V4 TELEPHONE REPEATERS

ENGINEERING

GENERAL

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1. INTRODUCTION

1.01 This section and the associated point sections listed above cover the engineering of V4 repeaters in voice-frequency circuits for message and data service.

1.02 The V4 repeaters are primarily parts of 4-wire circuits or of combination 4-wire and 2-wire circuits. They were not designed for use as 2-wire repeaters. Figures 1, 2, and 3 show the three general types of V4 repeaters: the Basic V4, the 24V4, and the 44V4. In general, a V4 repeater includes a mounting shelf (or part of one), plug-in components, and test jacks.

1.03 With V4 repeaters, it is usually practicable to achieve circuits of low net loss, high return loss, and good frequency response. The V4s do not degrade signaling in the voiceband, but they do impose some restrictions upon the ranges of dc signaling and pulsing, as earlier types of repeaters do.

1.04 The Basic V4 repeater was produced as an interim arrangement to permit the early use of 227-type amplifiers while the 24V4 and 44V4 were being developed. As requirements dictate, it may be used with or without other equipment to provide terminal or intermediate amplification for a 4-wire section. Test jacks for repeaters are provided centrally in each bay.

1.05 The 24V4 and 44V4 repeaters were developed to permit grouping together all the VF transmission equipment needed for each circuit in a given office. The 24V4 is used at a 2-wire switching terminal of a 4-wire circuit, or at a junction of the 2-wire and 4-wire portions of a circuit. The 4-wire portion may be carrier or voice-frequency. The 44V4 is used at an intermediate point in a 4-wire circuit. Sometimes this may be at a junction between the VF side of a carrier system and 4-wire VF facilities.

1.06 The 24V4 and 44V4 repeaters offer several advantages over earlier types of repeaters:

(a) They are easily set up for their initial assignment and just as easily rearranged for subsequent assignments.

(b) They obviate many cross-connections formerly required and thus promote office engineering and quick installation. A compromise network is built into the terminating set.

(c) Being designed primarily for only one loading system or for nonloaded facilities, they surpass earlier equipment in transmission performance.

(d) They cost less than earlier equipment and take less space.

(e) They require only one type of power: 48 volts or 24 volts.

(f) They permit use of "prescription design," which is the complete specification of plug-in units and their settings by the circuit-layout forces. The central office forces need only plug in the units specified in the circuit-layout information, set the screw-type switches as called for, and adjust amplifier gains. There is no need for them to use the time-consuming cut-and-try procedure often required with earlier equipment. Even with prescription design, however, some touch-up in repeater adjustments may be necessary during the final line-up of the overall circuit, particularly where circuit tolerances are small.

(g) Test jacks located on the same shelf with each repeater minimize chances of plugging test cords into the wrong jacks and, once the cords are plugged in, practically eliminate the chance of adjusting the wrong repeater.

2. FIELDS OF USE

2.01 The V4 repeaters are suitable for both voice and data transmission over 4-wire facilities. Their applications include:

Direct trunks

Tandem trunks

Intertandem trunks

Short intertoll trunks or VF extensions of carrier channels in intertoll trunks

PBX tie trunks and central office trunks

Foreign-exchange lines

Off-premises extensions

Special-service lines

Voiceband data circuits.

2.02 V4 repeaters and 4-wire facilities are generally needed where 2-wire facilities with E-type repeaters would fail to meet transmission requirements for low net loss, flatness of net loss, high return loss, or some combination of these. Two-wire facilities with E-type repeaters are at a disadvantage because (a) they have no built-in means of equalization and (b) because direct reflections within the facilities can seriously reduce the return loss of the circuit.

2.03 Lower return loss means poorer echo performance or necessitates increased net loss. Because they are one-way streets, the amplifiers in 4-wire circuits eliminate direct reflections entirely. Even where a passive network is used in place of an amplifier, the round-trip path of a direct reflection is at least 8 db longer than it would be in a 2-wire circuit because of loss in the terminating set.

2.04 This ability to eliminate direct reflections or to reduce their magnitude gives the 4-wire circuit a transmission advantage over the 2-wire circuit, especially where the available facilities lack uniformity. This transmission advantage is, of course, attained at the price of using two pairs instead of one, plus the difference between the installed cost of V4 and E-type repeaters.

