted for present regulated 24- and 48-volt power plants eliminates the need for the 130-volt power supply required by the V1 and V3 repeaters. Miniature size coils replace the large 120 and 173 types for use as repeating coils and in 4-wire terminating sets.

2. 24V4 REPEATER

A. General

2.01 The 24V4 repeater is designed for use between 900- or 600-ohm 2-wire central office equipment or PBX installations, and H88 loaded exchange cable, nonloaded cable, or 600-ohm equipment. The 24V4 repeater consists of a mounting shelf which holds a 1-type terminating set, two 227-type amplifiers or 849-type networks, a 359-type equalizer, and includes a jack field and power supply arrangements. Fig. 1 shows the general circuit configuration of this repeater. Specific circuit arrangements possible for different line facilities are covered in Fig. 2 to 7 and are referred to in the following descriptions of the various pieces of apparatus composing the 24V4 repeater.

B. 1-type Terminating Set

2.02 The 1-type terminating set has been designed for use between 2-wire 900-ohm or 600-ohm office equipment and 4-wire loaded and nonloaded cable or the 4-wire terminals of intertoll facilities. The terminating set employs two 2578-type miniature transformers in place of the large 120-tvpe coils used in the terminating sets of SD-96463-01. Two 2578D transformers are used in the 1A terminating set, designed for use with 900-ohm central office equipment, and two 2578E transformers are used for the 600-ohm 1B terminating set. The functions and physical dimensions of the 1A and 1B terminating sets are identical, the important differences being the ratios of the transformers, the values of the compromise networks, and the AMPL and NO AMPL shunts on the 4-wire side of the terminating sets.

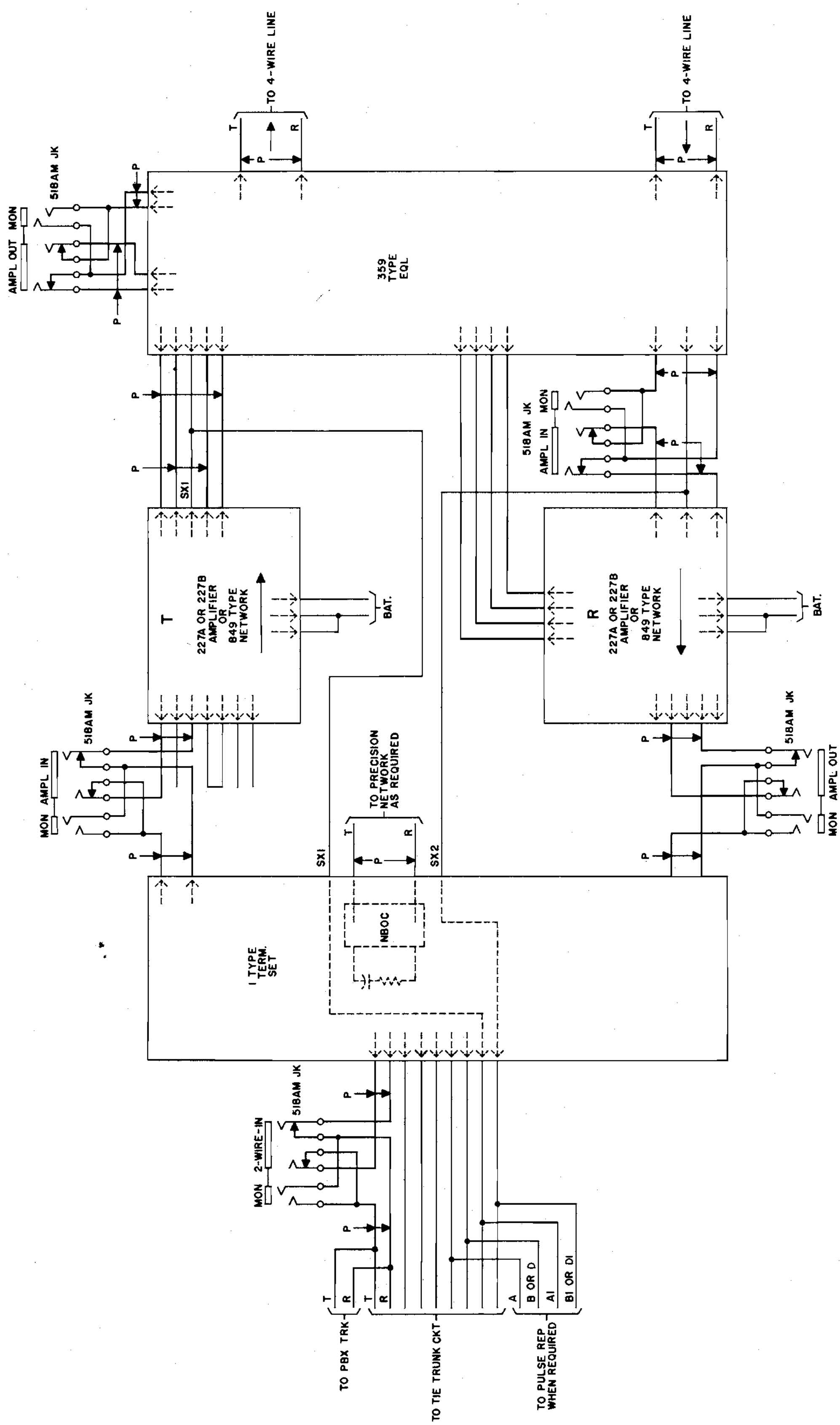

Fig. 1 — Block Diagram — 24V4 Repeater

2.03 As shown in Fig. 8 and 9, the current from the 2-wire office equipment or 2-wire line (terminals 12 and 13), flows through the 2-wire line windings of the two 2578-type coils. Because the balancing network winding of one coil is connected with reverse poling, with respect to the net winding of the other coil, the voltage is zero across the balancing network circuit and the incoming power divides equally between the transmitting and receiving line windings. One half of the power is dissipated in the receiving circuit and the remaining half passes to an amplifier or network in the transmitting circuit.

2.04 Power from the receiving side of the terminating set flows through the receiving windings and is equally divided between the office line windings and the network (line-balancing) windings. Because of the opposed poling of the two net windings, zero voltage is induced into the transmitting line. This ideal condition will occur only if the impedance of the network circuit matches the impedance of the office line equipment.

2.05 The network (line-balancing) circuit consists of a compromise network, a capacitor between the net windings, and a network building out capacitor (NBOC), variable from 0 to 0.1 μf in 0.001-μf steps, to balance the office cabling on the line side of the terminating set. The adjustments are of the screw-down type and are located on the faceplate of the terminating set. Terminals are also provided for a precision network when required. The capacitor placed between the net windings compensates for a dc blocking capacitor of equal value between the 2-wire line windings.

