L4 CARRIER
OVERALL SYSTEM
DESCRIPTION
MAIN STATION TRANSMISSION

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1. GENERAL

1.01 The L4 coaxial cable carrier system (Section 359-200-100) provides high-quality long-haul transmission. Transmission equipment is installed at line repeater stations along the cable and in main stations, which are up to 150 miles apart.

1.02 This section is reissued to include descriptions of later equipment arrangements, to expand the explanations, and to delete references to the 20.448-MHz line pilot which is now manufacture discontinued. Due to the extensive revision, arrows normally used to indicate changes have been omitted.

1.03 A ***main station*** is a large underground building which includes repeaters, line connecting, line switching, and power equipment. A main station may be attended or unattended; at least every other main station includes a control center and must be attended.

1.04 ***Repeaters*** in the L4 system provide the amplification, regulation, and equalization necessary to maintain the overall transmission objectives of the system. Transmission deviations in the L4 carrier system are corrected at the repeater locations by ***post***-deviation and ***pre***-deviation changes in gain. Approximately one-half of the correction is made at each end of the line section in which the deviation occurs. An improved signal-to-noise ratio results because the maximum signal-level deviations allowed are half as great as in a carrier system where only post-deviation corrections are made.

1.05 L4 repeaters are of five types which can be divided into two groups according to location: line repeaters and main station repeaters.

1.06 ***Line repeaters*** (Section 359-200-101) include basic, regulating, and equalizing repeaters which are located in underground rooms at a nominal 2-mile spacing along the cable.

1.07 ***Main station repeaters*** are of two types: receiving and transmitting. These repeaters and associated transmission equipment are mounted in shock-protected bays, as shown in Figures 1 and 2.

1.08 All main station transmission equipment is powered from −24 volt office battery and −25 volt dc-dc converters which are mounted in the bays. All line repeaters are powered by high-voltage direct current applied to the center conductor of each coaxial line in the cable. This

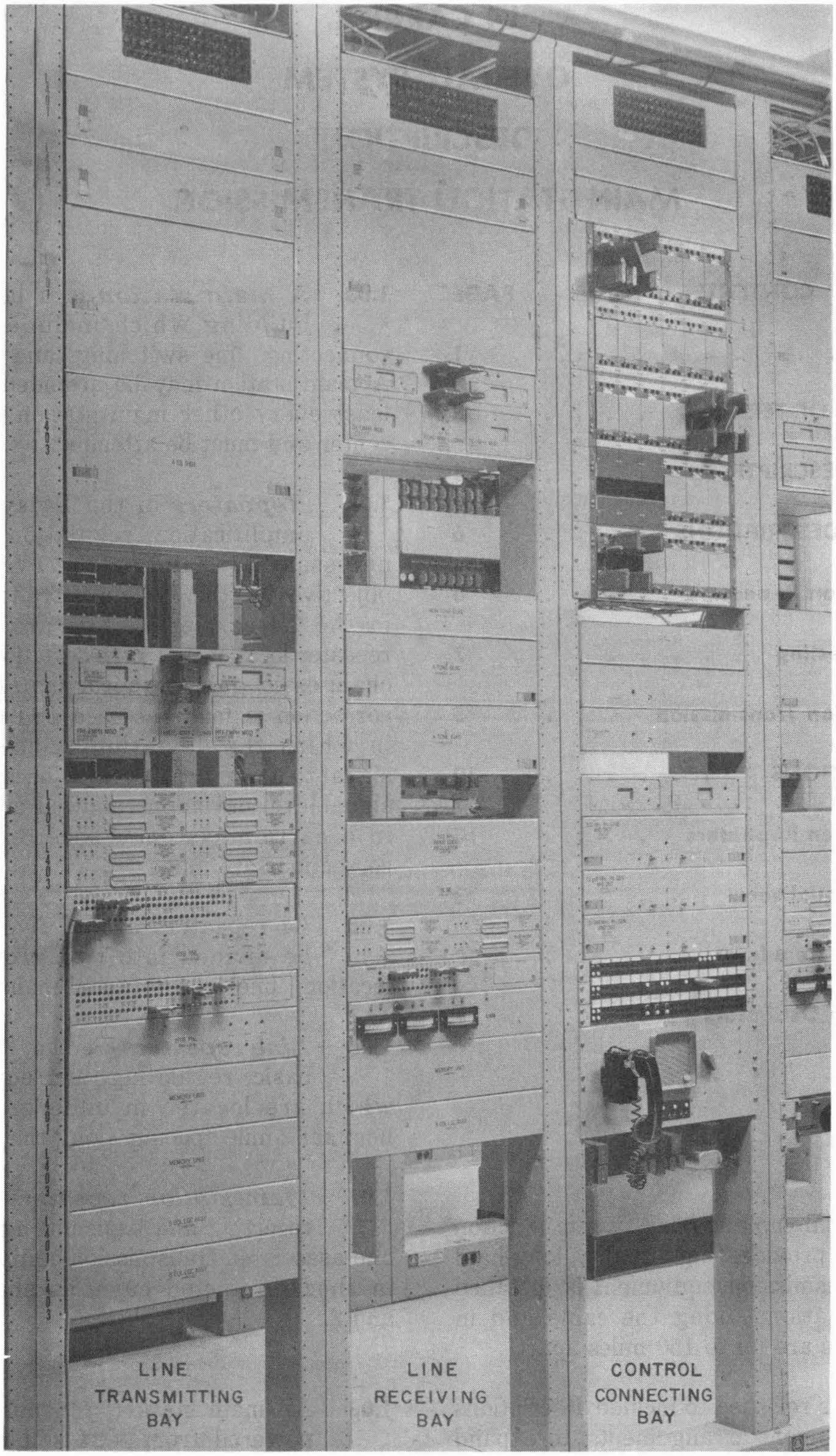


Fig. 1—Main Station Bays

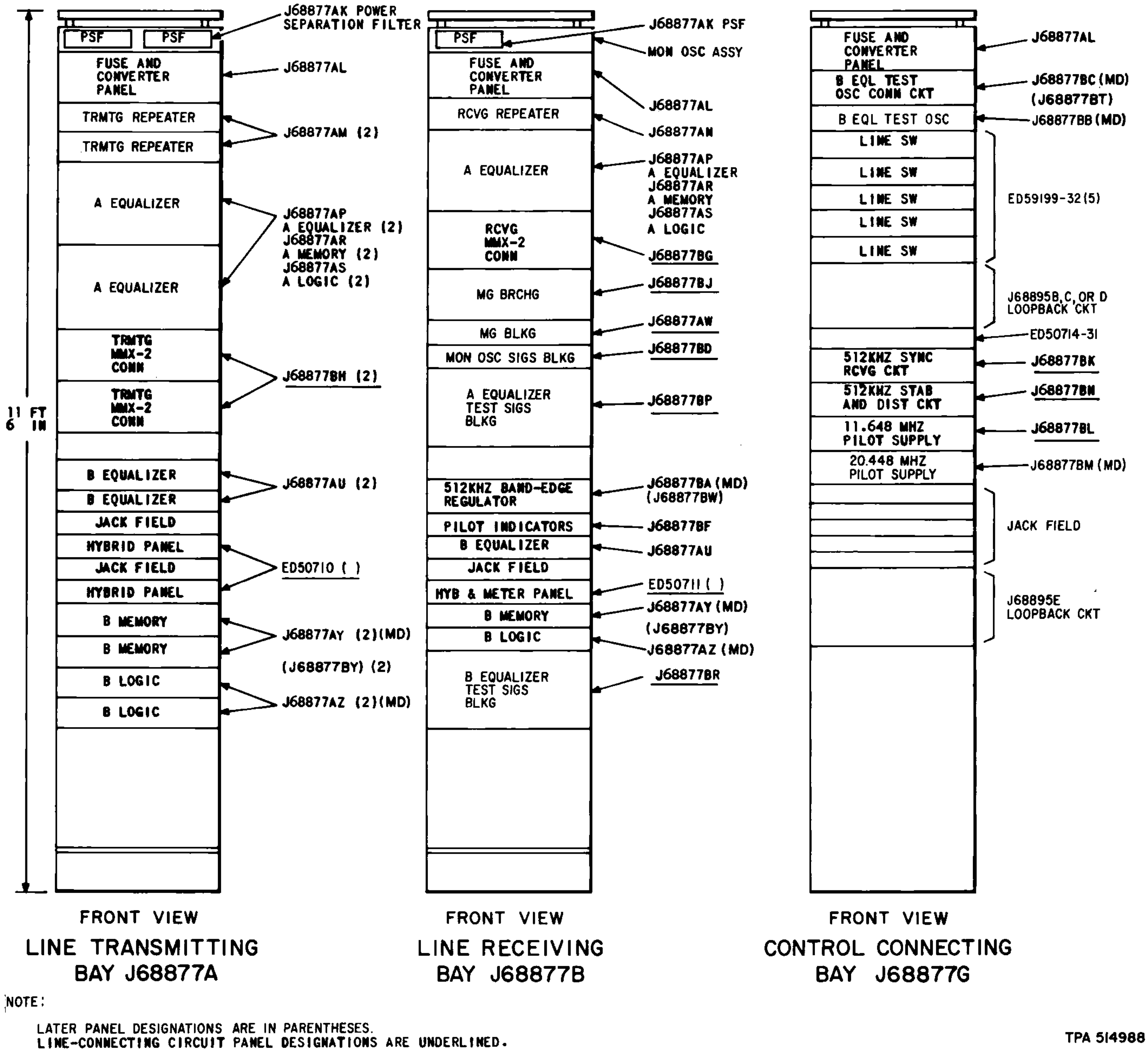


Fig. 2—Equipment Arrangements in Main Station Bays

high-voltage power is produced by dc-dc converters in the main stations.

2. EXPLANATION OF TERMS

2.01 This part explains some terms pertaining to the L4 carrier system. Other terms are explained where introduced in this section.

2.02 A ***coaxial line*** provides one direction of transmission and includes repeaters at 2-mile spacing. An ***L4 cable*** may contain as many as twenty 0.375-inch coaxial lines. The twenty lines provide one standby and nine regular lines in each direction of transmission. In addition, the cable contains paper-insulated pairs which are used for voice order wires, for carrying dc power to monitoring oscillators, and for some other uses.

2.03 The ***L4 spectrum*** includes the following frequency allocations (Fig. 3):

- Multiplex signals from an MMX-2C terminal for six mastergroups between 0.564 and 17.548 MHz
- Line pilot signals at 0.512 and 11.648 MHz
- Equalizer test signals at 16 frequencies throughout the L4 spectrum
- Line switching signals at seven frequencies from 280 to 296 kHz
- Command carrier signals at 12 frequencies between 300 and 500 kHz
- Monitoring oscillator signals at 16 or 21 frequencies from 18.50 to 18.56 MHz.

The multiplex and line pilot signals are present continuously on working L4 lines. The other signals listed are applied to a line only for short periods during line switching and when the remote control system (Section 359-200-105) is being used for equalizer adjustments and for trouble locating.

2.04 A ***control center,*** located at certain main stations only, includes sending and receiving circuits that permit control of remote locations, measurement of gain deviations, adjustment of equalizers, and display of monitoring oscillator signals.

2.05 ***Command carrier*** signals are sent from a control center to main station and equalizing repeater locations to control equalizer test oscillators, equalizer adjustments, and monitoring oscillators.

2.06 A ***route*** is the transmit and receive coaxial lines in a cable extending in one direction from a main station. An L4 cable usually bypasses large cities; the message signals to and from these cities are connected via a ***sideleg*** route. A control center will serve up to ten routes.