2.05 Although the 4-wire technique solves the return-loss problem presented by facility mixtures, it does not ensure a well-equalized repeater section. Prescription equalization is available for a limited range of mixed loaded and nonloaded facilities. Outside this range, however, the results become progressively poorer. The only practicable way to improve results is to place a 44V4 repeater at the junction between loaded and nonloaded facilities.

3. TYPES OF FACILITIES

3.01 The components described herein were designed specifically for use with H88-loaded high-capacitance cable or with nonloaded cable. Two basic types of equalizers are provided: loaded and nonloaded. Where facilities are too short to need equalization, dummy units may be used.

3.02 For loaded cable of higher cut-off frequency than that of H88 loading on high-capacitance

cable, only the low-frequency section of the equalizer is used.

3.03 Combinations of loaded and nonloaded cable in the same repeater section are sometimes practicable, but equalizer assignments and settings must be determined by trial, either on simulated circuits or on the circuits themselves.

4. EQUIPMENT ARRANGEMENTS

4.01 In general, all three types of repeaters consist of mounting shelf, jack field, and plug-in components, all described in other practices.

4.02 All jack fields are similar. They permit picking up an amplifier input and output at the IN and OUT jacks for measurement and adjustment, monitoring with high-impedance receiver at MON jack facing amplifier IN or OUT jack, and picking up for measurement the circuit facing an amplifier at either MON jack. For this last purpose, however, a dummy plug must be inserted in the adjacent IN or OUT jack to lift off the amplifier, which otherwise would shunt the measuring equipment. In the 24V4 repeater, two additional jacks are included. One, similar to the IN and OUT jacks, is labeled 2W IN and permits picking up the 2-wire side of the terminating set; the other, labeled MON, permits monitoring at that point with a high-impedance receiver. The latter also permits picking up for measurement the circuit facing the 2-wire side of the terminating set. For this last purpose, however, a dummy plug must be inserted in the 2W IN jack to lift off the terminating set, which otherwise would shunt the measuring equipment.

4.03 The mounting shelf for the Basic V4 repeater accommodates amplifiers only, and in the bay arrangements the test jacks are grouped in the middle of the bay with designation strips. The plug-in units of the Basic V4 repeater are:

Two 227-type amplifiers or two 849-type networks or one amplifier and one network.

4.04 The mounting shelf for the 24V4A repeater includes the jack field and accommodates the following plug-in units:

(a) One 1-type terminating set

(b) Two amplifiers or networks, or one of each, as in the Basic V4 repeater

(c) One 359-type equalizer.

4.05 The 24V4B repeater is electrically equivalent to the 24V4A but was designed for mounting in cabinets on customer premises. It accommodates amplifiers and an equalizer on the bottom shelf, a terminating set on the second shelf, and a jack field at the top. Unlike the 24V4A repeater, it provides access to the wiring between terminating set and amplifiers at a terminal board at the back of the bay. This access is often needed for cross connection of other apparatus, especially at customer premises.

4.06 The 24V4C repeater was developed to provide space for auxiliary equipment on the same shelf with the other 24V4 equipment and to provide access to the wiring between the terminating set and the amplifiers. The 24V4C shelf is much like the 24V4A in appearance, but accommodates additional plug-in units without taking up any more bay space. Units now available for the extra space include 4066-type balancing networks and the 648A filter. This low-pass filter is needed to prevent singing in a 4-wire section when the latter is operated at a gain. Its 3-db point is at 3150 cps.

4.07 The mounting shelf for the 44V4A repeater includes two jack fields and accommodates two 44V4A repeaters, each consisting of the following plug-in units:

(a) Two amplifiers or networks, or one of each, as in the Basic V4

(b) Two 359-type equalizers.

4.08 The mounting shelf for the 44V4B repeater (also known as the 44V4L3) has been designed for voice-frequency data applications. It is covered in other practices.

5. TRANSMISSION FEATURES

5.01 Four-wire cable circuits equipped with V4 repeaters are generally capable of operating at about 2-db minimum net loss, with stability in the idle condition and during switching. If idle-circuit terminations are available in the switching circuits, lower losses may be practicable.