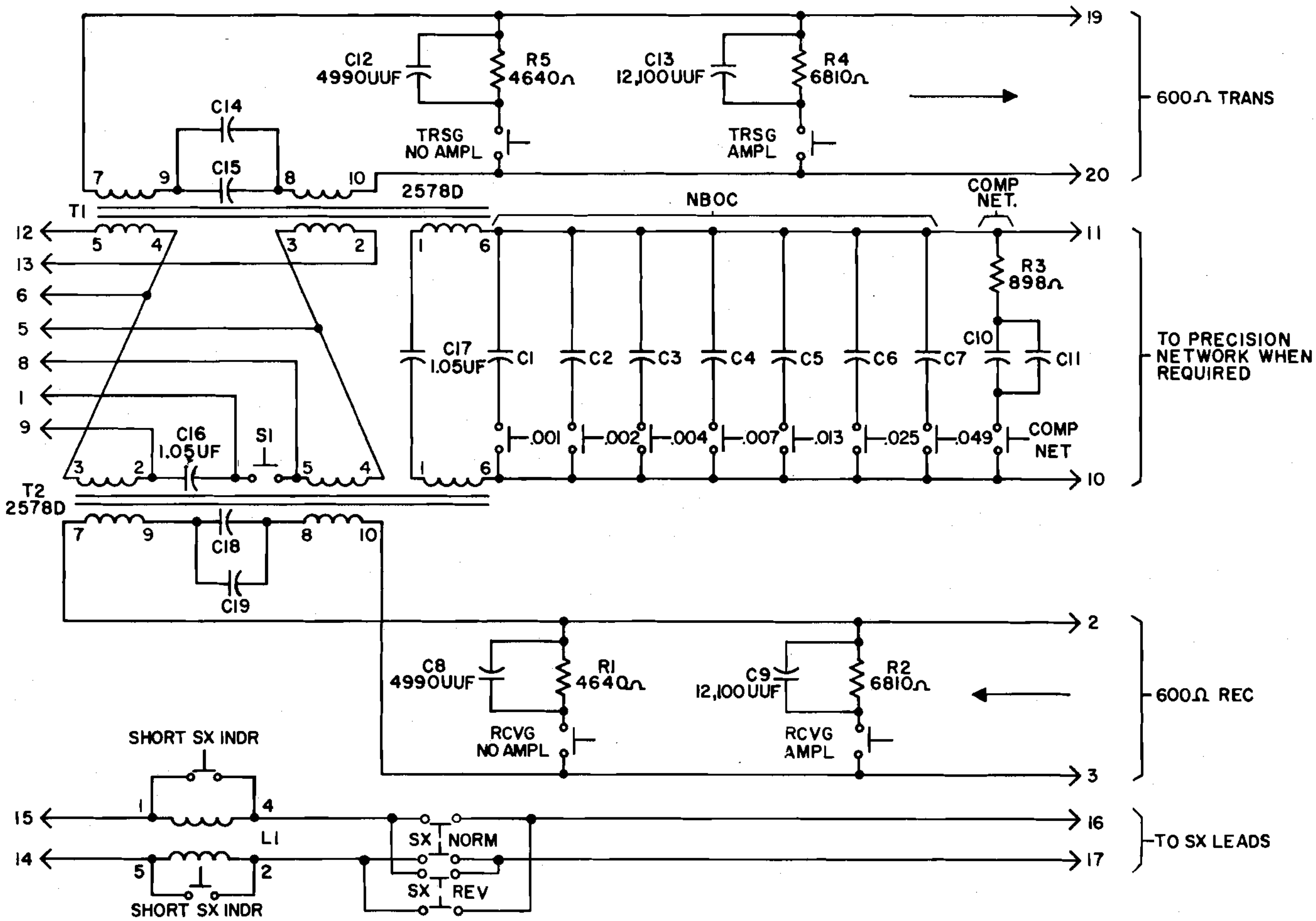

Fig. 8 — 1A Terminating Set for 900-ohm 2-wire Office Equipment

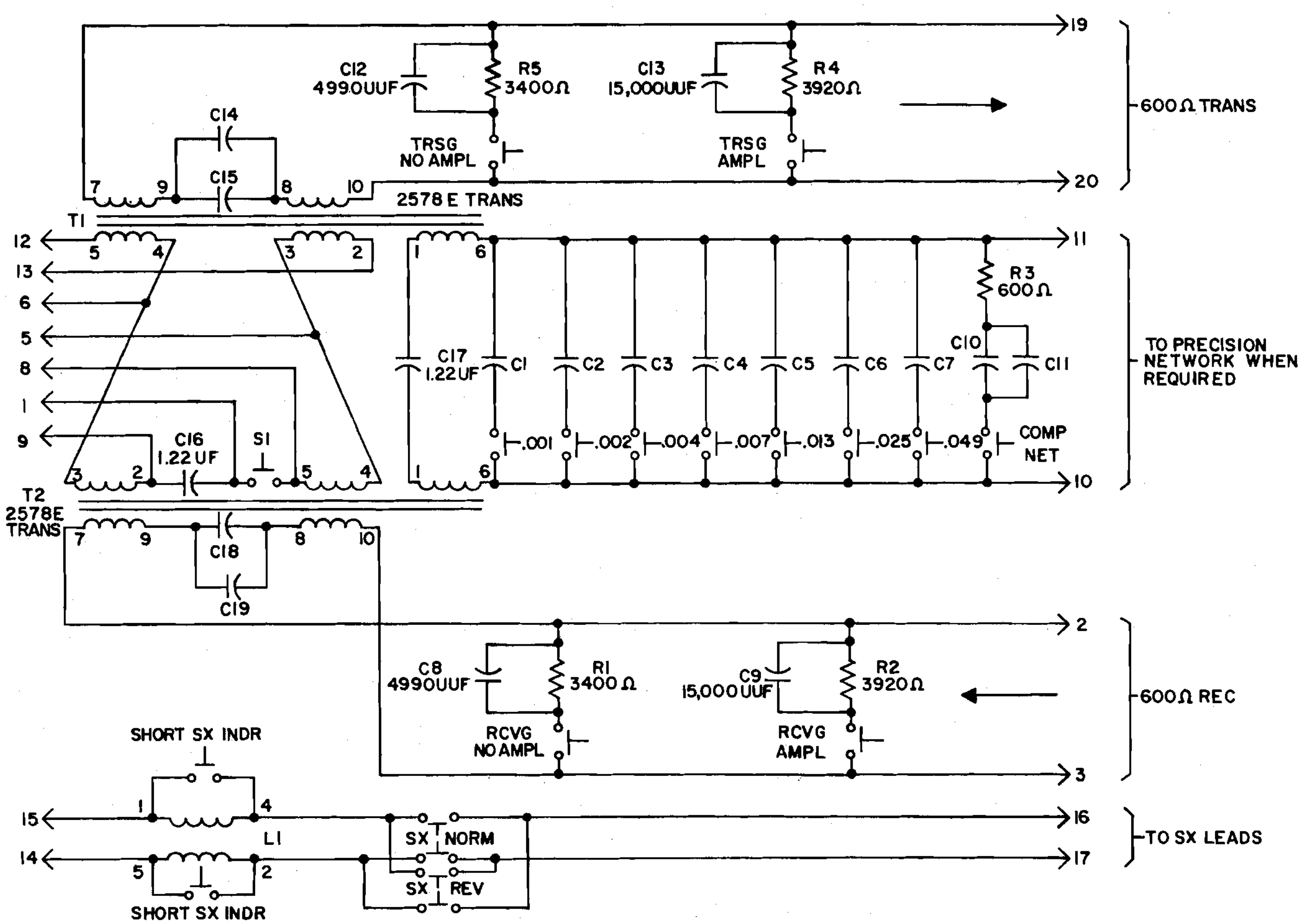

Fig. 9 – 1B Terminating Set for 600-ohm 2-wire Office Equipment

2.06 To make the impedance looking into the 2-wire side of the terminating set more nearly that of the ideal, 900 ohms in series with 2.16 μf or 600 ohms in series with 2.16 μf, two shunts each consisting of a resistor and capacitor in parallel are provided on the 4-wire transmitting and receiving sides. One shunt is used when 227-type amplifiers are employed and the other when 849-type networks are used. The components of the 4-wire shunts of the 1A 900-ohm terminating set, Fig. 8, differ in value from the components of the 1B 600-ohm terminating set 4-wire shunts, Fig. 9.

2.07 Fig. 10 and 11 show the return loss characteristics of the 1A and 1B terminating sets, respectively, with various lengths of 22-gauge nonloaded exchange area cable terminated in 600 ohms on the 4-wire sides. It will be noted that the return loss is degraded rapidly as the length of cable is increased beyond 1000 feet. Return loss limits for the highest class offices involving 2-wire switching are shown in heavy lines on the graphs.

2.08 Fig. 12 shows the return loss characteristics of the 1A and 1B terminating sets terminated with 227-type amplifiers. Both amplifiers used input pad and maximum feedback gain adjustments placing them in the minimum (0 to 13) gain range condition. Experiments have shown that for best return loss results, the receiving amplifier should use the maximum feedback condition (i.e., the top gain adjustment screw on the faceplate of the amplifier should be turned out and the input pad screws and po-

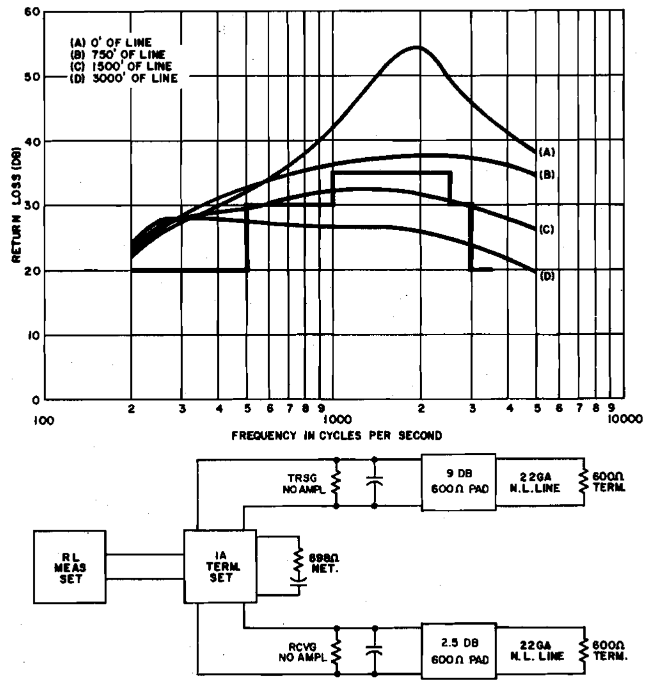

Fig. 10 – Return Loss versus Frequency — 1A Terminating Set (900 ohms)—Various Lengths of 22-gauge Nonloaded Line

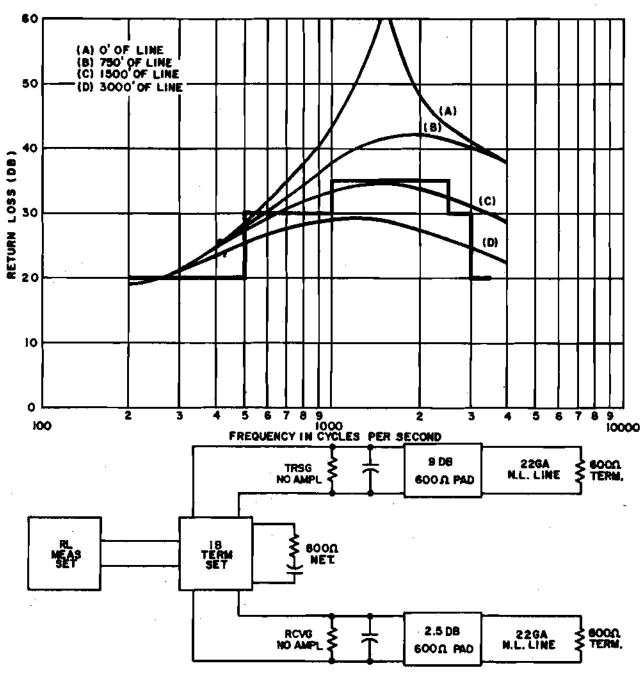

Fig. 11 – Return Loss versus Frequency — 1B Terminating Set (600 ohms)—Various Lengths of 22-gauge Nonloaded Line

tentiometer adjusted for the required gain); the transmitting amplifier should use the input pad adjustment [i.e., the middle adjustment screw turned in and the bottom screw turned out with the feedback screw (top) and the potentiometer adjusted for the required gain].

2.09 It has been assumed that when two terminating sets are switched together, the normal office wiring will contain 25-ohm series resistance. The 1A terminating set has been designed for an optimum return loss when balanced against 875 ohms in series with 2.14 μf. Likewise, the 1B terminating set was balanced against 575 ohms in series with 2.14 μf. The return losses shown were obtained with the terminating sets matched against these mentioned values. In actual practice the NBOC in the line balancing network may be adjusted to take care of any variation in cable capacitance in the office wiring.