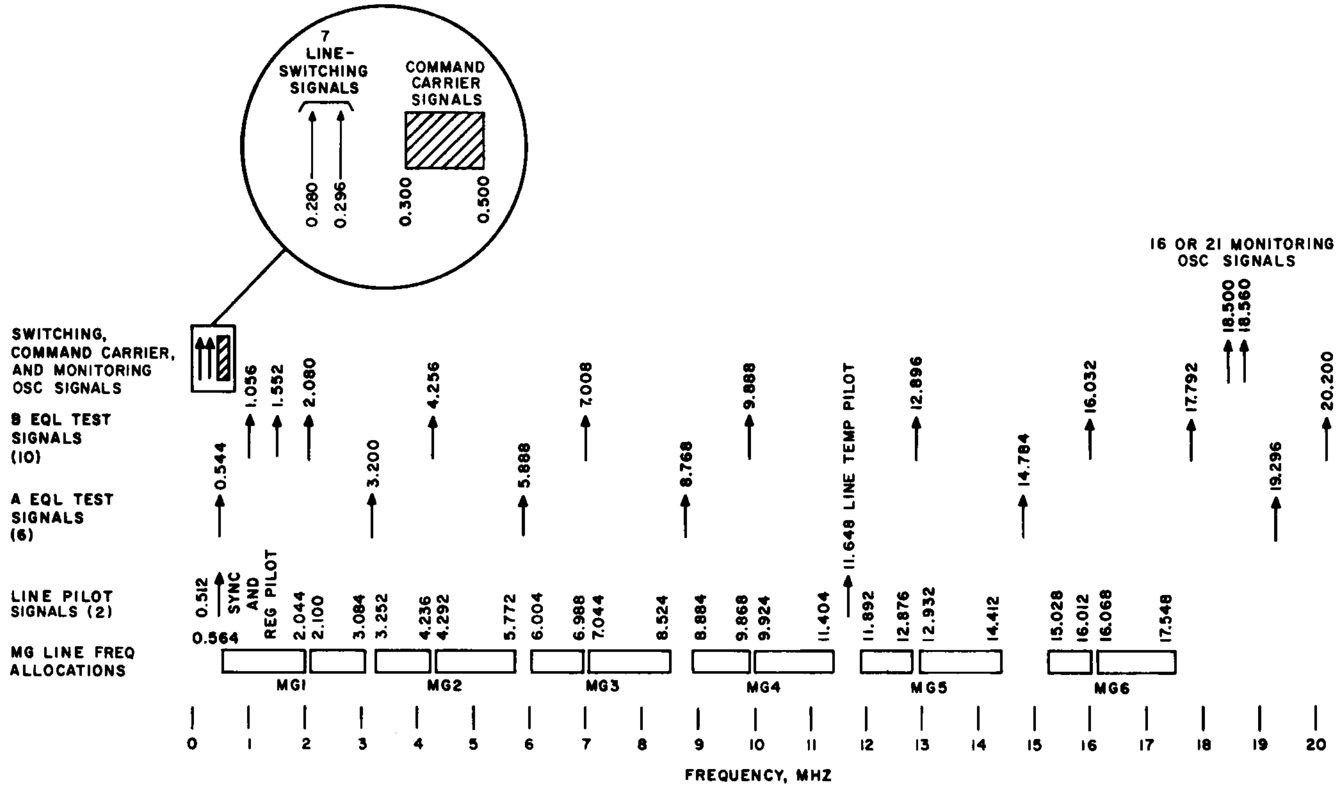


Fig. 3—L4 Frequency Allocations

2.07 ***Equalizer test signals*** are produced by oscillators which may be turned on by command from a control center. Each equalizing and main station repeater includes an ***A*** equalizer and oscillators which produce the six A equalizer test signals. Each main station repeater includes a ***B*** equalizer; each control connecting bay includes a set of ten B equalizer test oscillators which serve all the lines in a route. The A and B equalizer test signal levels are measured at the control center and equalizer adjust commands are sent to the equalizer locations to correct for gain deviations.

2.08 A ***monitoring oscillator*** is associated with each repeater. Monitoring oscillators associated with a group of adjacent repeaters in a line may be turned on from a control center and the signals may be displayed on a spectrum analyzer in the control center. A main section (Fig. 4) includes up to six groups of monitoring oscillators which are powered from the equalizing repeater and main station locations.

2.09 ***Line pilots*** in the L4 system are used for regulation of repeater gains, for initiation of automatic line switching, and for synchronization of primary frequency supplies in main stations.

2.10 ***Line switching*** provides protection for the regular lines. Switching occurs automatically when line pilots in a regular line deviate from nominal levels. Switching equipment at the adjacent main stations connects the standby line to replace the failed one of the nine regular lines. Line switching bays contain the control equipment for line switching. The coaxial switches for a route are mounted in the upper part of each control connecting bay (Fig. 1).

3. EQUIPMENT DESCRIPTIONS

3.01 Main station transmission equipment is mounted in three types of bays: line transmitting, line receiving, and control connecting. These bays are designed for 23-inch mounting plates and two-sided access. Bays are provided in three sizes: 11-foot 6-inch, 10-foot 6-inch, and 9-foot heights. Transmission equipment is plug-and-jack connected and is usually mounted on sliding shelves in the bays.

3.02 Each main station contains the following equipment:

(a) A control connecting bay for each route

(b) Line receiving bays and line transmitting bays which contain the repeaters and associated equipment for the coaxial lines

(c) Line connecting equipment

(d) Line power equipment which furnishes 520 mA dc to each line to power the line repeaters

(e) Line switching equipment.

3.03 Power to the equipment in a bay is connected via a fuse and converter panel at the top of the bay. Both 24-volt office battery and regulated −25 volt dc power are provided. The panel includes dc-dc converters which operate from the 24-volt office battery to supply regulated −25 volt power. Self-indicating fuses and a fuse alarm lamp are located on the front of the panel.

3.04 A line transmitting bay includes the transmission equipment for ***two transmit*** lines. A transmitting repeater, an A equalizer, and a B equalizer are provided for each line. A transmitting MMX-2 connecting panel serves for connecting signals from an MMX-2C terminal, where mastergroup signals are ***added*** to a transmit line.

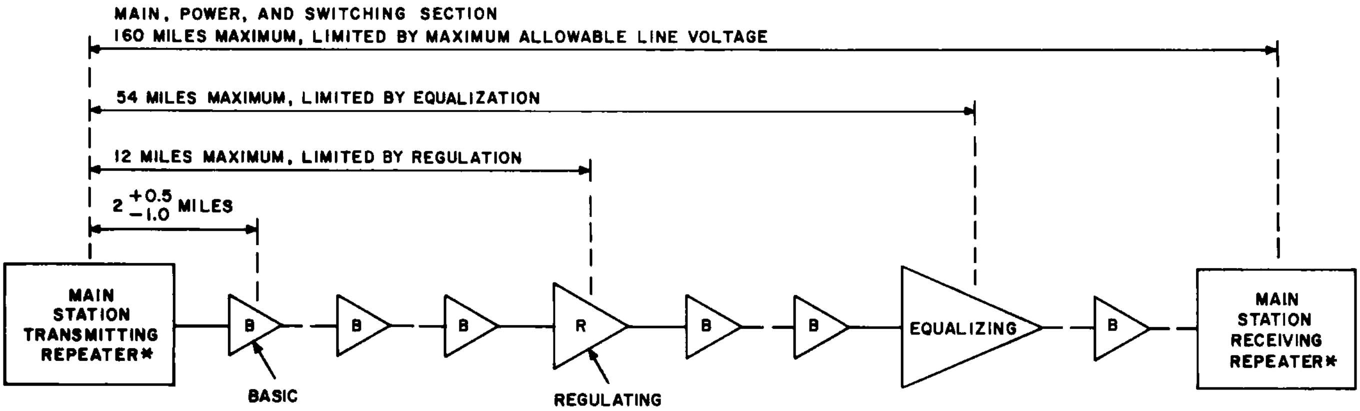
3.05 A line receiving bay includes the transmission equipment for ***one receive*** line. A receiving repeater, an A equalizer, and a B equalizer are provided.

(a) A receiving MMX-2 connecting panel serves for connecting signals to an MMX-2C terminal, where mastergroup signals are ***dropped*** from a receive line.

(b) A mastergroup blocking panel provides a through transmission path to a transmit line.

(c) A mastergroup branching panel serves for connecting signals from a receive line to a transmit line in a route different from the one to which the through transmission path connects.

In the mastergroup blocking and mastergroup branching panels, various filter combinations are



* MAIN STATION REPEATERS ARE POWERED FROM SEPARATE LOW-VOLTAGE DC SOURCES.

FUNCTION		REPEATERS				
		MAIN STATION TRMTG	BASIC	REGULATING	EQUALIZING	MAIN STATION RCVG
LINE BUILDING OUT		✓	✓	✓	✓	✓
AMPLIFICATION	PRE	✓	✓	✓	✓	
	POST		✓	✓	✓	✓
FIXED DEVIATION EQUALIZATION		✓		✓	✓	✓
TEMPERATURE REGULATION	PRE	✓		✓	✓	
	POST			✓	✓	✓
ADJUSTABLE EQUALIZATION	A	✓			✓	✓
	B	✓				✓
BAND – EDGE REGULATION						✓

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Fig. 4—L4 Main Section—Repeater Spacings and Functions

provided, as required, to pass only the desired mastergroup signals and other signals in the L4 spectrum.

3.06 A control connecting bay includes the common equipment for all transmit and receive lines in a route. This equipment includes two line pilot panels, a B equalizer test oscillator panel, coaxial switches for automatic line switching, remote control system loopback panels, and cutoff switches for alarms originating in the associated line transmitting and line receiving bays.

3.07 ***Line pilot supplies*** for 512 kHz and 11.648 MHz are provided in each control connecting bay. Each supply can furnish pilot signals for up to ten transmit lines in a route. Pilots are inserted in the transmit lines as follows:

(a) Into each ***standby*** transmit line at every main station

(b) Into each ***regular*** transmit line at the first main station on the cable.

(c) Into a ***regular*** transmit line where required because of pilot blocking in the mastergroup blocking panel or because of pilot removal due to line switching.

4. FUNCTIONAL DESCRIPTIONS

A. Main Station Repeaters

4.01 Gain-correction functions of the main station and line repeaters are listed in Fig. 4. These functions are described in the following parts.

Amplification

4.02 Each main station receiving and transmitting repeater provides ***gain*** to compensate for one mile of coaxial line. Each line repeater provides gain to compensate for two miles of coaxial line; one mile of line preceding the repeater and one mile of line following the repeater. Thus, each repeater compensates for one-half the adjacent line section(s).

Regulation

4.03 ***Regulation*** refers to gain corrections controlled by temperature changes at cable depth or by the levels of received line pilots.

4.04 The gains of all L4 repeaters, except basic repeaters, are regulated as follows:

(a) Main station ***transmitting*** repeaters provide preregulation. A preregulator, normally controlled by a buried thermistor, is controlled at a main station by an adjustable resistance. This is done because it is difficult to sense true ground temperature near a main station building. This resistance is manually adjusted periodically to compensate for gain deviations due to ground-temperature changes. This regulation compensates for one-half the anticipated gain deviation to the adjacent regulating repeater.

(b) ***Regulating*** and ***equalizing*** line repeaters provide post-regulation under control of the level of the received 11.648-MHz pilot.

(c) ***Regulating*** and ***equalizing*** line repeaters provide preregulation based on the effects of ground temperature on a thermistor buried outside the repeater station.

(d) Main station ***receiving*** repeaters provide post-regulation under control of the levels of the received 512-kHz and 11.648-MHz pilots. The 512-kHz pilot controls a band-edge regulator which compensates for low-frequency gain deviations, introduced in the preceding main section, due primarily to the effects of changes in ambient temperature on the repeater circuits.

Equalization

4.05 All repeaters except the basic repeaters include a ***fixed equalizer***. This equalizer corrects accumulated deviations caused by a number of basic repeaters having a total gain which does not exactly compensate for the loss-frequency characteristic of a line section.

4.06 Two types of ***adjustable equalizers***, designated A and B, are used in the L4 system. The A equalizers are used in the equalizing repeaters and in the main station transmitting and receiving repeaters; the B equalizers are used only in the main station repeaters. An A equalizer includes six networks and a B equalizer includes ten networks. Each equalizer network is adjustable, in steps, by means of commands from a control center at a main station.

4.07 Associated with each A and B equalizer is a set of test oscillators which may be turned on from a control center. The test signals may be connected, by command, either at the input or at the output of the equalizer selected. The levels of these test signals received at the control center are indicated on meters. Commands are sent from the control center to adjust the equalizer networks to compensate for gain deviations.

4.08 Three circuits are associated with the A and B equalizers: a ***command receiver*** to select and demodulate the command carrier signals which are moduled by combinations of audio-frequency signals, ***logic*** to decode the audio command signals and initiate the proper responses, and a ***memory*** which establishes and maintains the desired equalizer settings.

Line Building Out

4.09 Geographic and other considerations do not always permit the location of repeaters at the nominal 2-mile spacing. Line building-out (LBO) networks are used in each of the line and main station repeaters to electrically build out short lengths of coaxial line to the nominal 2-mile spacing between repeaters. These networks are available to simulate up to 1 mile of line in 0.1-mile steps.