5.02 Other attractive features of V4 repeaters are listed below:

(a) Variety of plug-in terminating sets for impedance matching, level control, and adaptation to various signaling arrangements.

(b) Variety of plug-in equalizers to meet transmission requirements with varied facilities.

(c) Variety of plug-in networks for use where amplification is not needed.

(d) For essentially solid-gauge 4-wire loaded facilities, tables of prescription settings for equalizers are given to produce nearly "flat" circuits (0.5 db short to 1.5 db long, with respect to 1-kc loss, between 0.3 and 3 kc). Still flatter circuits may be attained by touch-up in the field.

(e) For nonloaded facilities, a table of equalizer choices is given to produce reasonably flat circuits (0.5 db short to 3.0 db long, with respect to 1-kc loss, between 0.3 and 3 kc). To 1-kc loss, between 0.3 and 3 kc).

(f) High return loss at the 2-wire side of the terminating set (echo return loss of 30 db or more against compromise network, for 1A or 1B terminating set with amplifiers in the 4-wire legs).

(g) Adjustable (by screw-type switches) building-out capacitor for use with either the compromise or an external cross-connected precision network.

(h) Series inductors in the simplex leads of the 1A and 1B terminating sets prevent the simplex circuit from shunting the capacitor between the A and B leads. Such shunting would reduce return loss. The inductors also impede noise picked up by the simplex circuit in the cable from getting into the 2-wire side of the terminating set.

(i) Impedance-improving networks on the 4-wire legs contribute to the high 2-wire return loss.

(j) Individual jack field on each repeater shelf facilitates "picking up" amplifiers for gain setting, monitoring with high-impedance receiver at any point, and testing on lines or repeaters.

(k) Measurements with existing 600-ohm test gear obviate need for new test sets.

(l) Leads available for developing pad control.

(m) Transistorized amplifiers, giving a finer adjustment of gain, excellent gain stability, and substantially long life without maintenance.

(n) No external repeating coils required for bypassing signaling.

6. SIGNALING

6.01 V4 repeaters impose penalties or restrictions on some types of signaling and are incompatible with some others. Nevertheless, they command a wide field of use in the exchange area and are expected to expand this field as the more modern signaling systems come into wider use. Auxiliary circuitry to bypass signals around the V4 repeaters cannot, at this time, be provided at reasonable cost.

6.02 It had been hoped that a basis could be established for judging compatibility of V4 repeaters with the various signaling circuits, and that tests of each circuit would not be needed. It appears, however, that laboratory tests provide the only reliable basis for judging compatibility and setting penalties. Section 859-501-101 includes in some detail the arrangements of the V4 equipment for various types of circuits and signaling and discusses compatibility and penalties established by test. A detailed listing of the compatible circuit arrangements verified by laboratory tests is included in common systems drawing SD-99421-03, entitled "Signaling Compatibility of V4 Repeater," or Section 179-100-303. Both SD-99421-03 and Section 179-100-303 will be reissued from time to time, as further tests uncover additional information.

Supervision

6.03 Supervision ranges are reduced by the resistance inserted in the signaling loop by V4 repeaters. Each 24V4 repeater inserts about 200 ohms in the loop, and each 44V4 about 60 ohms. These resistances must be included with the facility resistance when range computations are made. Where the use of these approximate values brings the total resistance close to the limit, the more accurate figures in Table I of Section 859-501-101 may be used. When Table I is used, it is important

to choose the figures that apply to the specific situation. For example, the simplex resistance of the 1200-ohm output of a 227-type amplifier is 30 ohms, but that of each transformer in the 359B or F equalizers is much less: 2 ohms for the 359B and 9 ohms for the 359F.

Ringing

6.04 The 20-cps loss introduced by a 24V4 repeater is caused mainly by the resistance of its components in the ringing path. Resistance figures are given in Table I of Section 859-501-101.

Voice-Frequency Tones

6.05 V4 repeaters amplify, and thus maintain, proper levels of all voice-frequency tones, such as multifrequency, TOUCH-TONE®, single-frequency, and inband-coin-control.