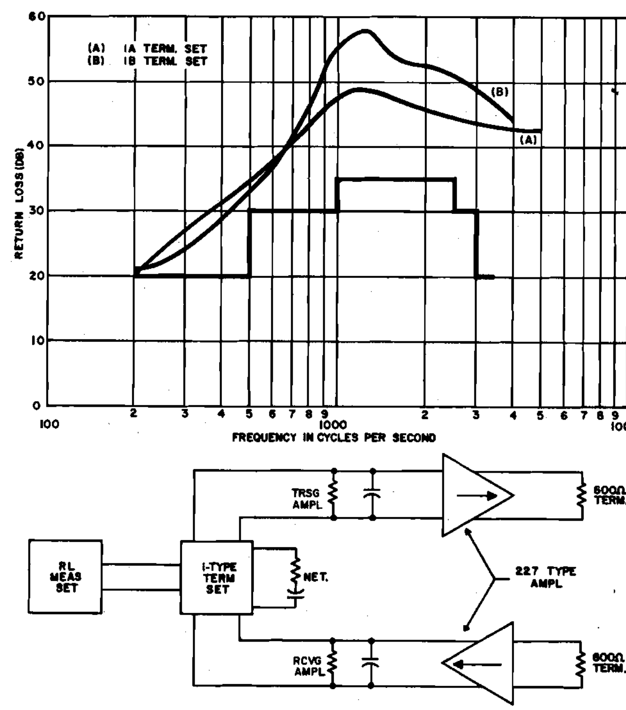

Fig. 12 – Return Loss versus Frequency — 1A and 1B Terminating Sets — 227-type Amplifier Termination

2.10 Typical 2-wire to 4-wire loss frequency characteristics of the terminating sets are shown in Fig. 13. A 900-ohm oscillator was used to supply the signal for the 1A curve, and a 600-ohm oscillator was used to obtain the 1B characteristic. These results were taken with the AMPL and NO AMPL shunts out of circuit. The 1000-cycle loss from 2-wire to 4-wire is approximately 3.3 db for the 1A set and 3.7-db loss for the 1B set. The NO AMPL shunt causes an increased over-all loss of approximately 0.5 db and 0.8 db, respectively, for the 1A and 1B terminating sets; the AMPL shunt increases the over-all loss approximately 0.4 db for the 1A set and approximately 0.7 db for the 1B terminating set.

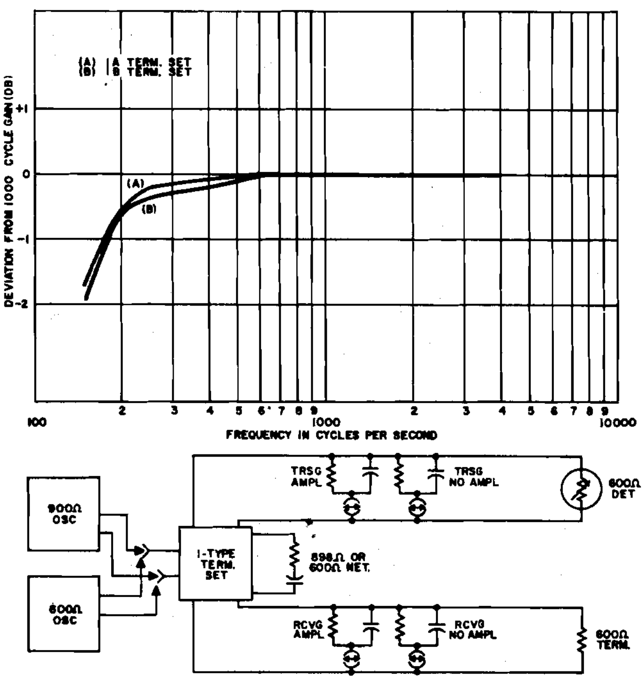

Fig. 13 – 1A and 1B Terminating Sets — 2-wire to 4-wire Frequency Characteristics

2.11 The 4-wire to 4-wire loss characteristics of the 1A and 1B terminating sets are shown in Fig. 14. The 2-wire and balancing network sides of the terminating sets were balanced in 898 ohms in series with 2.14 μf, and 600 ohms in series with 2.14 μf, respectively, for the 1A and 1B loss characteristics.

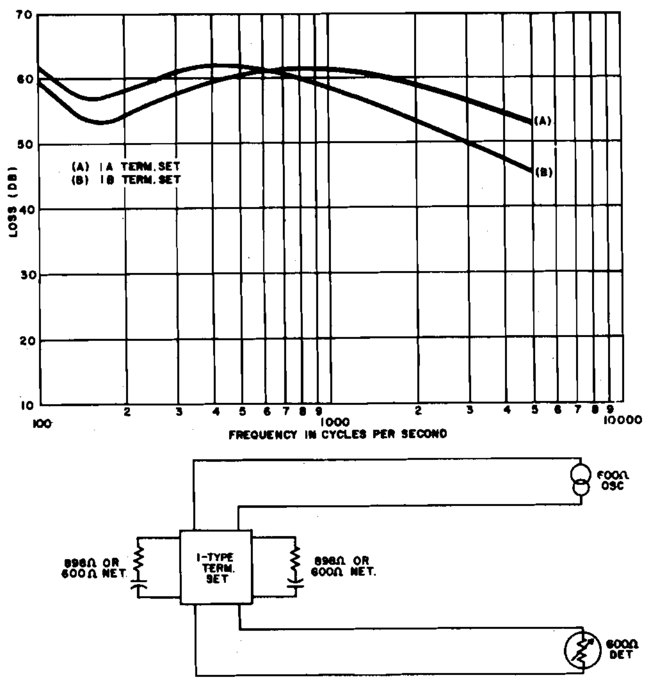

Fig. 14 – 1A and 1B Terminating Sets — 4-wire to 4-wire Loss

C. 227-type Amplifiers

2.12 The V4 telephone repeaters are primarily made up of two one-way transistorized 227-type amplifiers which are described in Section 332-104-101. Possible 2- to 4-wire repeater circuit arrangements employing the 227-type amplifiers are shown in Fig. 2 to 5.

D. 849-type Networks

2.13 *General:* Fig. 5, 6, and 7 show the application of the 849-type networks designed for use in place of the 227-type amplifiers when gain is not required. The networks can be plugged directly into the amplifier shelf-mounted sockets. The network consists of a 2543J 600:1200-ohm ratio transformer, a 600-ohm pad, and a plug-in 89-type resistor. By choosing the proper 89-type resistor, the receiving side of the circuit may be set to the required net loss. Likewise, by using the appropriate 89-type resistor on the transmitting side, the outgoing circuit level may be set to the desired value.

2.14 ***The 849A Network:*** The 849A network as shown in Fig. 5, 6, and 7 is used on the transmitting side of the terminal repeater when gain is not required. The 849A network consists of a 600-ohm pad, an 89-type resistor, and a 2543J 600:1200-ohm transformer for matching the nominal 600-ohm impedance of the 1-type terminating set, 4-wire side, to the H88 loaded exchange cable. Simplex provisions are included.

2.15 ***The 849B Network:*** The 849B network, see Fig. 6 and 7, is essentially the same as the 849A network, but is designed for use with or without H88 loaded exchange cable equalization on the receiving 4-wire side of the 1-type terminating set. Receiving level adjustment is obtained through a balanced 600-ohm pad and plug-in 89-type resistors. Simplex signaling provisions are supplied.

E. 359-type Equalizer for 24V4 Repeater

2.16 ***General***

(a) Fig. 1 and 15 show the circuit and shelf locations of the 359-type equalizer when used with the various arrangements of the 24V4 repeater. Table A shows features of the various equalizers and the conditions of the circuits in which they are used.

(b) As noted in Table A, the 359A and 359D equalizers are used on H88 loaded cable when equalization is needed. The 359B, C, and E equalizers are employed for nonloaded cable, 600-ohm circuits, and short lengths of loaded cable, respectively, as shown in Fig. 3, 4, 5, and 7. These latter equalizers do not contain actual equalizer elements but do contain strap-through or repeating-coil features as described later in this section.

(c) All equalizers contain strapping for the 518AM AMPL IN, MON and AMPL OUT, MON jacks and simplex facilities. The shelf-mounted equalizer receptacles are wired to accept the various 359-type equalizers. The necessary wiring changes required to satisfy the different circuit demands are incorporated within the respective plug-in equalizers.

2.17 ***359A Equalizer***

(a) The 359A equalizer, shown in Fig. 2, is used on the line side of the terminal repeater when gain and equalization is required

TABLE A

EQUALIZER	CABLE	EQUALIZATION REQUIRED	IMPEDANCE CONDITION	EQUALIZER FEATURES
359A	Loaded	Rcvg Ampl	1200-ohm Amplifiers	Strap thru for xmtg ampl Eql for rcvg ampl
359B	Nonloaded	None	600-ohm Amplifiers	600:150-ohm coils for xmtg and rcvg amplifiers
359C	600 ohm	None	600-ohm Amplifiers	Strap thru for xmtg and rcvg amplifiers
359D	Loaded	Rcvg Net.	1200-ohm Networks	Strap thru for xmtg net. Eql for rcvg net.
359E	Loaded	None	1200-ohm Net. and Ampl	Strap thru for xmtg net. and rcvg ampl
			1200-ohm Networks	Strap thru for xmtg and rcvg networks

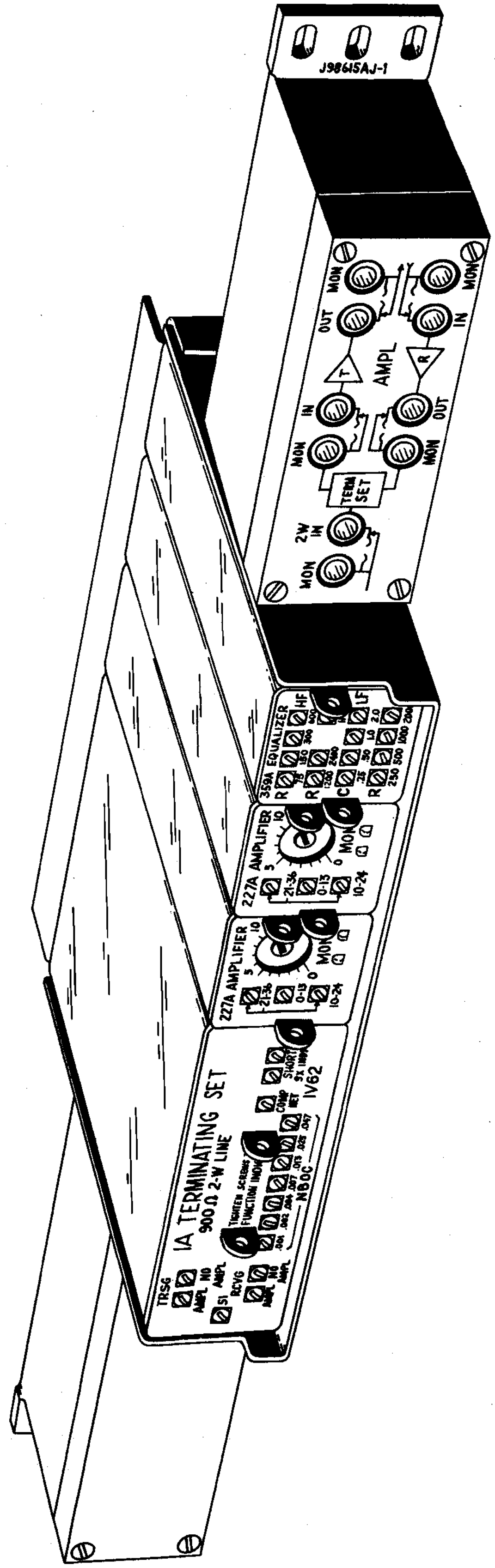

Fig. 15 – 24V4 Repeater

for H88 loaded exchange cable. The transmitting amplifier section of the equalizer has a strap-through feature with connections for the 518AM AMPL OUT, MON jack. The receiving section contains the actual equalizer components for equalization of the H88 loaded line.