B. Line Connecting

4.10 Line-connecting equipment (Section 359-200-104) is mounted on panels in the main station bays, as shown in Fig. 2.

4.11 Line-connecting equipment is provided in all main stations and may be arranged to serve a number of functions, in various combinations, as required by the system layout. Line connecting circuits serve to:

(a) Connect a receive line to a transmit line for through transmission.

(b) Connect a receive line to a transmit line for branching.

(c) Connect a receive line to an MMX-2C terminal.

(d) Connect the received 512-kHz line pilot to a synchronization circuit for the primary frequency supply.

(e) Connect an MMX-2C terminal to a transmit line.

(f) Insert one or both of the line pilots on a transmit line.

(g) Connect command carrier signals from a control center to one regular transmit line in each route.

(h) Connect the command carrier signals from one regular receive line of each route to the associated loopback circuit.

(i) Connect switching signals to the transmit lines and from the receive lines.

(j) Connect an output of a monitoring oscillator to a transmit line.*

*For a receive line, the monitoring oscillator signal is applied at the power separation filter in the line receiving bay. One monitoring oscillator serves two transmit and two receive lines in a cable.

(k) Block the received monitoring oscillator signals at each main station having a control center.

(l) Block one or both of the line pilots.

(m) Block the multiplex signals of one or more adjacent mastergroups in the L4 spectrum on a receive line.

(n) Block the equalizer test signals from entering the MMX-2C terminal and from entering a transmit line via the branching circuit.

(o) Block the switching signals.

C. Main Station Transmission

4.12 Main station transmission paths are shown in Fig. 5.

Receiving

4.13 Each ***receive*** line connects to the power separation filter (PSF) at the top of a line receiving bay. This filter separates the L4 signals and the high-voltage direct current which powers the line repeaters. A monitoring oscillator signal is connected, via the PSF, to the input of the receiving repeater.

4.14 A ***receiving repeater*** provides gain to compensate for the loss in one mile of line. The preceding basic repeater compensates for the loss in the other one mile of line. The L4 signals are equalized in the A and B equalizers. These equalizers are adjusted from a control center in this main station ***or*** in the next main station to the east.

4.15 If this main station includes a control center, the L4 signals are connected from the receiving hybrid to the receiving circuit in the control center. If this main station does not have a control center, the L4 signals are connected, via the through transmission path and a transmit line, to the next main station to the east, which ***will*** have a control center.

4.16 A band-edge regulator monitors the received 512-kHz pilot and provides continuous regulation to correct for gain deviatons at the low end of the L4 band. Deviations at the lower frequencies are caused primarily by the effects of temperature changes on line repeaters. Switching signals and command carrier signals, which are below 500 kHz, are adversely affected by low-frequency gain changes.

4.17 If this main station includes a control center, monitoring oscillator signal blocking is provided to prevent these signals from entering a transmit line via the through transmission path. If this main station does not include a control center, the monitoring oscillator signal blocking will be omitted so the monitoring oscillator signals can continue, via the transmit line, to the next main station which ***will*** have a control center.

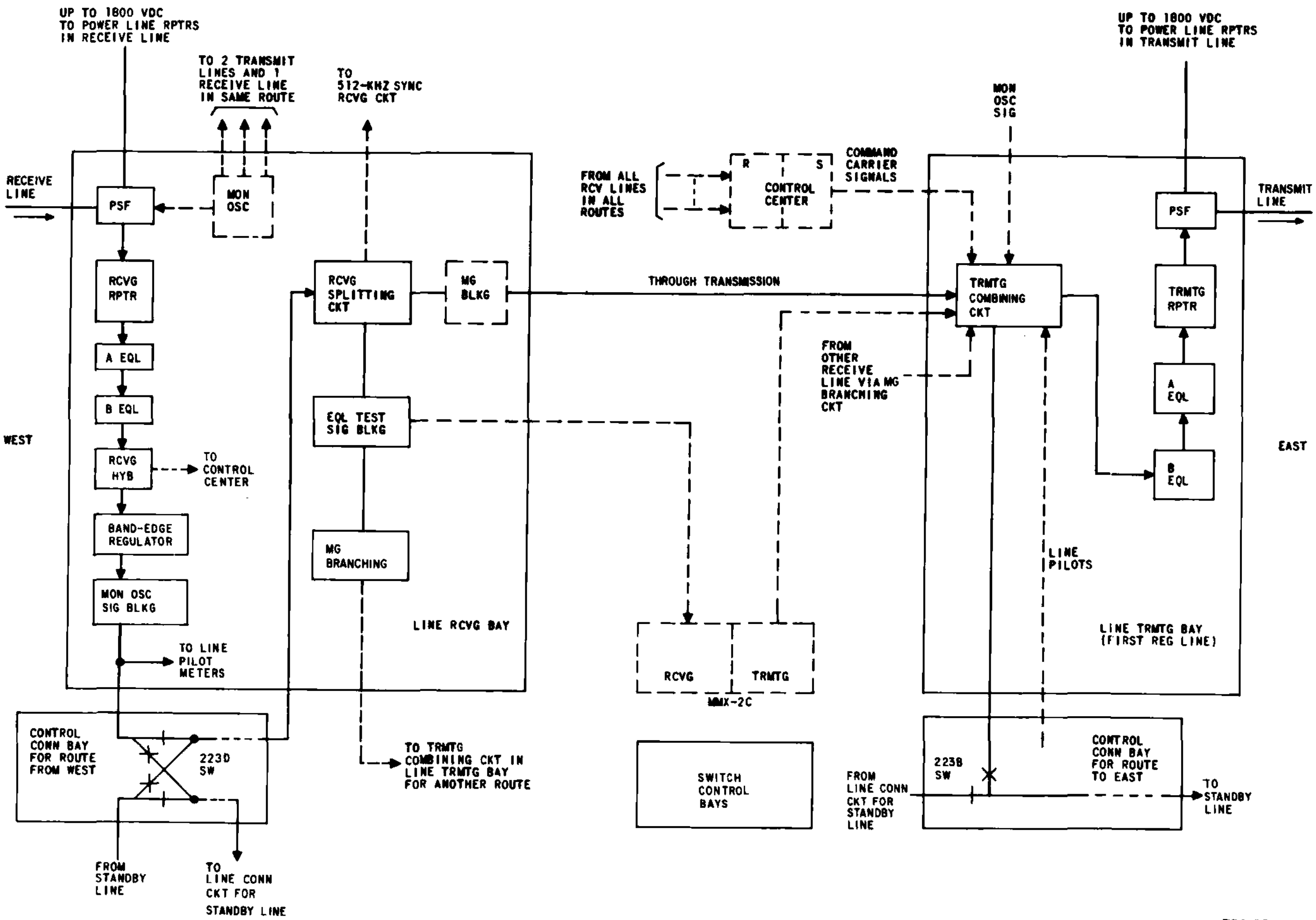

Fig. 5—L4 Main Station Transmission

4.18 The receiving splitting circuit has several outputs which can be used, if required:

(a) Through transmission to the mastergroup blocking panel which passes only the desired signals

(b) Branched transmission to the mastergroup branching panel which passes only the desired signals

(c) Dropped mastergroups to an MMX-2C terminal in this main station

(d) 512-kHz pilot from ***one*** receive line is used for synchronizing the primary frequency supply(s) in this main station.

4.19 The transmitting combining circuit has several inputs which can be used, if required:

(a) Through transmission from the mastergroup blocking panel

(b) Branched transmission from the mastergroup branching panel

(c) Added mastergroups from an MMX-2C terminal in this main station

(d) Command carrier signals from a control center

(e) Monitoring oscillator signals

(f) Line pilot signals.

Line Switching

4.20 Line pilot meters in the line receiving bay continuously indicate the relative levels of the received 512-kHz and 11.648-MHz pilot signals. These pilots control the automatic line switching.

4.21 Line switching is on a main-section basis. A ***main section*** (Fig. 4) includes the transmitting repeater in one main station, the line, the line repeaters, and the receiving repeater in the next main station. The coaxial switches are shown in simplified form in Fig. 5. The received L4 signals are connected, via a coaxial switch in the control connecting bay, to the receiving splitting circuit. In case a ***regular*** line fails, a coaxial switch operates at each end of the main section to transfer the L4 signals to the ***standby*** line between the two main stations.

(a) At the transmitting main station, a 223B switch operates to connect the L4 signals from the regular line transmitting combining circuit to the standby line.

(b) At the receiving main station, a 223D switch operates to connect the L4 signals received on the standby line to the regular line receiving splitting circuit.

4.22 The transmitting combining circuit has two outputs:

(a) To a ***regular*** transmit line via the B and A equalizers, transmitting repeater, and power separation filter

(b) To a coaxial switch in the control connecting bay. If the ***regular*** transmit line fails, the switch operates and the L4 signals are connected to the ***standby*** transmit line.

The A and B equalizers for each transmit line are adjusted from the next control center to the east. A transmitting repeater provides gain to compensate for the loss in one mile of line. The following basic repeater compensates for the loss in the other one mile of line.

4.23 A power separation filter for each transmit line, at the top of the line transmitting bay, separates the L4 signals and the high-voltage direct current which powers the line repeaters.

5. UNIT DESCRIPTIONS

5.01 This part includes physical and electrical descriptions of the main station repeaters, A and B equalizers, band-edge regulator, and monitoring oscillators.

A. Main Station Repeaters

5.02 ***Receiving repeater*** J68877AN (Fig. 6) mounts in the line receiving bay. This repeater includes two detachable LBO networks which must be in place to complete the transmission path. A complete repeater weighs approximately 19 pounds and is 3.4 by 12 by 17 inches in size. The repeater is powered from regulated −25 volt power.

5.03 Figure 7 is a block diagram of the receiving repeater. Three lists are shown. List 1 is the original repeater. List 2 is the same as the original repeater except, if pilot is lost, the temperature post-regulator remains where it was immediately before loss of pilot. List 3 is the same as List 2 except the gain more closely matches the loss of one mile of coaxial line, particularly at the low end of the L4 band.

5.04 The input amplifier compensates for the loss of one mile of line at 55°F. This amplifier provides shaped, fixed gain from 0 dB at 0.5 MHz to 16 dB at 20 MHz.

5.05 Two LBO networks, as shown in Fig. 6, must be in place prior to placing a repeater in service. Each LBO network has two coaxial plugs for signal connections; screws hold the network to the repeater chassis. LBO 1 is a 4100-type network which is selected according to the length of the line from the preceding basic repeater. LBO 1, in conjunction with the LBO in the preceding basic repeater, builds out the line to the nominal 2-mile spacing between repeaters. LBO 2 is a network which is selected as a part

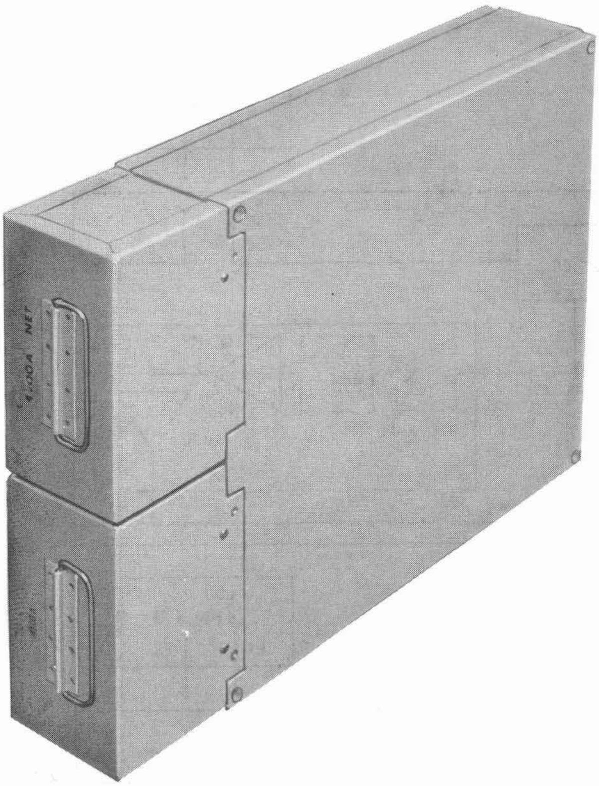

Fig. 6—Receiving Repeater J68877AN

of the repeater and offers a fixed loss across the L4 band.