Pulsing

6.06 In general, a 24V4 repeater adds series resistance and inductance and shunt capacitance to the signaling loop. The 44V4 adds only series resistance. The effects of the 24V4 are particularly serious in the four cases outlined below:

(a) Certain step-by-step outgoing loop-type trunk circuits (repeaters) use pulsing relays that must be tuned to the connected facility. These relays cannot be properly tuned when the capacitance of a pair of 24V4s is added to the pulsing loop. Outgoing step-by-step repeaters with tuned relays, therefore, should not be used with 24V4 repeaters.

(b) The capacitance added by a pair of 24V4 repeaters is sufficient to make revertive pulsing trunks fail. These repeaters should not, therefore, be used on revertive-pulse trunks.

(c) When added to either a line or a trunk terminating in a No. 5 crossbar office or a crossbar PBX, a 24V4 repeater may produce resonance that results in split dial pulses, with consequent overcounting of selectors. The resonance may be prevented as outlined in Section 859-501-101.

(d) When added to either a line in a step-by-step office or a PBX extension in a step-by-step PBX, a 24V4 will impose additional limitations on the number of ringing bridges. In such cases the ringers at a subscriber's station must be limited to four high-impedance ringers or one low-impedance ringer with a series capacitor of not more than 1 μf and low-impedance ringing bridges (such as a J-type relay in series with 2 μF) must be removed from PBX cord circuits.

7. CIRCUIT LAYOUT INFORMATION

7.01 The following information will ordinarily be furnished on the circuit-layout form:

(a) Circuit identification, consisting of number, terminals, direction, pulsing, and type. Also the class of each terminal office and the traffic class

(b) Control office

(c) Circuit Order No.

(d) Customer's name (for special service only)

(e) Total mileage

(f) Restoration priority plus either special service marking or selected circuit indicator

(g) Usage (combined or joint)

(h) Test frequencies

(i) EML (expected measured loss)

(j) Design data (VNL objective)

(k) Type of switching equipment at terminal (4A, XBT, etc)

(l) Losses of switching pads

(m) Balance requirements for 2-wire sections

(n) Noise objectives (Section 606-403-500).

7.02 The actual layout of equipment and facilities is to be placed on the form in wired sequence (switch at A to switch at Z). Transmission levels at the output of each unit of equipment or each facility are to be indicated rather than losses in equipment or facilities. Since true levels at repeater outputs are difficult to measure, however, desired measured repeater gains should be specified. In

general, information of transmission significance (return loss in db, resistance in ohms, etc) will be placed in the MISC column next to the entry to which it pertains.

7.03 The selection of plug-in units and their prescription settings should be determined by the circuit-layout forces, wherever practicable, and shown on the form. BSP references to settings of various units of V4 repeater equipment are given below:

1-Type Terminating Sets

COMP NET. screw	852-307-101
NBOC screws	
Office Balance—General Description and Considerations	AB23.331 660-475-100
Office Balance Testing Methods—2-W No. 5 XB	310-200-550
Office Balance Testing Considerations—PBX 4-W Tie Trunks	310-350-100
Office Balance Testing Procedures—PBX 4-W Tie Trunks	310-350-500
Office Cabling Balance Tests in 2-W Toll Switching Offices	
Manual and No. 4 XB	660-475-500
SXS	660-475-501
NO. 5SB	660-475-502
XB Tandem	660-475-503
AMPL screws	852-307-101
NO AMPL screws	852-307-101
SX screws	852-307-101 859-501-101
SHORT INDR screws	852-307-101 859-501-101
Pads for 1C, 1D, 1G terminating sets	332-810-100 852-307-102
Gain Screws of 227-Type Amplifiers	852-307-102
359-Type Equalizer Screw Settings	852-307-101
849-Type Network Pads (89-type plug-in resistors)	852-307-102