(b) This receiving section of the equalizer, which is electrically wired into the receiving amplifier circuit, contains a low-frequency and a high-frequency section separated by an impedance improving T pad which reduces interaction between the high- and low-frequency sections. The general circuit configuration may be seen in Fig. 16.

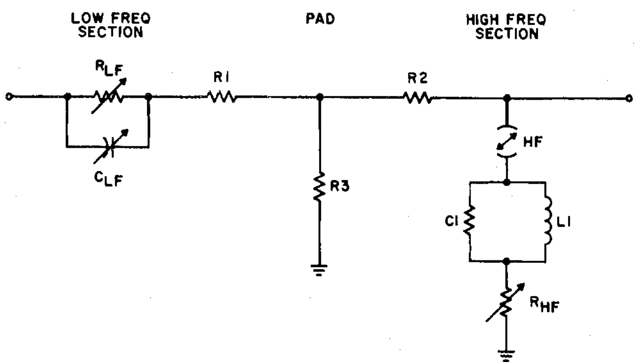

Fig. 16 – General Configuration of the 359A Equalizer

(c) R_{LF} and C_{LF} make up the low-frequency section; L1, C1, and R_{HF} make up the high-frequency section; and R1, R2, and R3 make up the impedance improving T pad between the high- and low-frequency sections.

(d) The series low-frequency components, R_{LF} and C_{LF}, influence the shape of the characteristic curve of the amplifier and line at frequencies up to approximately 1000 cycles. Fig. 17 shows the result of keeping C_{LF} constant and varying R_{LF}, with the high-frequency section out of circuit. Likewise, varying C_{LF} and keeping R_{LF} constant gives the results shown in Fig. 18, with the high-frequency section of the equalizer out of circuit. For any setting of the low-frequency equalizer likely to be encountered, the loss at 1000 cycles and above should be relatively small.

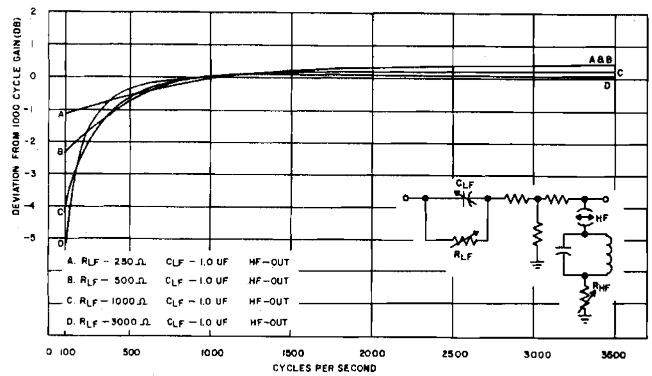

Fig. 17 – 359A Equalizer — Effects of Varying R_{LF} and Keeping C_{LF} Constant (1.0 μf), with the HF Section Out of Circuit

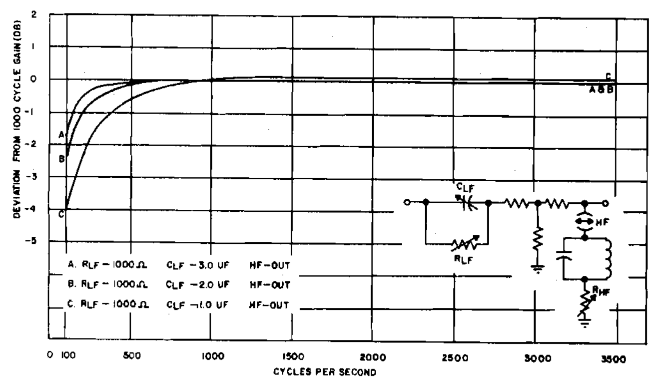

Fig. 18 – 359A Equalizer — Effects of Varying C_{LF} and Keeping R_{LF} Constant (1000 ohms), with the HF Section Out of Circuit

(e) The components L1 and C1 form a sharply tuned circuit which has a low loss at a predetermined frequency just above 3000 cycles, but inserts loss below and above that frequency. The action of the equalizer is as follows: At low frequencies, the reactance of the inductor is fairly low, so that the equalizer acts substantially as a resistance shunted across the circuit and the equalizer introduces relatively large losses at these frequencies. At higher frequencies, the reactance of the inductor becomes greater, so that the loss introduced by the equalizer is decreased. At still higher frequencies, the inductor and capacitor approach resonance in which case their parallel impedance is very high, and the equalizer introduces very little loss in the through-circuit. Above this tuned frequency, the loss of the equalizer increases again as the reactance of the capacitor becomes less. The effects of varying R_{LF} with the low-frequency section of the equalizer shorted out is shown in Fig. 19.

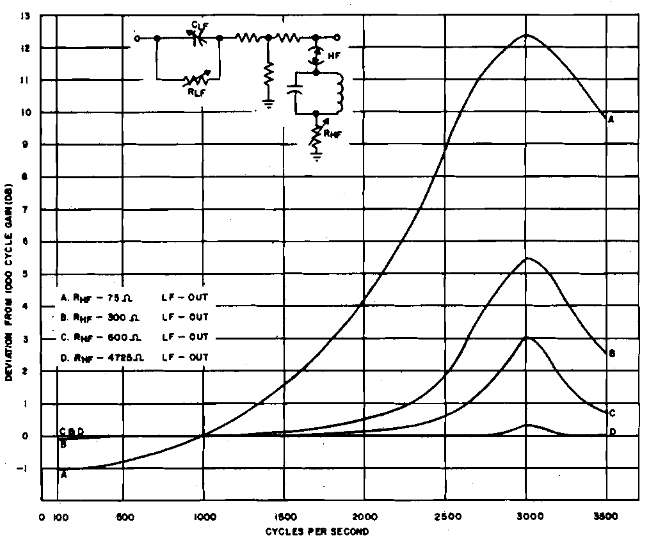

Fig. 19 — 359A Equalizer — Effects of Varying R_{HF} with the LF Section Out of Circuit

(f) A 600-ohm impedance T pad, consisting of resistors R1, R2, and R3, is inserted between the high- and low-frequency equalizer components to minimize interaction between the two sections. This T pad has a nominal loss of 6 db.

(g) Observations of the characteristics of maximum lengths of 19-, 22-, and 24-gauge H88 cable show that the equalizer must be able to compensate for a line loss of 6 db less at 200 cycles than at 1000 cycles, and 4 db more at 3000 cycles. Therefore, a 1000-cycle signal introduced into an amplifier set at its nominal maximum gain of 36 db, equipped with a 359A equalizer will be amplified approximately 26 db by the equalizer-amplifier combination.

(h) Fig. 20 shows a comparison of characteristic curves resulting from sending a 1000-cycle signal through a 22-gauge H88 loaded line and a 227B amplifier with different 359A equalizer settings. Curve A is the characteristic, referred to 1000 cycles, of 72,000 feet of 22-gauge H88 cable and a 227B amplifier in the medium-gain-range condition with maximum feedback. Curves B, C, and D show characteristics of the same length line and amplifier with various settings of the 359A equalizer. Curve B is the most desirable curve while curves C and D show results of two less desirable combinations of C_{LF}, R_{LF}, and R_{HF}.

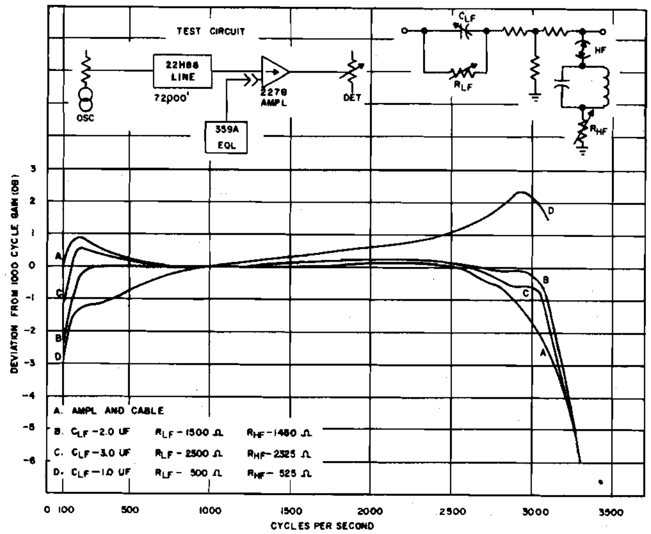

Fig. 20 — 359A Equalizer Characteristics

2.18 ***359B Equalizer:*** The 359B equalizer is used when connecting the 4-wire side of the terminating set to nonloaded lines. As shown in Fig. 3, the 227-type amplifiers are in the 600-ohm condition. The transmitting side of the equalizer is a strap-through feature with a 2543K miniature 600:150-ohm ratio transformer to match the amplifier output to the nonloaded line. The receiving half of the equalizer also is a 2543K transformer to match the nonloaded line to the 600-ohm amplifier input. By this expedient of effectively terminating the nonloaded lines in 150 ohms, the transmission frequency characteristic of the length of cable anticipated will be relatively flat, so that no further equalization should be necessary.