5.06 The fixed-loss deviation equalizer compensates for predictable deviations accumulated in the basic repeaters in the preceding regulating section. These deviations result because several basic repeaters in tandem do not correct the loss exactly in the line over the L4 band. A deviation equalizer is selected according to the number of basic repeaters in the regulating section and is installed prior to placing the repeater in service. This equalizer connects the L4 signals to LBO 2 and to a feedback path.

5.07 The feedback path includes filters which pass the 11.648-MHz pilot only, two pilot amplifiers, and a dc amplifier. The dc amplifier output, proportional to the level of the received 11.648-MHz pilot, controls the gain of the regulating amplifier.

5.08 The regulating amplifier is a 3-stage negative-feedback amplifier with a nominal 14.5-dB gain, flat across the L4 band. Changes in cable temperature affect the level of the L4 signals, including the line pilots. Amplifier gain is regulated by a direct current, proportional to the level of the received 11.648-MHz pilot, applied to a thermistor in the temperature post-regulation circuit.

5.09 ***Transmitting repeater*** J68877AM (Fig. 8) mounts in the line transmitting bay. This repeater includes two detachable LBO networks which must be in place to complete the transmission path. A complete repeater weighs approximately 19 pounds and is 3.4 by 12 by 17 inches in size. The repeater is powered from regulated −25 volt power.

5.10 Figure 9 is a block diagram of the transmitting repeater.

5.11 The flat-gain amplifier is a 3-stage negative-feedback amplifier with a nominal 13.5-dB gain, flat over the L4 band, and provides an 11.648-MHz pilot nick adjustment.

5.12 Two LBO networks must be in place prior to placing the repeater in service. Each LBO network has two coaxial plugs for signal connections; screws hold the network to the repeater chassis. LBO 1 is a 4100A network which is provided as a part of the repeater and offers no loss to the L4 signals. LBO 2 is a 4100-type network which is selected according to the length of the line to the following basic repeater. LBO 2, in conjunction with the LBO in the following basic repeater, builds out the line to the nominal 2-mile spacing between repeaters.

5.13 The fixed-loss deviation equalizer compensates for predictable deviations anticipated in the basic repeaters in the following regulating section. These deviations result because several basic repeaters in tandem do not correct the loss exactly in the line over the L4 band. A deviation equalizer is selected according to the number of basic repeaters in the regulating section and is installed prior to placing the repeater in service.

5.14 The temperature preregulator is a passive network which offers a loss under control of an indirectly-heated thermistor in the network. Heater current can be manually adjusted to set network loss to the proper value. This adjustment should be made when cable temperature is at an average value.

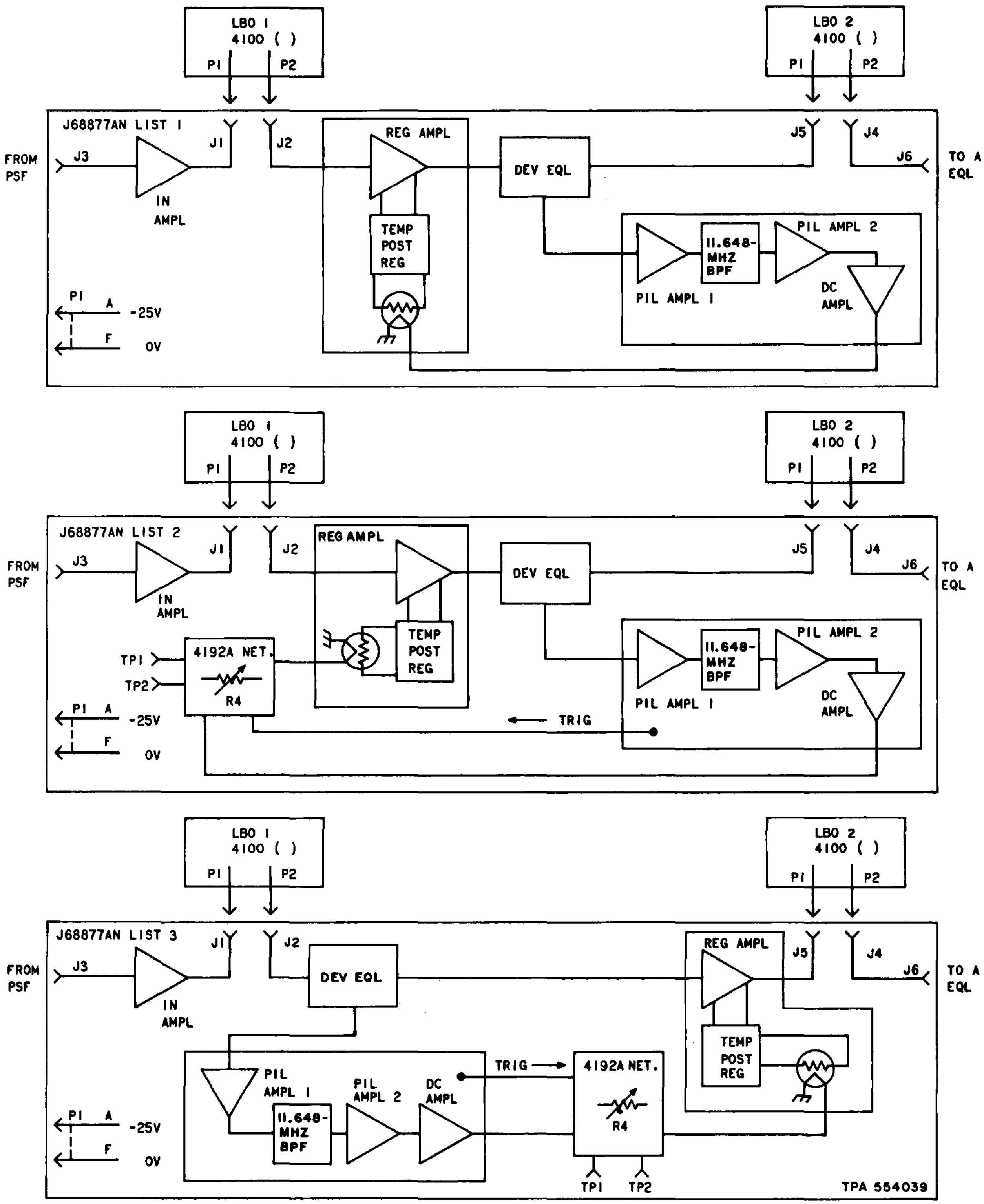

Fig. 7—Receiving Repeater—Block Diagram

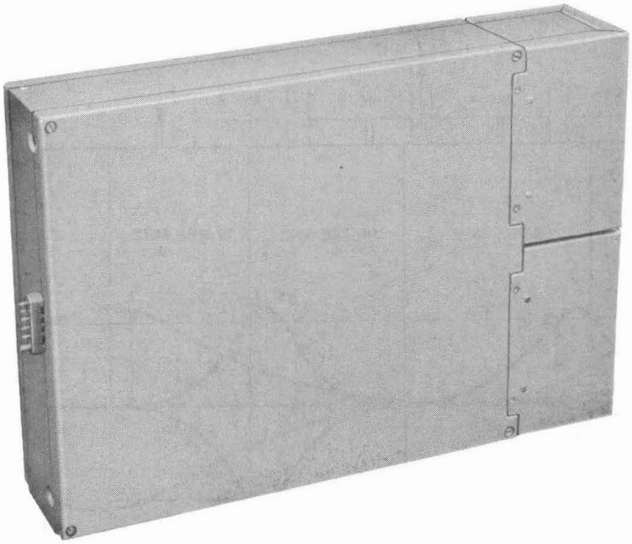

Fig. 8—Transmitting Repeater J68877AM

5.15 The output amplifier compensates for the loss of one mile of line at 55°F. This amplifier provides shaped, fixed gain from 6 dB at 0.5 MHz to 17 dB at 20 MHz.

B. A and B Equalizers

5.16 An ***A*** and a ***B*** equalizer are provided for each line at a main station. An A equalizer has six networks and a B equalizer has ten networks. These networks are step-adjustable, by commands from a control center, to provide bump-shaped gain changes at various frequencies as indicated in Fig. 10.

5.17 Each ***command*** consists of one, two, or three of ten audio signals at frequencies from 607.5 to 982.5 Hz. All commands are sent as signal pulses, 300 milliseconds long, except the commands to connect equalizer test signals or to connect monitoring oscillator signals. Commands

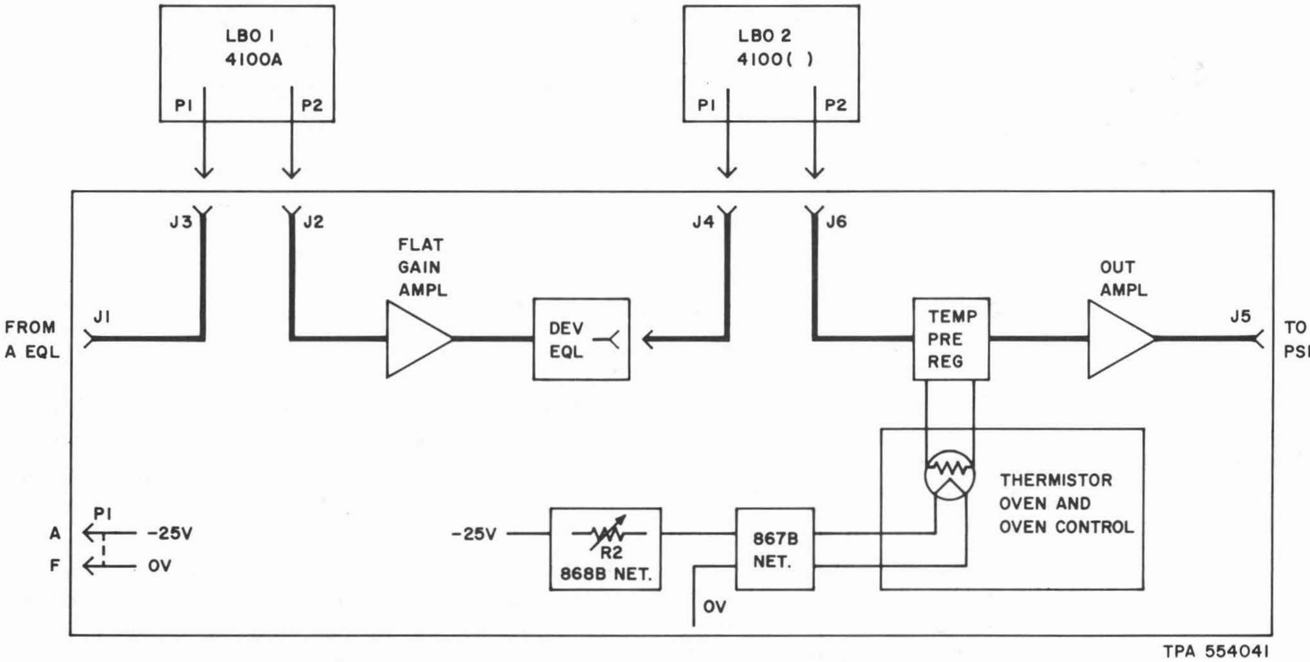

Fig. 9—Transmitting Repeater—Block Diagram

to the oscillators are sent as long as the oscillators are to remain on.

(a) In a main station containing a control center, commands are sent to the equalizers in that main station as audio command signals on office wiring.