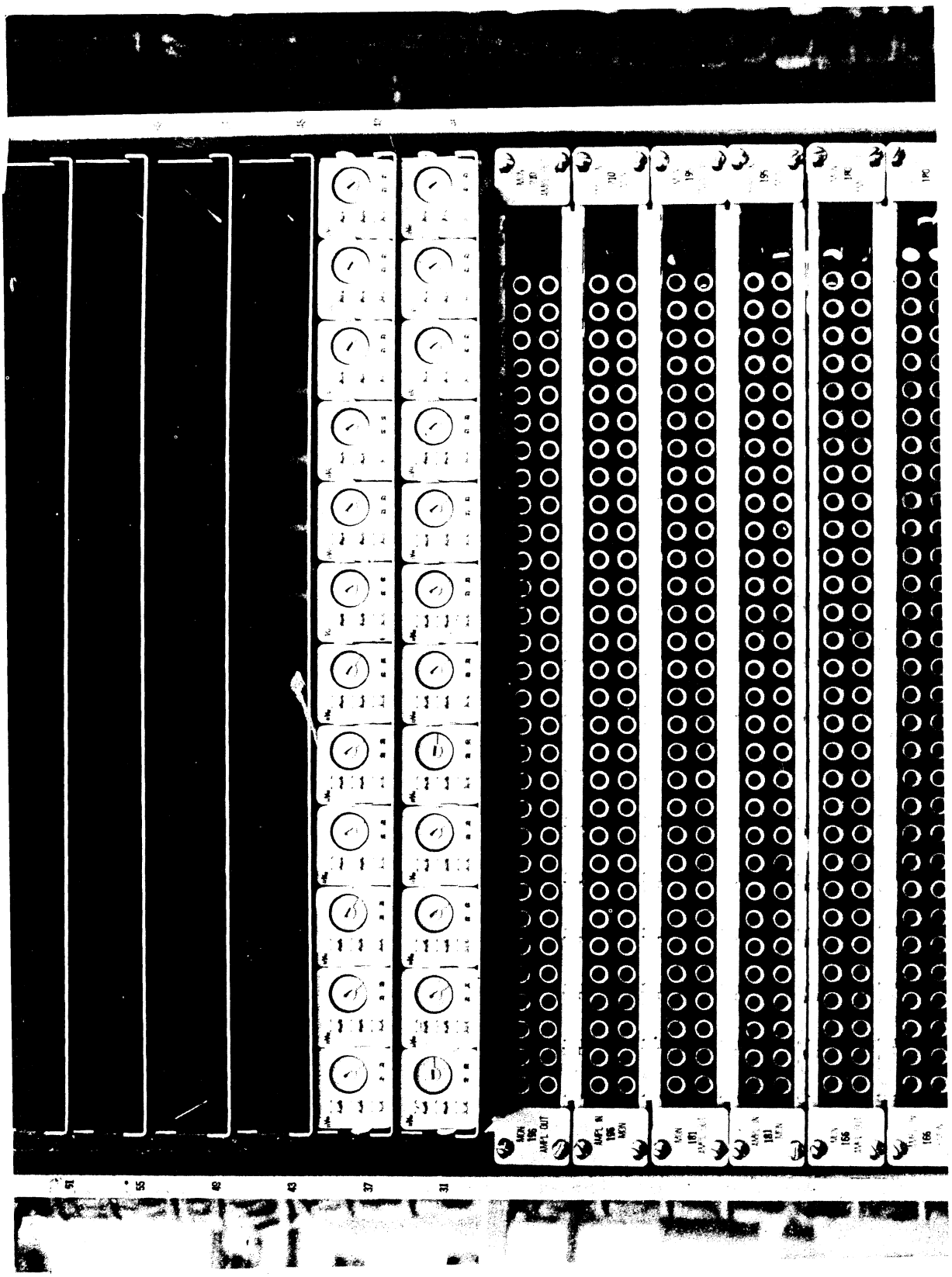

Fig. 1 – Basic V4 Repeater

8. REFERENCES

PELs:

6790—227-Type Voice-Frequency Amplifier

6883—24V4 and 44V4 Repeaters

7040—Signaling Potpourri

7194—24V4B Telephone Repeater

7320—Balancing Networks and Filters

Drawings:

SD-97047-01—V4 Repeater

SD-97138-01—Common Systems—Four-Wire Terminating Sets

SD-99421-03—Signaling Compatibility of V4 Repeater

SD-99739-01—24V4B Repeater

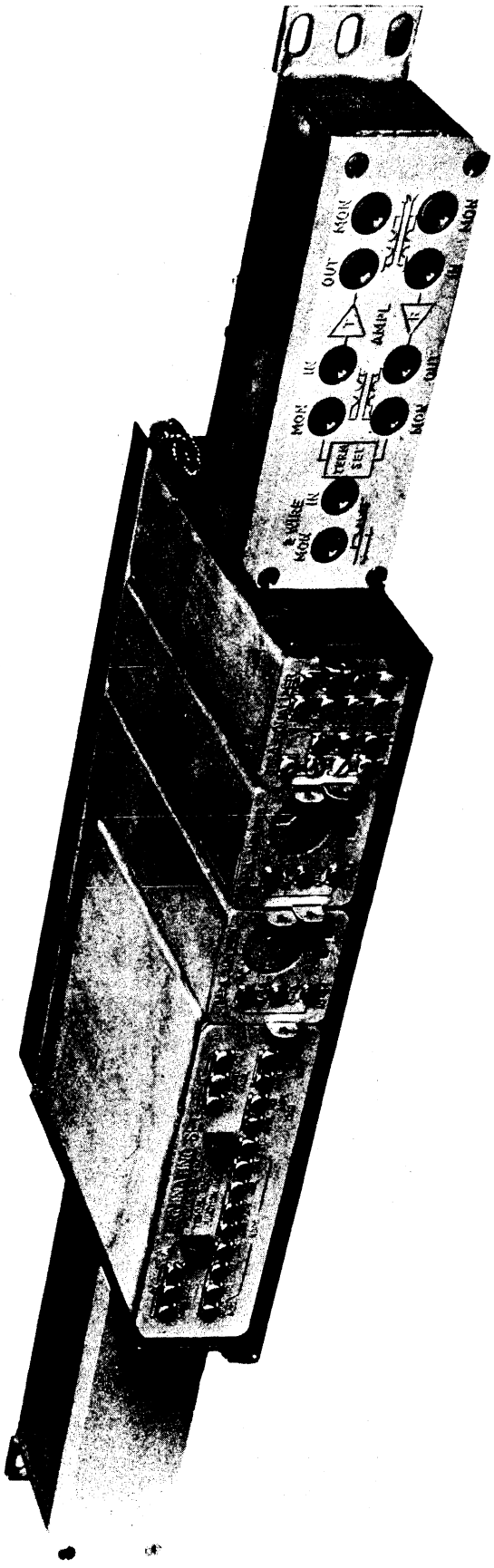

Fig. 2 – 24V4 Repeater

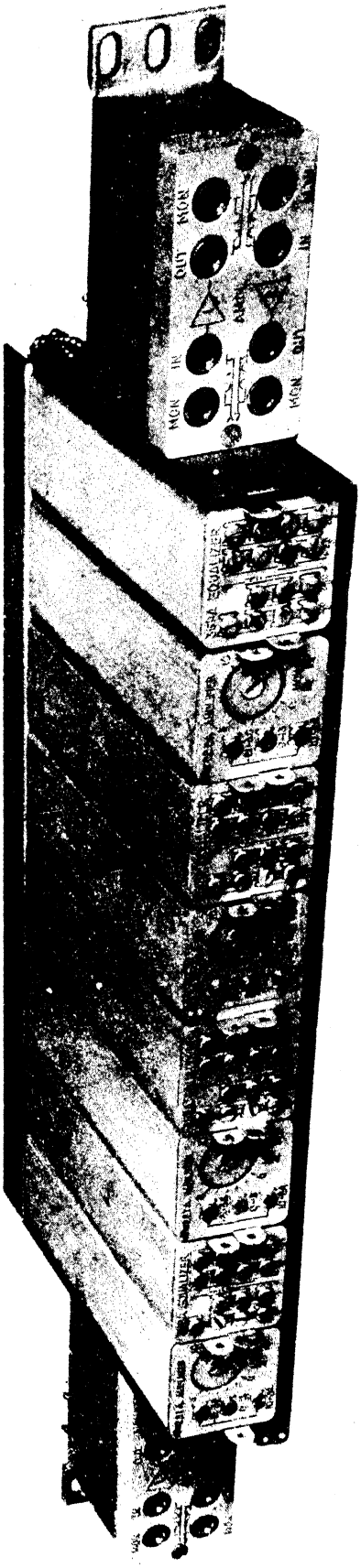

Fig. 3 – 44V4 Repeater