2.19 ***359C Equalizer:*** Fig. 4 shows the 359C equalizer which has been arranged for use in 600-ohm circuits where gain is required, but equalization is not required. The amplifiers on the 4-wire side of the 1-type terminating set are in the 600-ohm condition and require only strap-through arrangements to the 600-ohm line.

2.20 ***359D Equalizer***

(a) The 359D equalizer is employed when gain is not required, but equalization on the receiving side and transmitting and receiving level control is necessary. The 359D equalizer is used on the 4-wire side of the terminating set with the 849-type network and loaded exchange cable. The transmitting half of the equalizer has a strap-through feature for the transmission path and the usual connections available for the 518AM jack and simplex signaling. The receiving section of the 359D equalizer offers equalization for the loaded cable in the same manner as the 359A equalizer, and is used in conjunction with the 849B network, as shown in Fig. 6.

(b) The 359D equalizer contains the same equalizing components as does the 359A equalizer except that the fixed T pad inserted between the low- and high-frequency sections of the 359A equalizer is omitted. The 600-ohm plug-type pad located in the 849B network is used to eliminate the interaction between the high- and low-frequency sections of the equalizer. The self-mounted equalizer and amplifier-network receptacles are wired in such a manner as to place the pad electrically between the high- and low-frequency sections of the 359D equalizer.

(c) The over-all characteristics of the 359A and 359D equalizers are the same, but a desired net loss level of the circuit may be obtained with the 359D equalizer by inserting the necessary value of an 89-type resistor into the 6-prong socket mounted on the faceplate of the 849B network can.

2.21 ***359E Equalizer:*** The 359E equalizer is used with short lengths of H88 loaded exchange cable, when no equalization is needed and gain may or may not be necessary. Fig. 5 shows one example where transmission gain is not needed but receiving gain is needed. Fig. 7 shows a condition that does not require gain or equalization, but transmitting and receiving level control is accomplished by using two 849-type networks with plug-in 89-type resistors on the 4-wire side of the 1-type terminating set.

3. 44V4 REPEATER

3.01 The general circuit arrangement for the 44V4 repeater is shown in Fig. 21. The repeater can be placed between two lengths of loaded cable, nonloaded cable, 600-ohm lines, or between a length of loaded and a length of nonloaded cable. Examples of these conditions may be seen in Fig. 22 to 26.

3.02 The 44V4 repeater consists of two 227-type amplifiers, two 359-type equalizers, and a jack field. The mounting shelf which accommodates two complete repeaters may be wired to accept any combination of amplifier, equalizer, and power-supply arrangements necessary for a particular circuit. Physical positioning of the amplifiers and equalizers is shown in Fig. 27.

3.03 Description and operating principles of the 227-type amplifiers are covered in Section 332-104-101. The description of the 359-type equalizer covered in Part E for the 24V4 repeater may be applied to the equalizers used in the 44VA repeater.

4. EQUIPMENT

4.01 The equipment composing the V4 telephone repeater has been designed as plug-in type apparatus to facilitate fast initial installation or rearrangement as the demand for service may require. This equipment mounts on one of two 1-3/4 inch by 23-inch repeater shelves. The J98615AJ shelf contains one 24V4 repeater complete with associated jack field, and the J98615AH shelf houses two 44V4 repeaters and two associated jack fields.

4.02 The receptacles are wired to accept any one of various repeater elements. For example, if a circuit requirement in question changes from a 4-wire loaded cable to a 4-wire nonloaded cable, the 359A equalizer used for the loaded cable may be directly replaced by a 359B equalizer designed for use with nonloaded cable. The 602C tool designed to remove the J68647 (V3) amplifier from its socket is satisfactory for use in removing the V4 units.

4.03 Because of the convenient positioning of the adjusting screws and jack fields, as shown in Fig. 15 and 27, testing and alignment

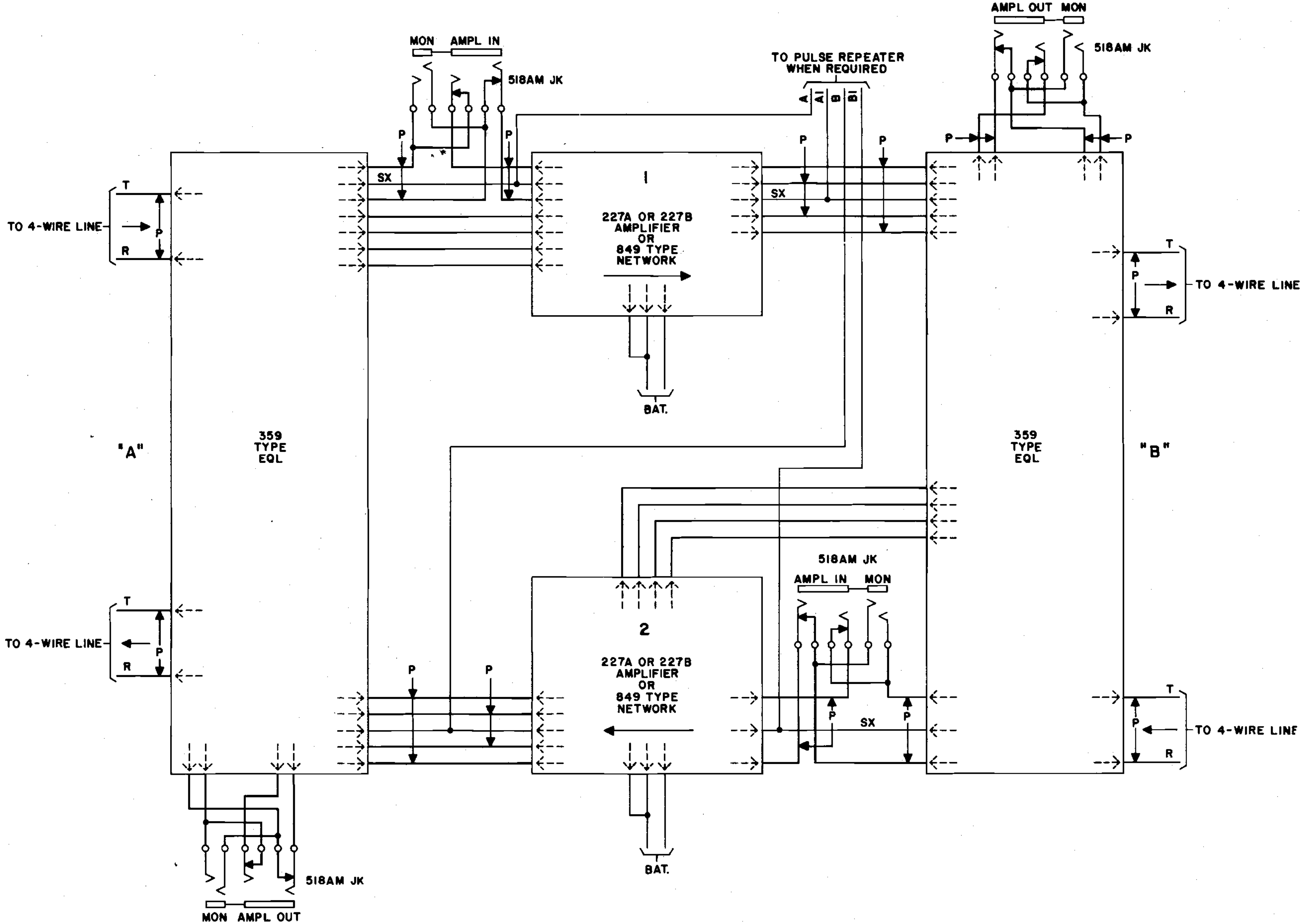

Fig. 21 – Block Diagram — 44V4 Repeater

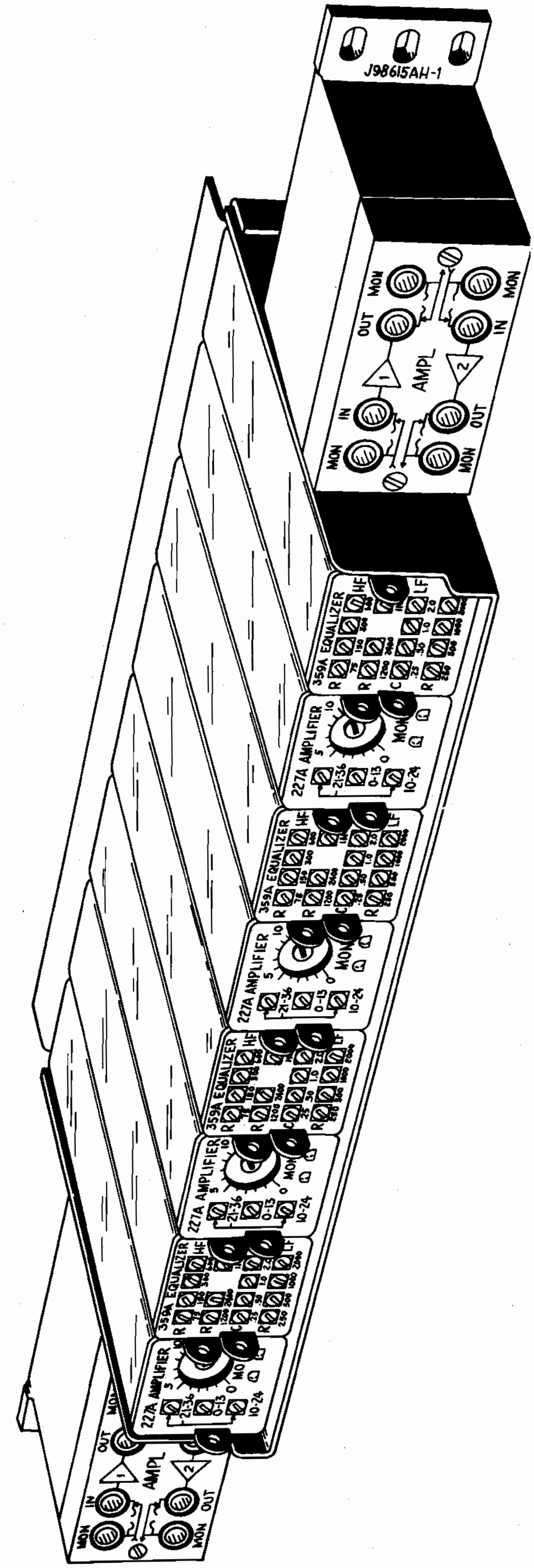

Fig. 27 — Two 44V4 Repeaters

procedures per Section 332-104-500 may be accomplished with the repeater elements plugged into the circuit.