(b) In a main station which does not have a control center, commands are sent to the equalizers in that main station from the control

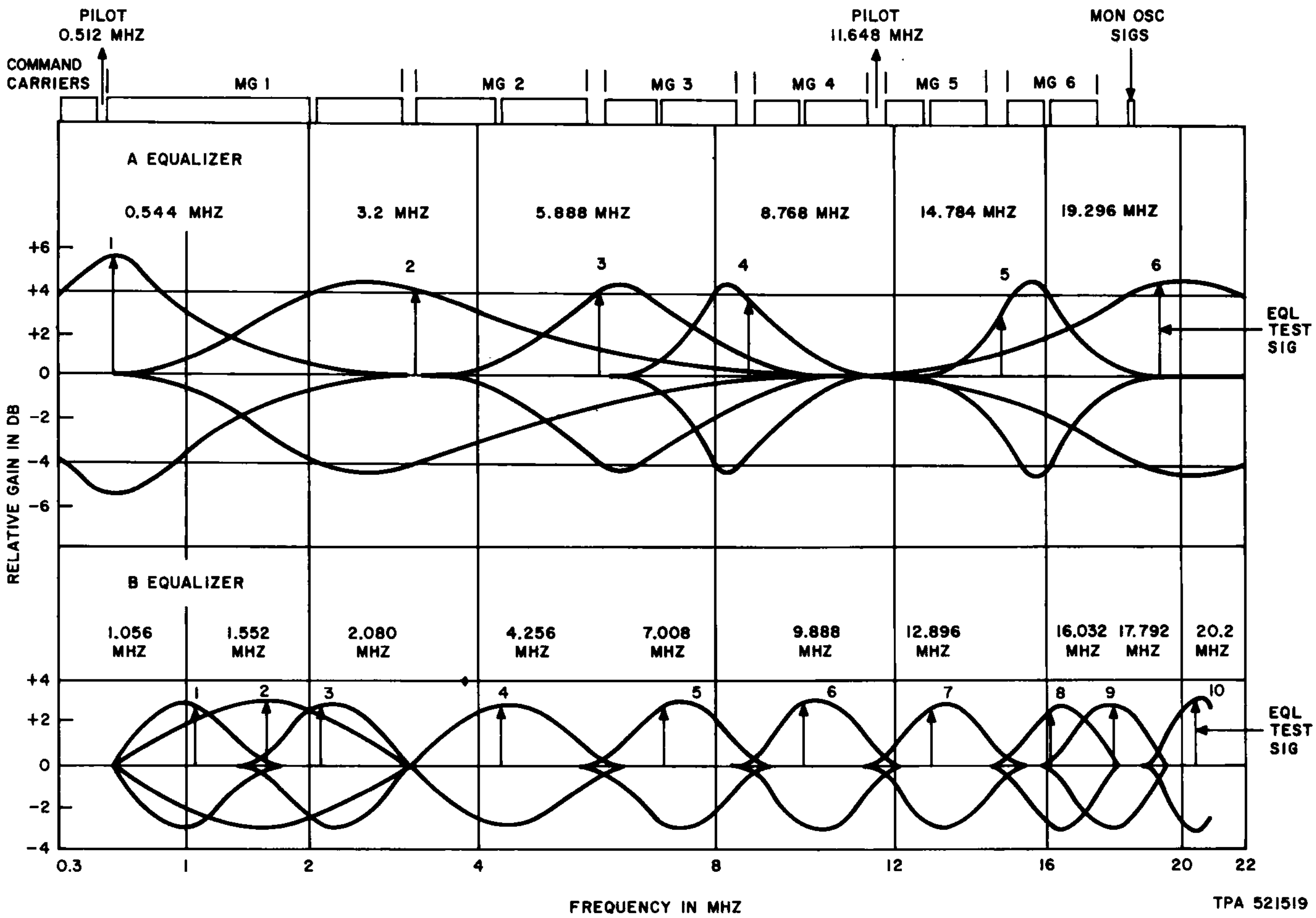

Fig. 10—Gain-Frequency Characteristics of A and B Equalizers

centers at the adjacent main stations. The audio command signals from the control centers are transmitted as modulation on command carrier frequencies in the band from 300 to 500 kHz. A loopback circuit is provided for each route and includes two command receivers. An ***equalizer*** command receiver in the loopback circuit selects and demodulates the command carrier signals addressed to the equalizers. A ***control*** command receiver in the loopback circuit connects the audio command signals from the equalizer command receiver to the desired A or B equalizer.

5.18 ***Logic*** associated with each equalizer decodes the audio command signals and initiates the proper response. These responses include turning on the A or B equalizer test oscillators, applying the equalizer test signals to the input or to the output of the desired equalizer, increasing or decreasing equalizer network gain in steps, resetting all equalizer networks to midgain, and, via A equalizer logic, turning on the monitoring oscillators.

5.19 ***Memory*** associated with each equalizer sets the desired gain in each equalizer network by providing the proper value of direct current to each network. Network gain remains at this setting until a new command is sent from the control center to change the memory.

5.20 An A equalizer shelf (Fig. 11) includes three plug-and-jack connected units: A equalizer, memory, and logic-test oscillators. Each of these units is 3.4 by 12 by 17 inches in size and is supplied −25 volt power from a dc-dc converter in the same bay.

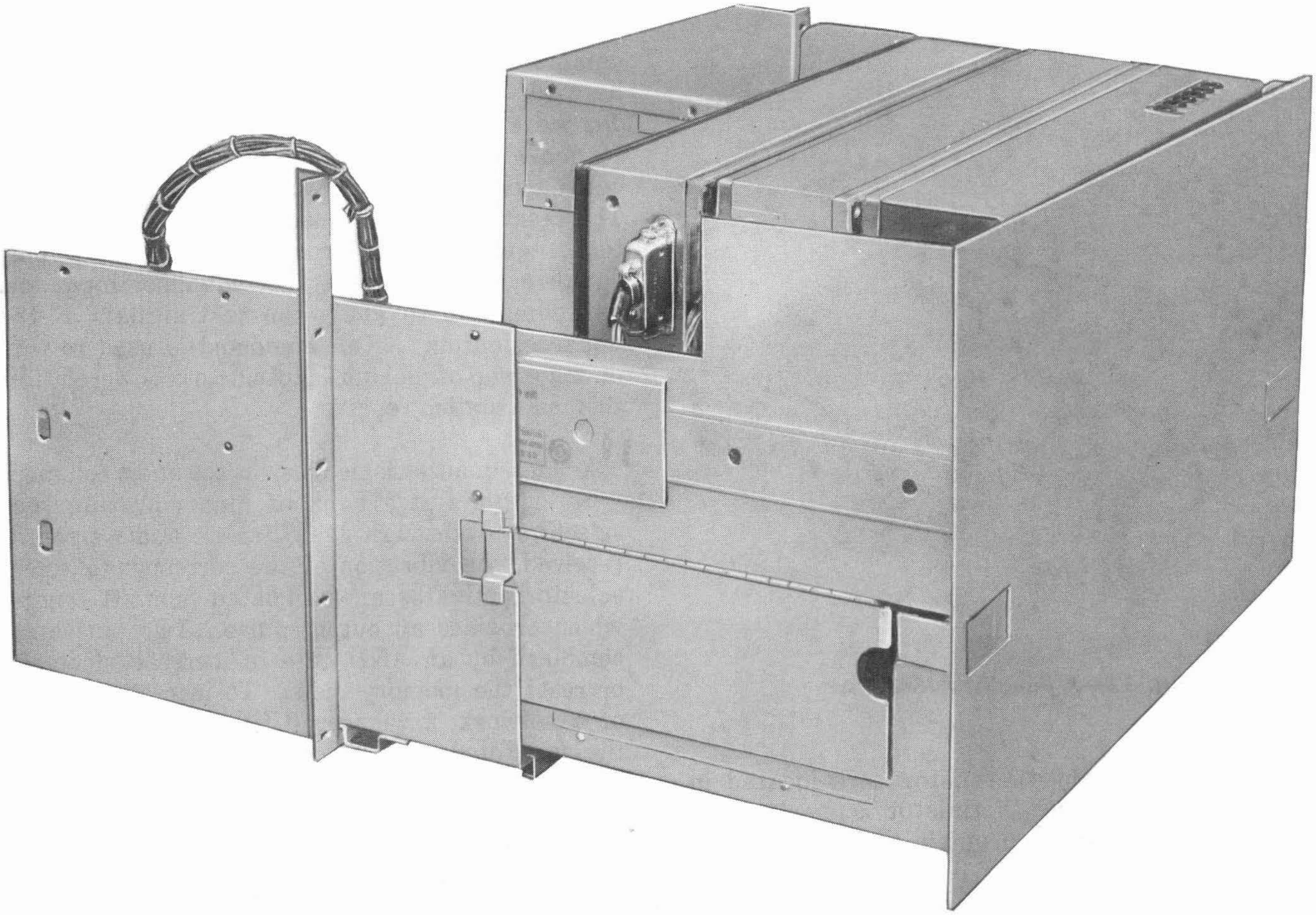

Fig. 11—A Equalizer Shelf

5.21 ***A equalizer*** J68877AP (Fig. 12) includes four amplifiers and six step-adjustable networks which control the gain across the L4 band. Each network contains an indirectly-heated thermistor under control of the equalizer memory. Six holes in the top of the equalizer provide access to potentiometers used to factory adjust the current to the equalizer network thermistors. Test points are provided at the top of the equalizer for checking the temperature of the thermistor ovens.

5.22 Figure 13 is a block diagram of the A equalizer. Hybrids at the equalizer input and output provide paths for inserting the A equalizer test signals. Four flat-gain amplifiers compensate for losses in the equalizer networks. A fixed-gain, factory-adjusted, trim equalizer compensates for gain-frequency deviations in the A equalizer when all six networks are at midgain.

5.23 The six equalizer networks have gain shapes as shown in Fig. 10. The gain of each network is determined by the resistance of an indirectly-heated thermistor in the network. Current to the heater of each thermistor is individually controlled by the memory. In each of the six heater circuits, a bias current is supplied through a potentiometer and is combined with a current from the memory. Potentiometer controls, accessible at the top of the A equalizer, are factory adjusted to compensate for variations in the equalizer thermistors.

5.24 Thermistors for the equalizer networks are contained in two ovens, with three thermistors in each oven. These ovens maintain a uniform temperature. Thermistor resistance is a function of heater current and is independent of ambient temperature.

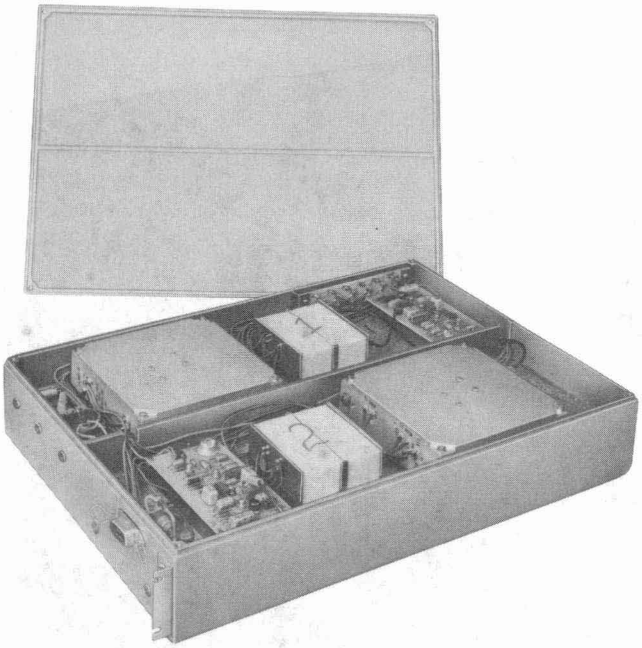

Fig. 12—A Equalizer J68877AP

5.25 Two auxiliary thermistors are located in each oven; one thermistor is used by an oven control network to maintain oven temperature and the other thermistor is terminated in test points on top of the equalizer. Oven temperature can be checked by measuring the resistance between the test points.

5.26 ***A equalizer logic and test oscillators*** (Fig. 14) are described in the following paragraphs.

5.27 ***A equalizer logic*** is similar to B equalizer logic (Fig. 15) except that only six memory units are controlled. The A equalizer logic also controls the power to a group of monitoring oscillators.

5.28 Equalizer logic receives the audio command signals from a control center directly or via a loopback circuit which serves that route. Audio command signals are applied to a bank of vibrating reed selectors which are resonant elements, like miniature tuning forks, with an effective bandwidth of 1 Hz. A equalizer logic includes nine selectors, A through J; the B equalizer logic includes all ten selectors.

5.29 A equalizer logic is arranged to detect 16 commands from a control center. Thirteen commands are used to adjust the A equalizer networks; six commands are used to individually ***increase*** the gain of the networks, six commands to ***decrease*** the gain of the networks, and a ***reset*** command to return all six networks to midgain. The reset command is useful when a new line is to be equalized. One command is used to apply equalizer test signals at the equalizer input and one command to apply the test signals at the equalizer output. One command is used to turn on the group of monitoring oscillators powered from this main station repeater.

5.30 A equalizer logic receives the audio command signals at a bank of nine vibrating reed selectors, A through J. When an audio signal is received, the vibration of the corresponding reed selector activates an associated Schmitt trigger which provides an output pulse. Two pulses are combined by an AND gate to increase, decrease, or reset the memory units. To increase the gain of a network, a countup (CU) pulse is applied to the associated memory unit; to decrease the gain, a countdown (CD) pulse is applied.

5.31 A steady audio signal of frequency G operates relay CT1 which energizes the equalizer test oscillators and connects the six test signals at the A equalizer ***input***. Similarly, audio signal H operates relay CT2 which connects the equalizer test signals at the A equalizer ***output***.

5.32 A steady audio signal of frequency J applies power to a group of monitoring oscillators.

5.33 ***A equalizer test oscillators*** (Fig. 16) produce the six test signals used during A equalizer adjustments. These oscillators are crystal controlled and the output of each oscillator is applied to a filter which suppresses all undesired signals. A command from the control center turns the oscillators on and connects the test signals, via relay contacts, either to the equalizer input or output, as desired. The received equalizer test signal levels are individually indicated on the control center meters. Equalizer networks can be adjusted by additional commands from the control center.

5.34 ***A equalizer memory*** J68877AR (Fig. 17) contains six memory units, one for each of the six adjustable A equalizer networks. Each

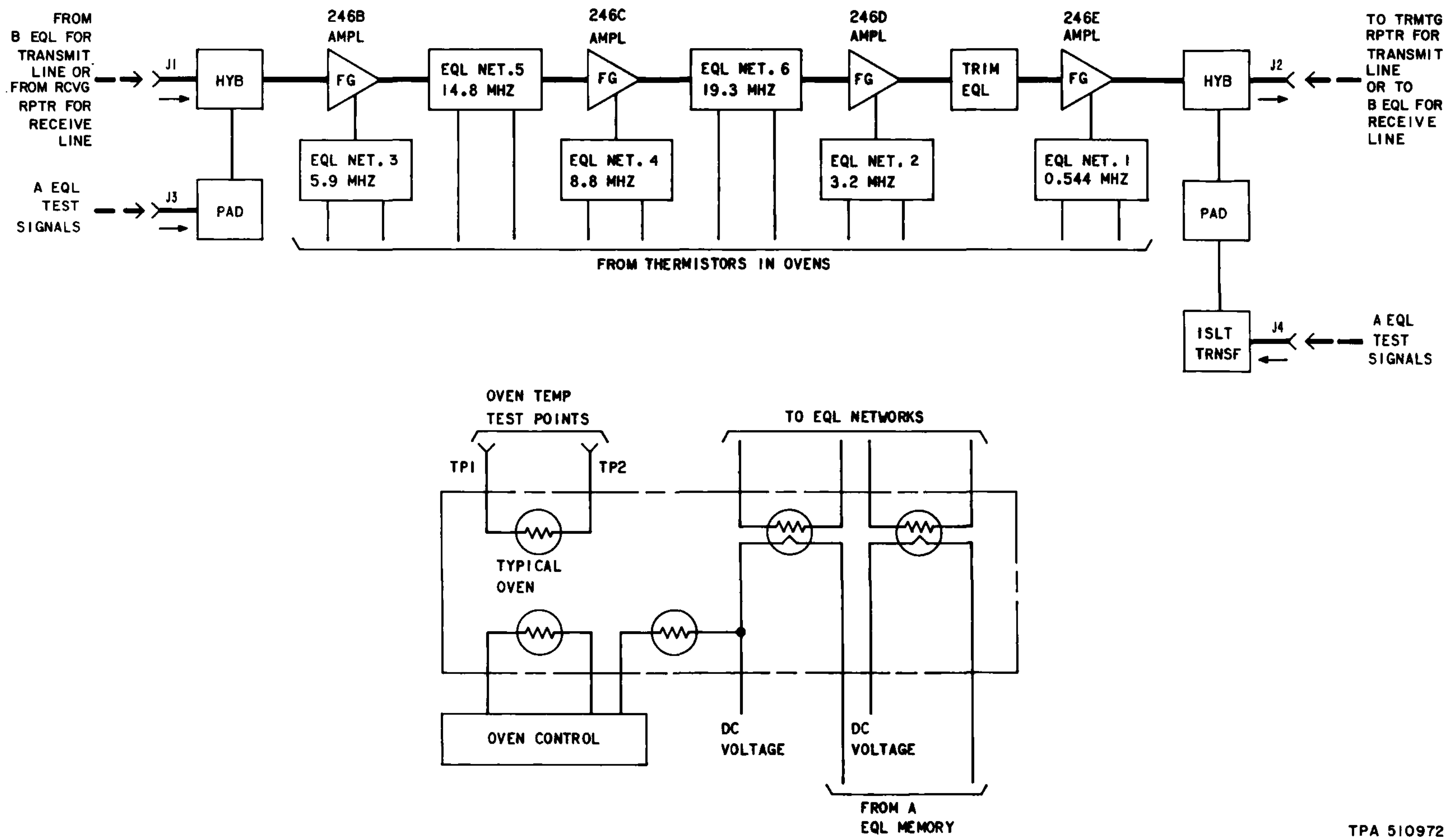

Fig. 13—A Equalizer—Block Diagram

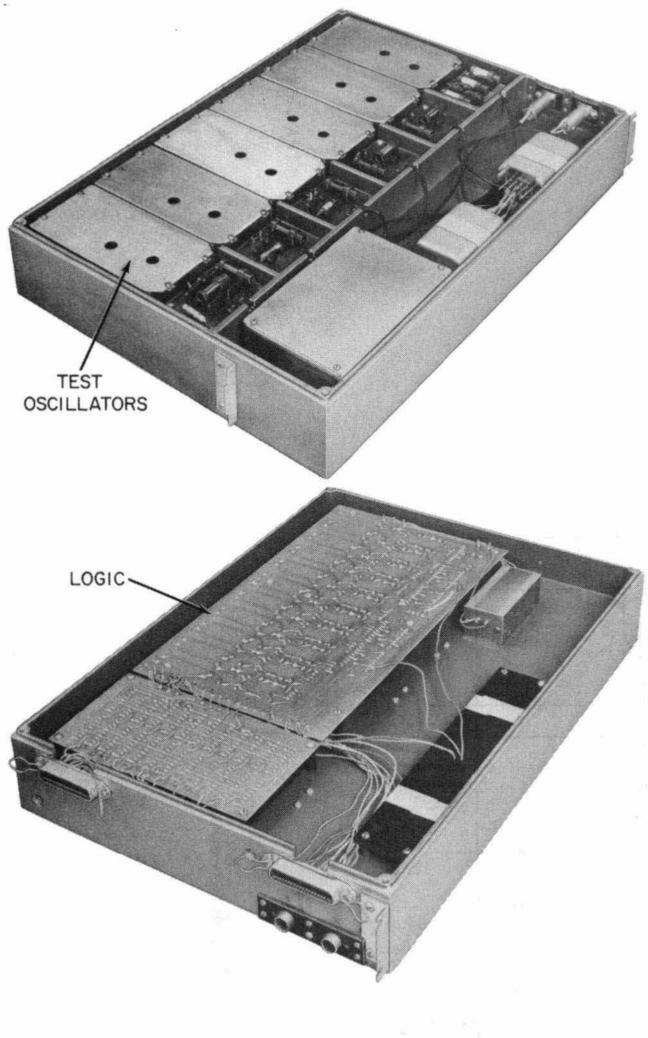

Fig. 14—A Equalizer Logic and Test Oscillators J68877AS

memory unit controls the thermistor heater current in the associated equalizer network.

5.35 A equalizer memory is similar to B equalizer memory (Fig. 18), except for the number of networks controlled.

5.36 Each memory unit consists of input steering logic, a 5-stage or 6-stage reversible binary counter, power amplifiers, and a resistive weighting network. The reversible binary counter can be set to any one of 32 (or 64) possible states. In the absence of a command to change, the counter will hold a given state as long as power is applied.

5.37 Three types of commands control the memory: countup, countdown, and reset. Countup and countdown commands, to increase and decrease gain, are applied to each memory unit independently. The reset command, to restore gain to midrange, is applied to all memory units simultaneously.

5.38 When a command to change the count in a particular memory unit is received and decoded by the logic, a 12-volt positive pulse is applied to the memory on the appropriate lead (countup, countdown, or reset). This pulse is applied to the reversible binary counter through a steering circuit. The binary counter will respond by increasing one count, decreasing one count, or resetting, depending on the command received. Overcount and undercount inhibits are provided in a counter. When a counter reaches maximum countup or countdown capacity, attempts to further advance the counter are inhibited. The overcount inhibit is released by either a countdown or reset command. Similarly, the undercount inhibit is released by a countup or reset command.

5.39 A continuous output is provided by each stage of the binary counter. Each output is connected through a power driver (PD) amplifier to a weighting resistor in the summing network. The combined current output of the summing network is proportional to the count stored in the binary counter. This current is applied to the thermistor heater of the appropriate A equalizer network. The thermistor heater current in turn determines the thermistor resistance and, thus, the loss of the associated equalizer network.

5.40 ***B equalizer*** J68877AU (Fig. 19) consists of a shelf and four plug-in drawers. The shelf contains hybrids, two pairs of relays, and connecting circuits. Each drawer contains an amplifier, equalizer networks, an oven, and an oven control circuit.

5.41 Figure 20 is a block diagram of the B equalizer which is electrically similar to the A equalizer. Hybrids at the equalizer input and output provide paths for inserting the B equalizer test signals. Four flat-gain amplifiers compensate for losses in the equalizer networks. A fixed-gain, factory-adjusted, trim equalizer compensates for gain-frequency deviations in the B equalizer when all ten networks are at midgain.

5.42 The ten equalizer networks have gain shapes as shown in Fig. 10. The gain of each network is determined by the resistance of an

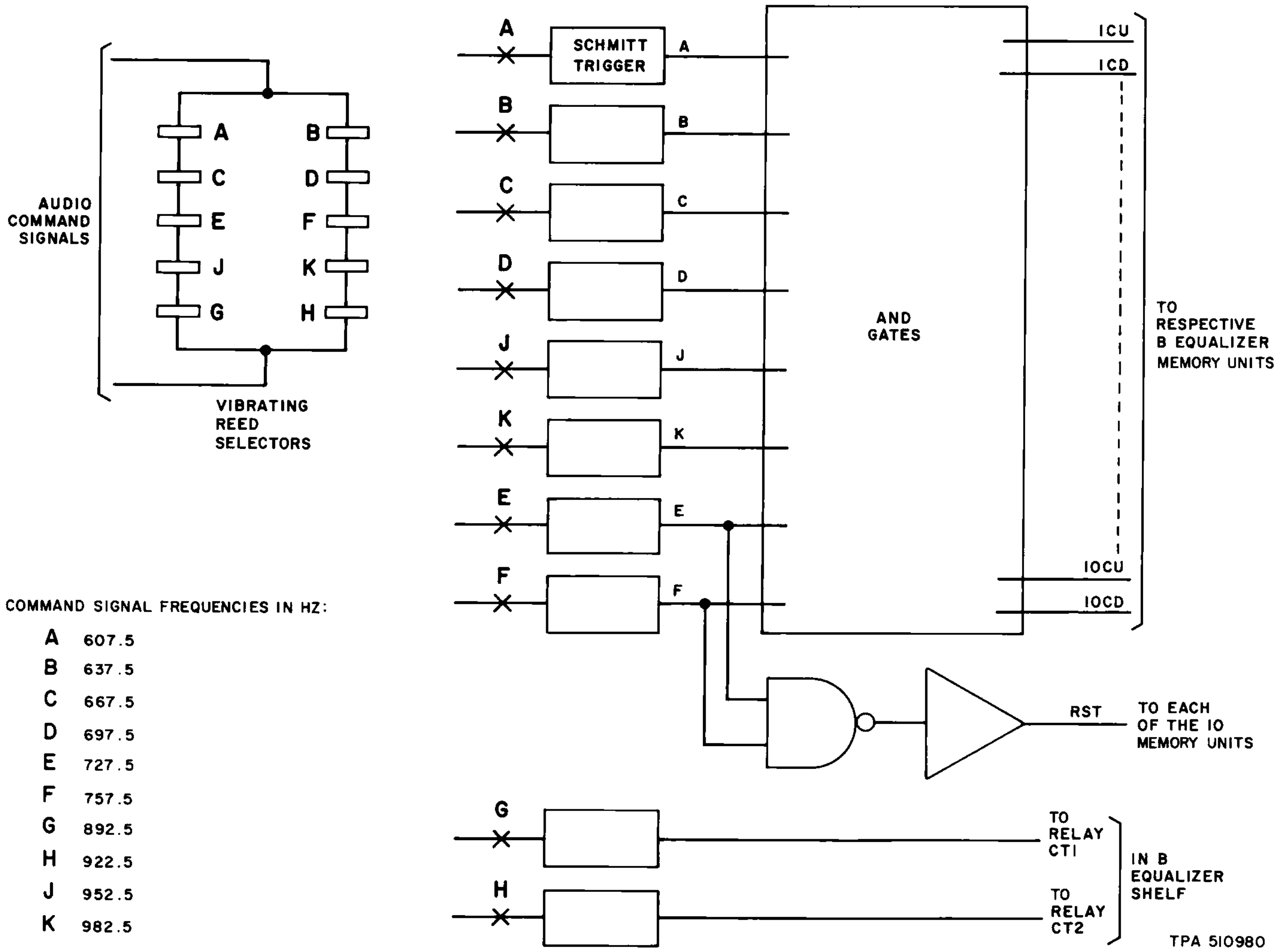

Fig. 15—B Equalizer Logic — Block Diagram

indirectly-heated thermistor in the network. Current to the heater of each thermistor is individually controlled by the memory. In each of the ten heater circuits, a bias current is supplied through a potentiometer and is combined with the current from the memory. Potentiometer controls are accessible at the front of the drawers. Potentiometers are factory adjusted to compensate for variations in the equalizer thermistors. Test points at the front of the drawers permit checking the temperature of the thermistor ovens.