4.04 The 24V4 repeater shelf contains one complete repeater. The 1-type terminating set is packaged in an extruded aluminum can 5-1/4 inches by 1-5/8 inches by 6-5/8 inches and plugs into a 20-pin connector. Adjusting screws with identifying designations are located on the faceplate of the terminating set.

4.05 Either a 227-type amplifier or an 849-type network may be plugged into each of the 15-pin connectors adjacent to the terminating-set receptacle. The network and amplifier are each contained in a 1-5/8 inch by 1-5/8 inch by 6-5/8 inch extruded aluminum can. Screw-type gain adjustments are provided on the amplifier faceplate while level adjustments of the network are made by changing the plug-in 89-type resistor mounted on the faceplate of the network package.

4.06 The 359-type equalizer is packaged in the same size aluminum can as that used for the amplifier, and plugs into a 20-pin shelf-mounted connector. Adjustments are also accomplished with faceplate mounted screws.

4.07 Ten 518AM jacks make up the jack fields used with the 24V4 repeater. The designations, and locations in the circuit are molded on the faceplate of the jack field to ensure correct usage when testing and adjusting the repeater.

4.08 The 44V4 repeater shelf houses two complete repeaters each of which is made up of two amplifiers, two equalizers, and two jack fields. The amplifiers and equalizers plug into the same type connectors as those used in the 24V4 repeater. The faceplates of these jack fields also show the jack designations and locations.

5. BATTERY SUPPLY ARRANGEMENTS FOR THE V4 TELEPHONE REPEATER

5.01 The 227-type amplifier operates from present 24-volt regulated power plants, or it may be operated from a 48-volt regulated battery by placing a 1400-ohm resistor in series with the power-supply lead. This resistor also acts as a satisfactory battery noise filter as described in Sections 332-104-501 and 332-104-101.

5.02 When the amplifier is operated from the 24-volt regulated battery, an external battery noise filter is necessary. A simple inductance-capacitance filter is used for a shelf of 1 to 12 amplifiers, and a decentralized filter is employed for up to a nominal one-half bay of amplifiers or from 12 to 240 amplifiers.

5.03 In the maximum-gain condition, the 227-type amplifier draws 18 milliamperes of current.

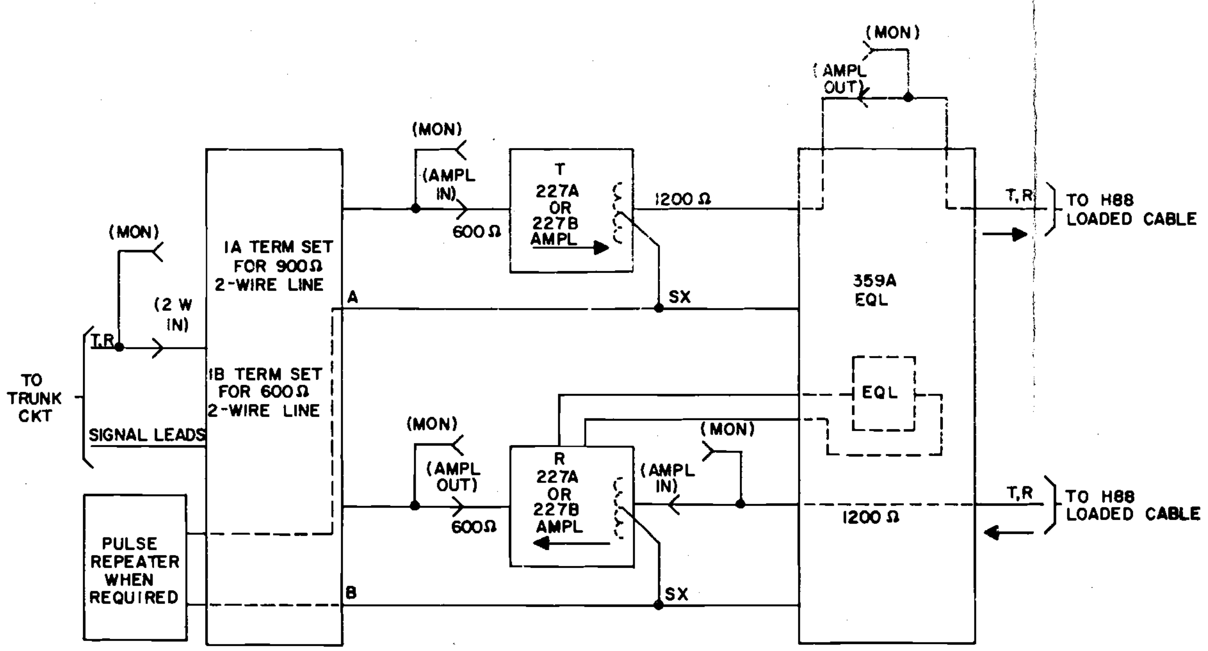

Fig. 2 – 24V4 Repeater Arranged for H88 Loaded Cable Requiring Gain, Equalization, and Loop Signaling

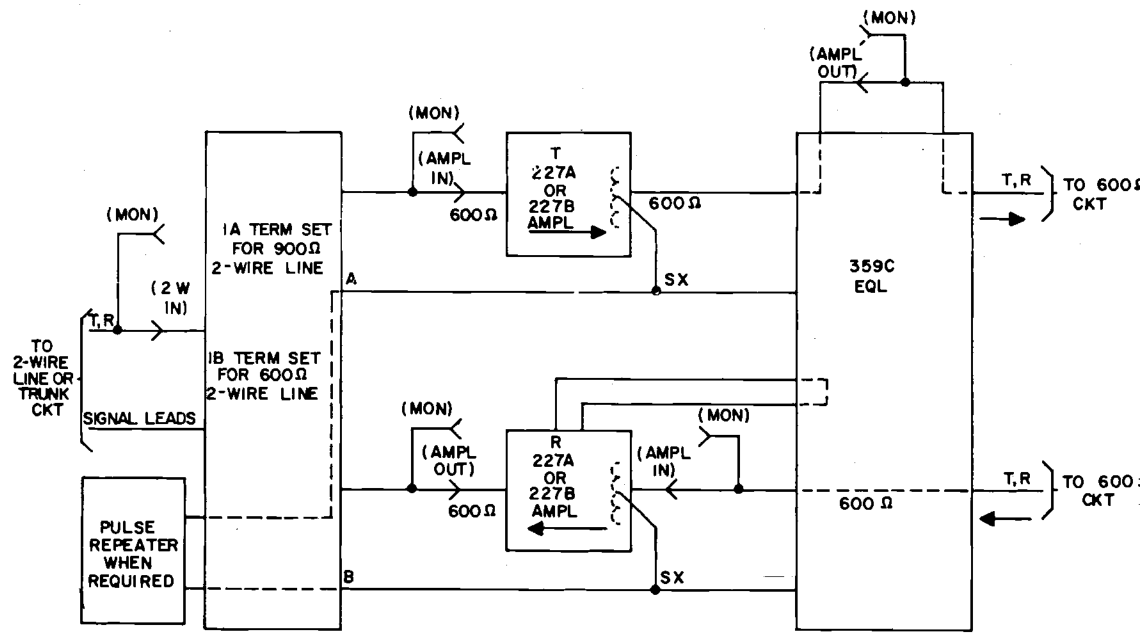

Fig. 4 – 24V4 Repeater Arranged for 600-ohm Circuits Requiring Gain and Loop Signaling

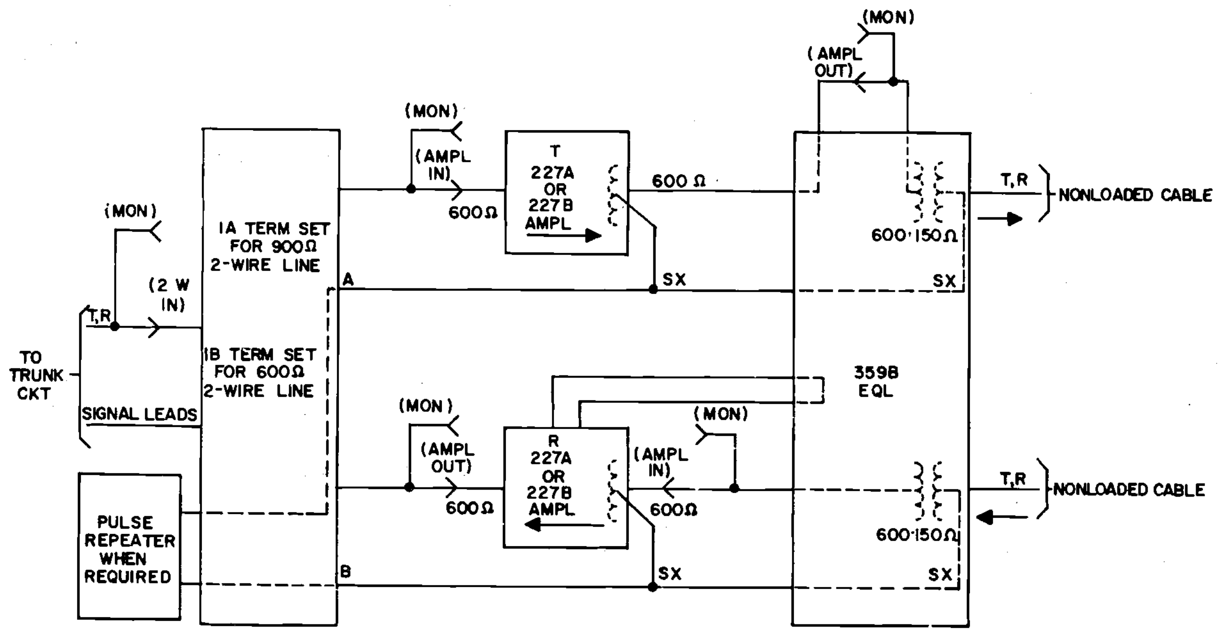

Fig. 3 – 24V4 Repeater Arranged for Nonloaded Cable Requiring Gain and Loop Signaling