5.43 ***B equalizer test oscillators*** produce the ten test signals used during B equalizer adjustments. These oscillators and a connecting circuit are provided in a control connecting bay. The equalizer test signals are distributed to each B equalizer in the line transmitting and line receiving bays for the route served by the control connecting bay. A command from the control center turns the oscillators on and connects the test signals either to the equalizer input or output, as desired. The received equalizer test signals are individually indicated on the control center meters and the equalizer networks can be adjusted by additional commands from the control center.

5.44 ***B equalizer logic*** is arranged to detect 23 commands from a control center. Twenty-one commands are used to adjust the B equalizer networks: ten commands to individually ***increase*** the gain of the networks, ten commands to ***decrease*** the gain, and a ***reset*** command to return all ten networks to midrange. One command is used to

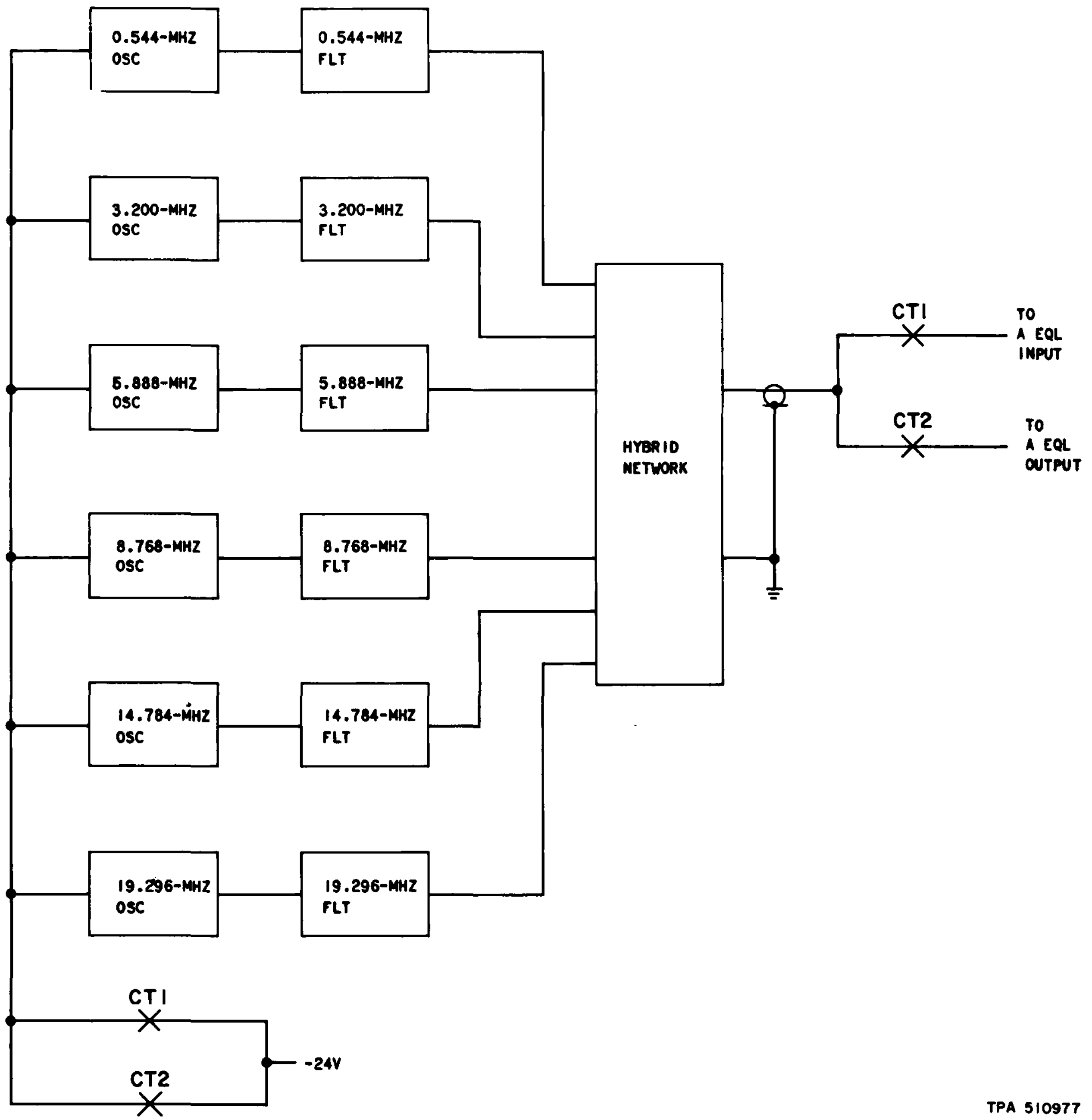

Fig. 16—A Equalizer Test Oscillators—Block Diagram

apply equalizer test signals at the equalizer input and one command to apply the test signals at the equalizer output.

5.45 ***B equalizer memory*** contains ten memory units. Each memory unit operates the same as an A equalizer memory unit.

5.46 ***B equalizer logic and memory*** J68877BY in later equipment serves the functions of B equalizer memory J68877AY and B equalizer logic J68877AZ which are manufacture discontinued.

C. Band-edge Regulator

5.47 A 512-kHz band-edge regulator and monitoring oscillator signal blocking J68877BW panel mounts in the line receiving bay to serve these two functions. Figure 21 is a block diagram of the 512-kHz band-edge regulator.

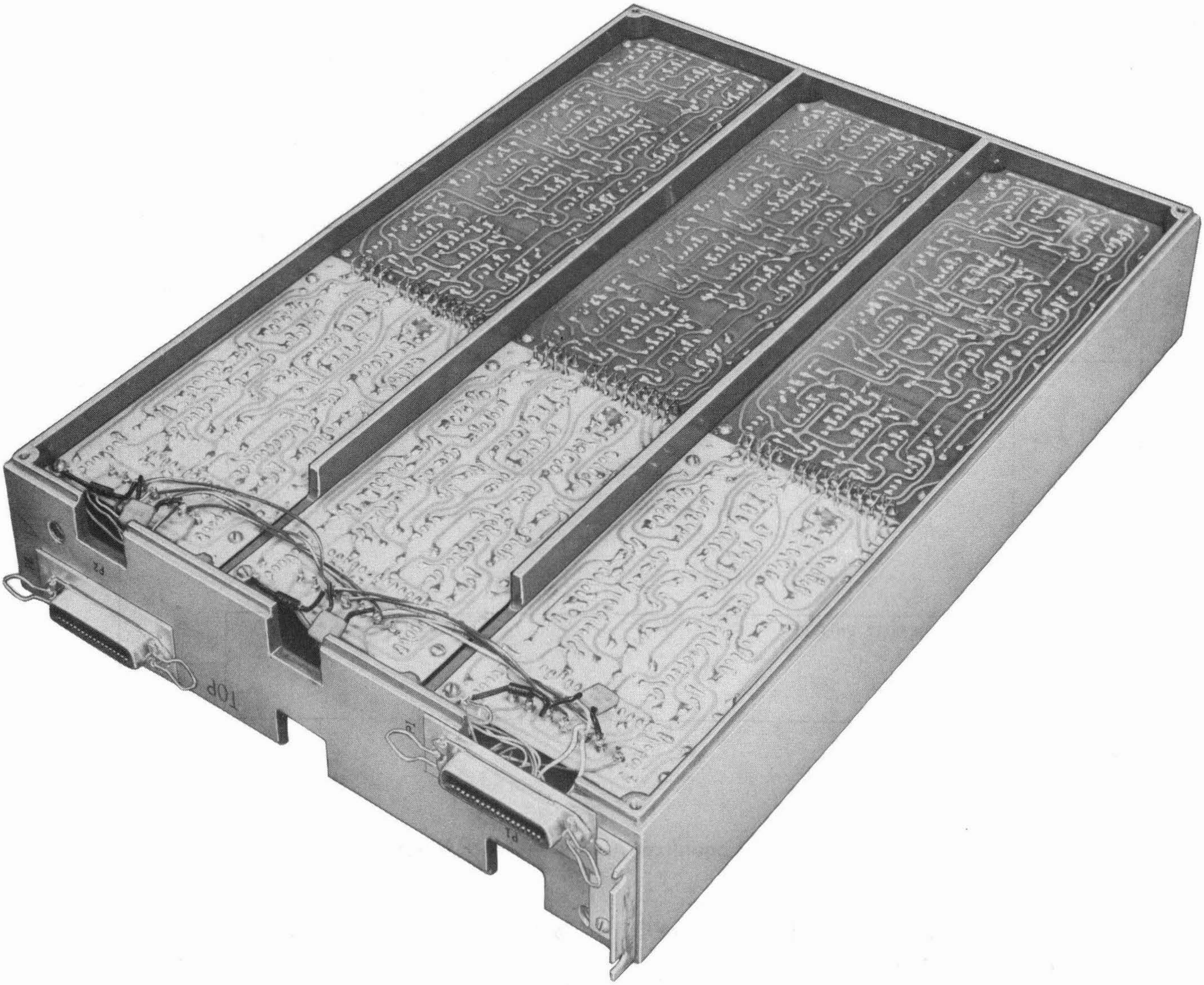

Fig. 17—A Equalizer Memory J68877AR

5.48 Temperature changes affect the gain of the L4 repeaters, particularly at the ends of the L4 band. The regulator, under control of the level of the received 512-kHz pilot, provides gain correction at the low end, below 3 MHz. The correction available in the regulator has a gain-frequency characteristic identical to that of the 544-kHz network in the A equalizer (Fig. 10).

5.49 L4 signals from the receiving hybrid connect to the regulating amplifier via a factory-adjusted pad which sets the overall gain of the regulator to 7.7 dB.

5.50 The regulating amplifier is a 2-stage negative-feedback amplifier which corrects for gain deviations at the low frequencies. The entire L4 band is connected to a 512-kHz crystal bandpass filter via the first pilot amplifier. Only the 512-kHz signal is applied to the second pilot amplifier which provides a dc output proportional to the level of the 512-kHz signal. A direct current from the dc difference amplifier varies the resistance of an indirectly-heated thermistor which changes the regulating amplifier gain. This results in a constant level for low-frequency signals at the output of the regulating amplifier.