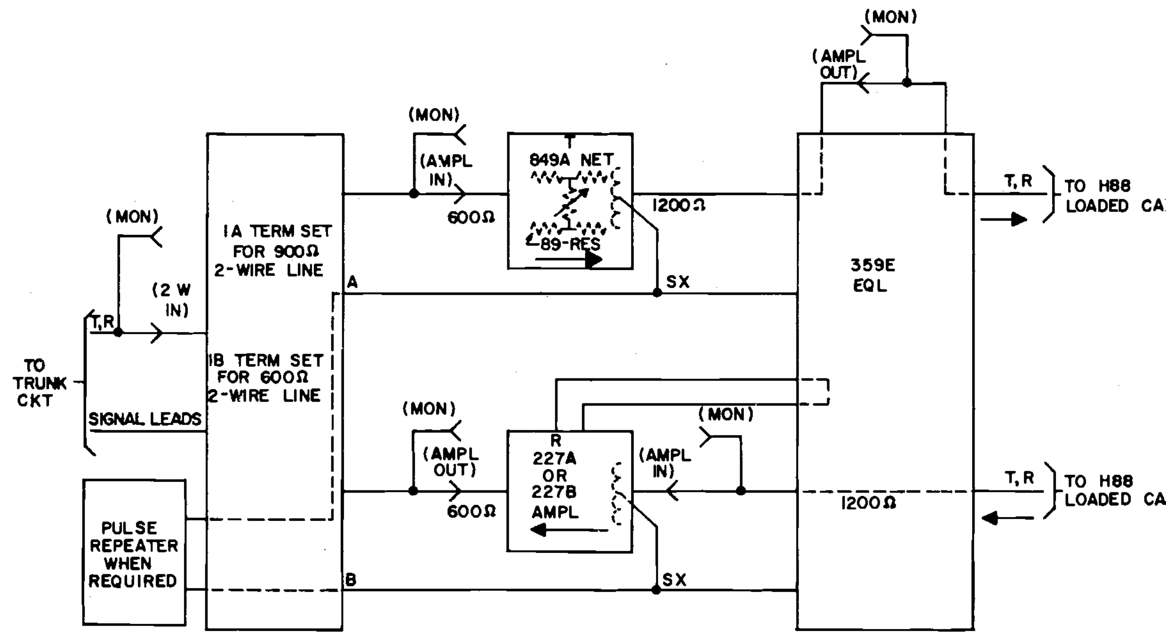

Fig. 5 – 24V4 Repeater Arranged for H88 Loaded Cable Requiring No Transmitting Gain, but Equipped with Receiving Gain and Loop Signaling

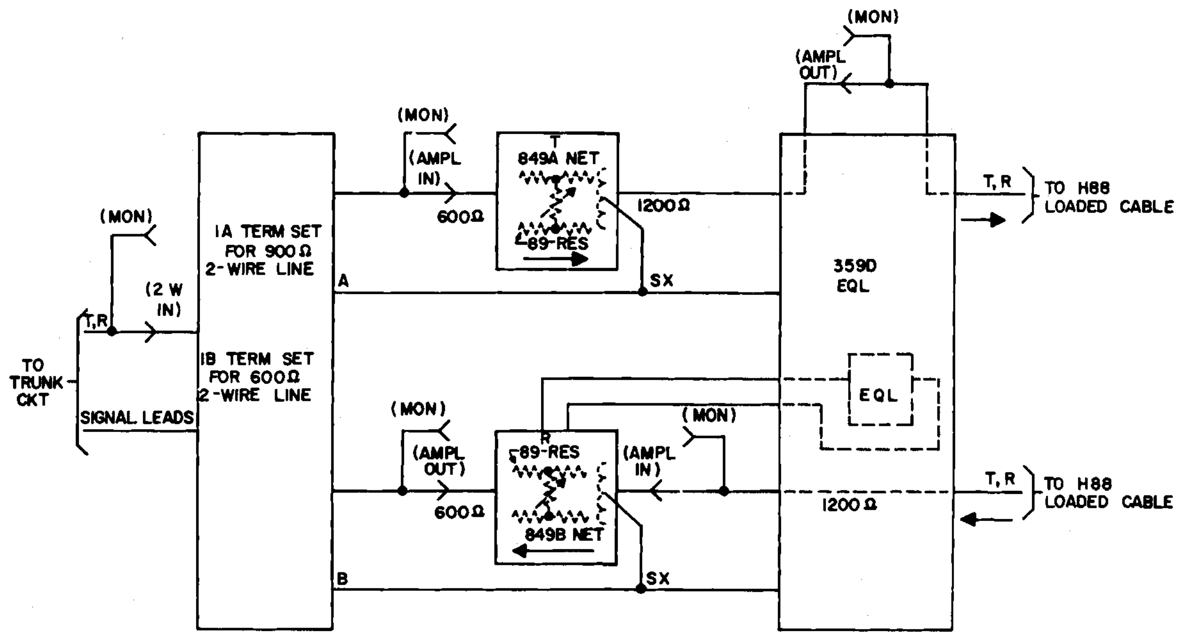

Fig. 6 – 24V4 Repeater Arranged for H88 Loaded Cable Where Gain is Not Required, but Transmitting Level Control, Receiving Level Control and Equalization, and Loop Signaling is Supplied

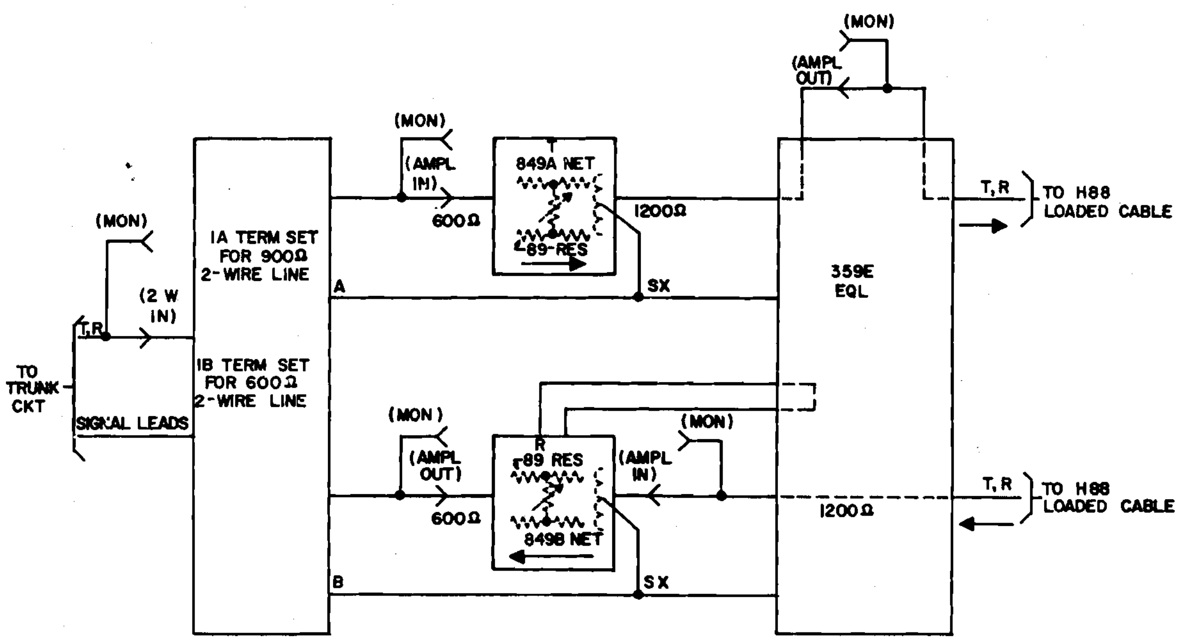

Fig. 7 – 24V4 Repeater Arranged for H88 Loaded Cable Where Gain is Not Required, but Transmitting and Receiving Level Adjustment and Loop

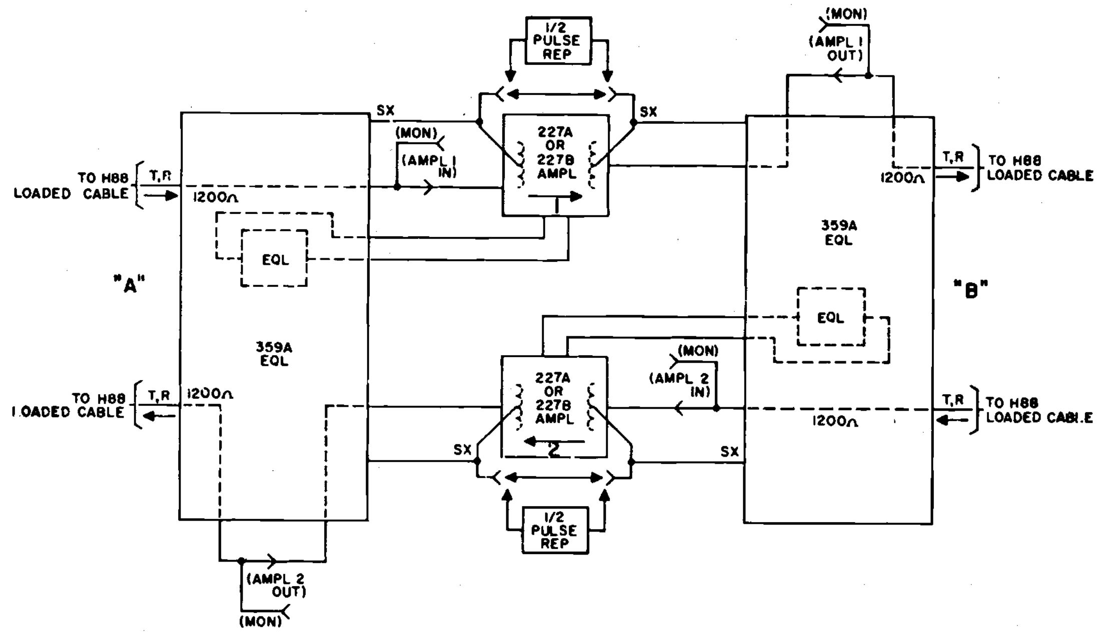

Fig. 22 – 44V4 Repeater Plug-in Units Arranged for H88 Loaded Cable Requiring Gain, Equalization, and Simplex Signaling

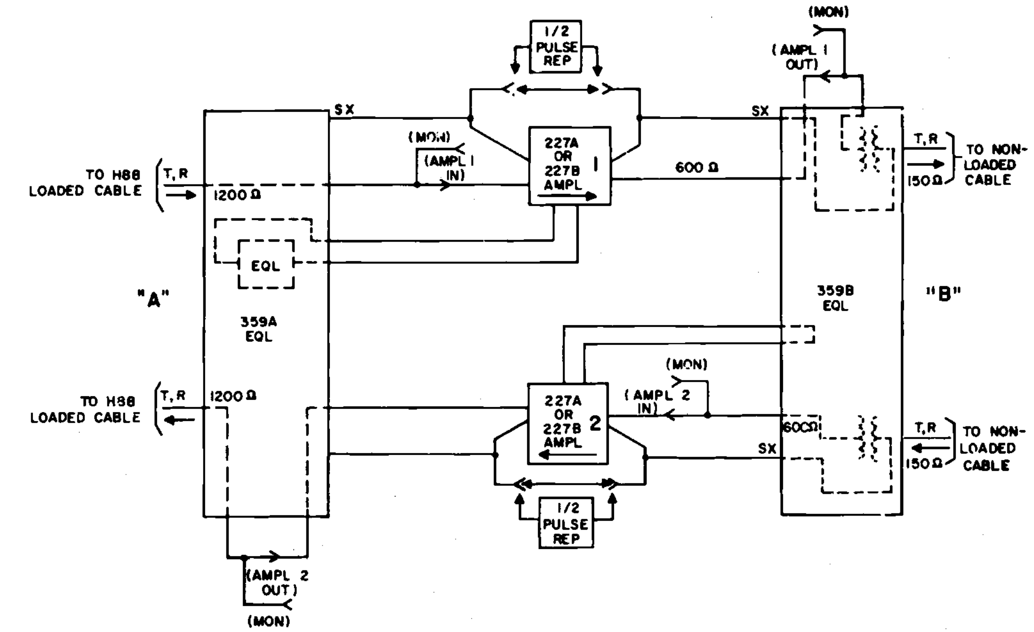

Fig. 24 – 44V4 Repeater Plug-in Units Arranged for Nonloaded Cable on "B" Side and H88 Loaded Cable on "A" Side with Gain, Equalization, and Simplex Signaling

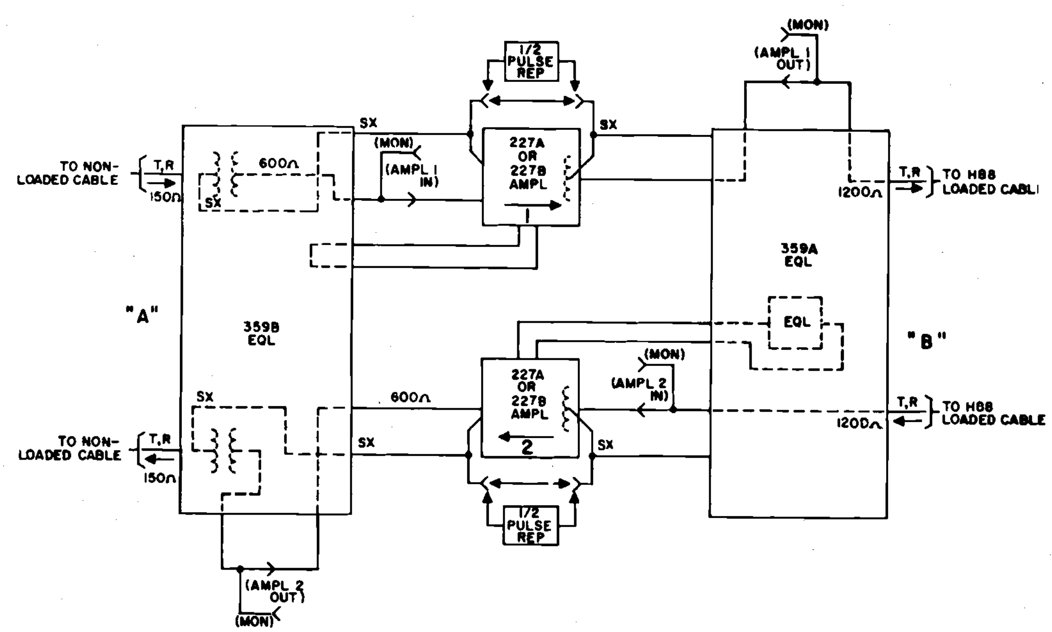

Fig. 23 – 44V4 Repeater Plug-in Units Arranged for Nonloaded Cable on "A" Side and H88 Loaded Cable on "B" Side with Gain, Equalization, and Simplex Signaling

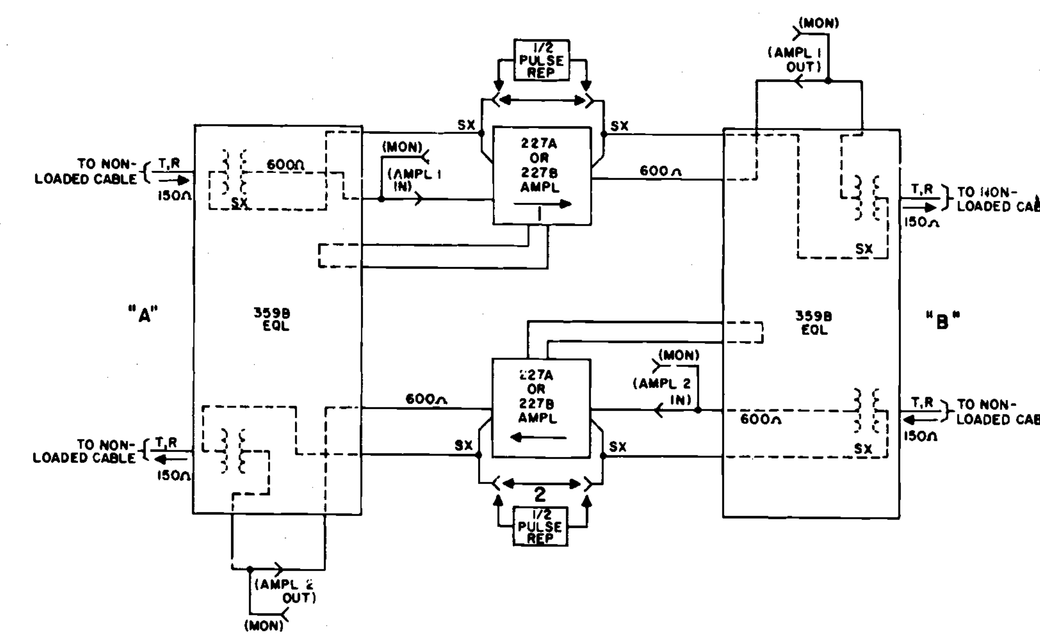

Fig. 25 – 44V4 Repeater Plug-in Units Arranged for Nonloaded Cable Requiring Gain, Equalization, and Simplex Signaling

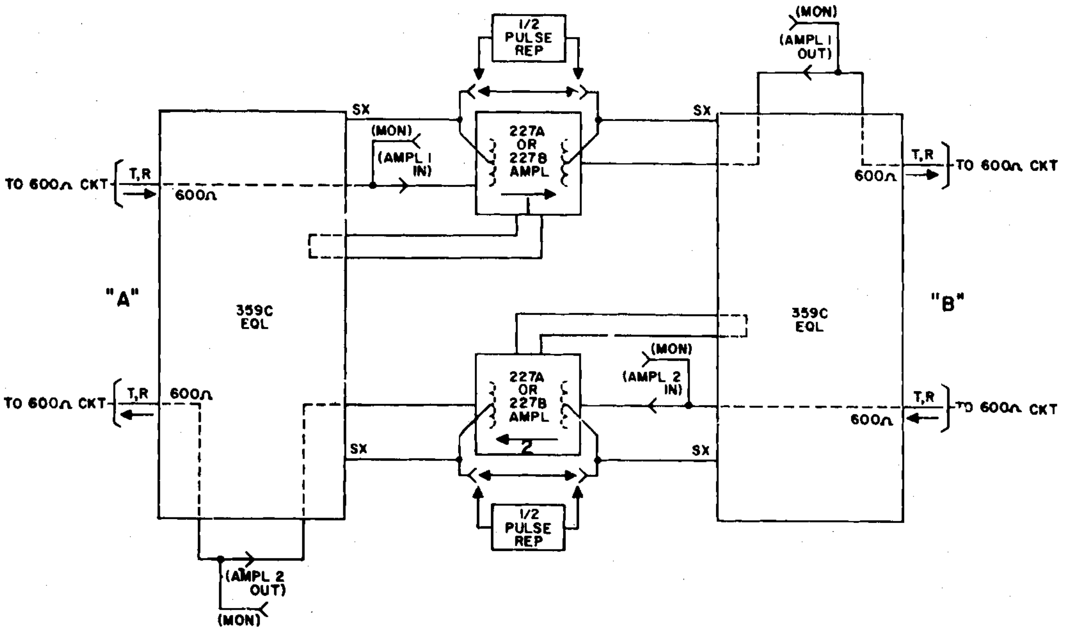

Fig. 26 – 44V4 Repeater Plug-in Units Arranged for 600-ohm Circuits with Gain and Simplex Signaling