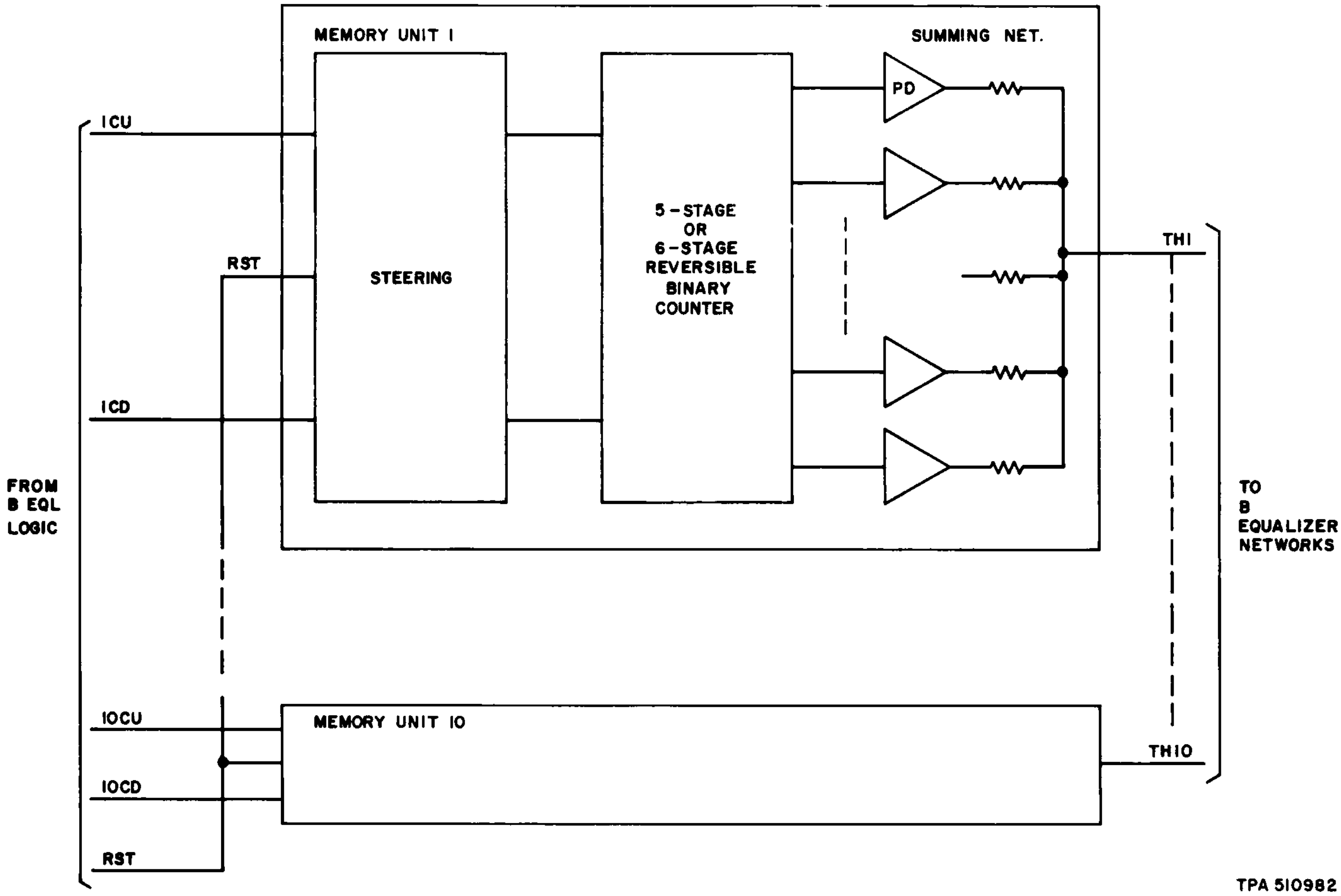

Fig. 18—B Equalizer Memory—Block Diagram

5.51 In earlier equipment, a 512-kHz regulator is provided in a J68877BA panel, monitoring oscillator signal blocking is provided in a J68877BD panel, and a 20.448-MHz regulator is provided in a J68877BE panel for regulation at the high end of the L4 band (15 to 20 MHz). These three panels are now manufacture discontinued.

D. Monitoring Oscillators

5.52 One monitoring oscillator assembly and a dc-dc converter are provided at each main station to serve two receive and two transmit lines of a route. This equipment and a power separation filter are mounted in a shelf (Fig. 23) at the top of one of the two line receiving bays served by the monitoring oscillator assembly.

5.53 Each monitoring oscillator produces an assigned frequency in the band from 18.50 to 18.56 MHz. A group of monitoring oscillators (Fig. 22) can be powered by a command received on any of the four lines. A ***group*** may contain up to 16 frequencies spaced at 4-kHz intervals or 21 frequencies spaced at 3-kHz intervals for a sideleg route. A frequency is assigned to each repeater location; the frequencies are in order with the lowest frequency in a group at the east or north end.

5.54 Monitoring oscillator signals are applied to four lines at a time, two lines in each direction. A spectrum analyzer in the control center displays the received monitoring oscillator signals.

5.55 When audio signal J is received at an A equalizer, the equalizer logic causes the 313A relay to operate and remain operated as long as this signal is received. Relay CMP operates and connects −24 volts to the dc-dc converter. The

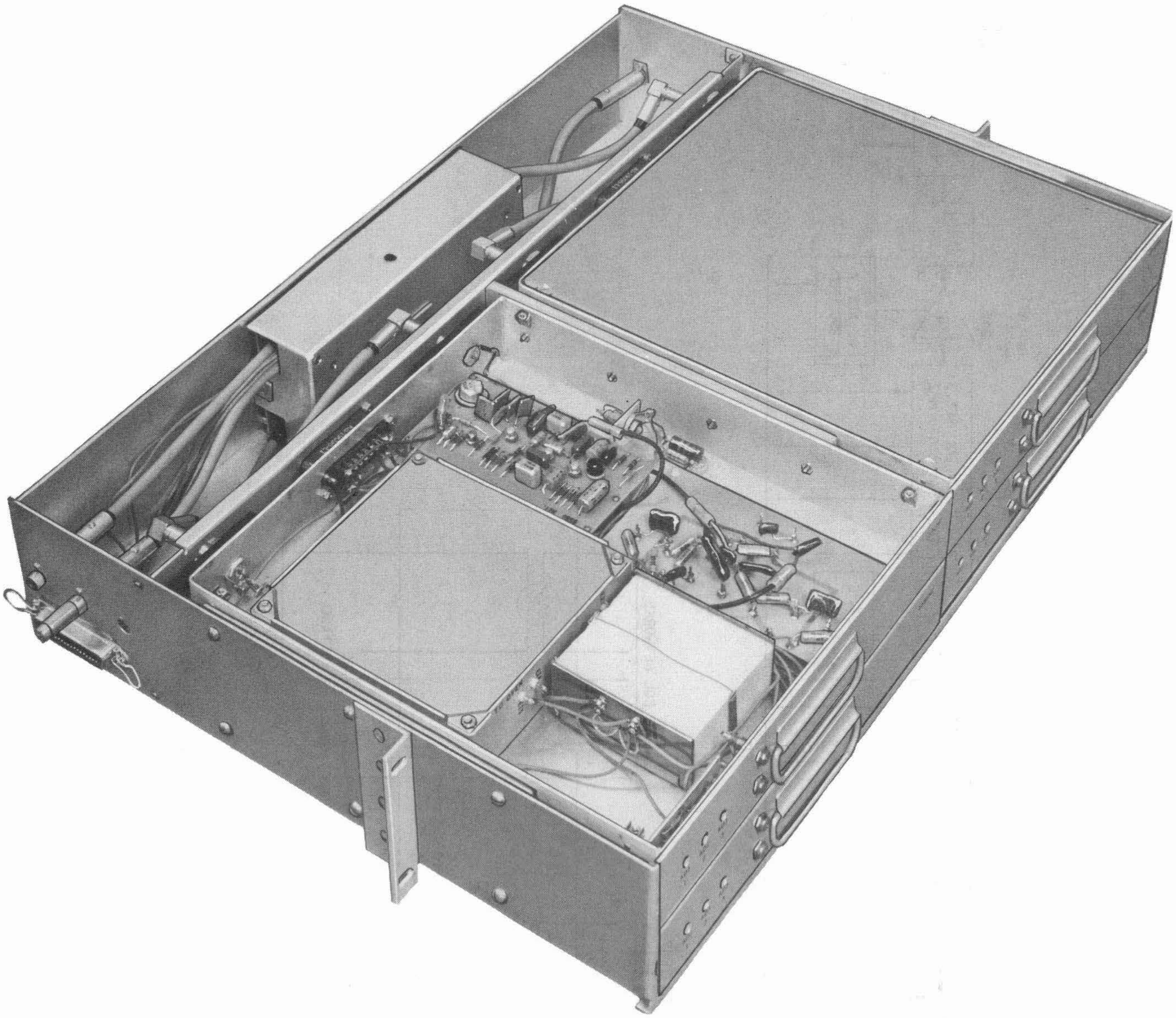

Fig 19—B Equalizer J68877AU

converter output is between 80 and 250 volts dc, as required, to supply 15 mA dc to the group of monitoring oscillators.

5.56 The monitoring oscillator output connects through a distribution network which provides four independently-adjustable outputs, one for each line served. Signal to a transmit line is connected at the transmitting combining circuit (Fig. 5) and signal to a receive line is connected at the power separation filter.

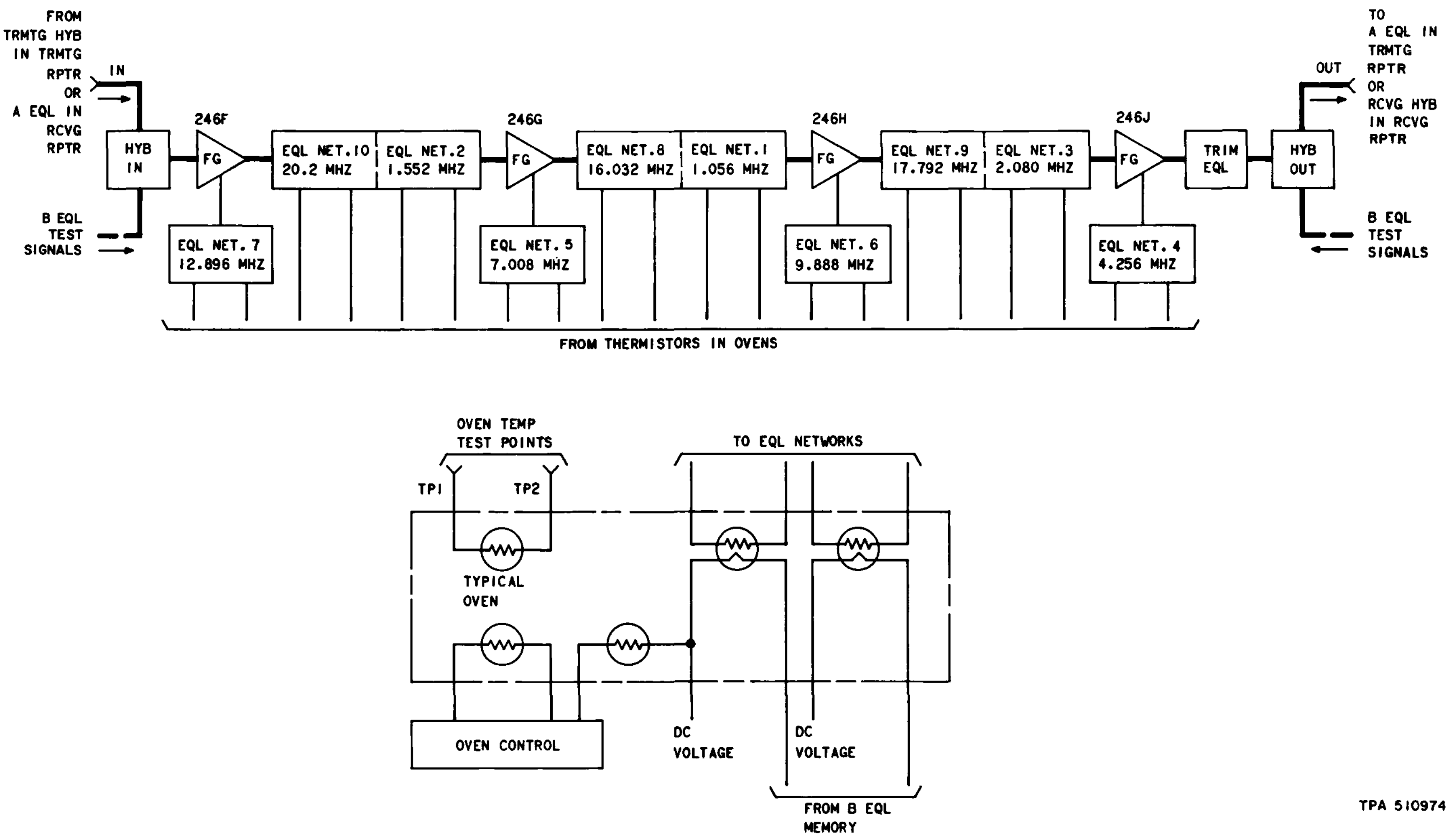

Fig. 20—B Equalizer—Block Diagram

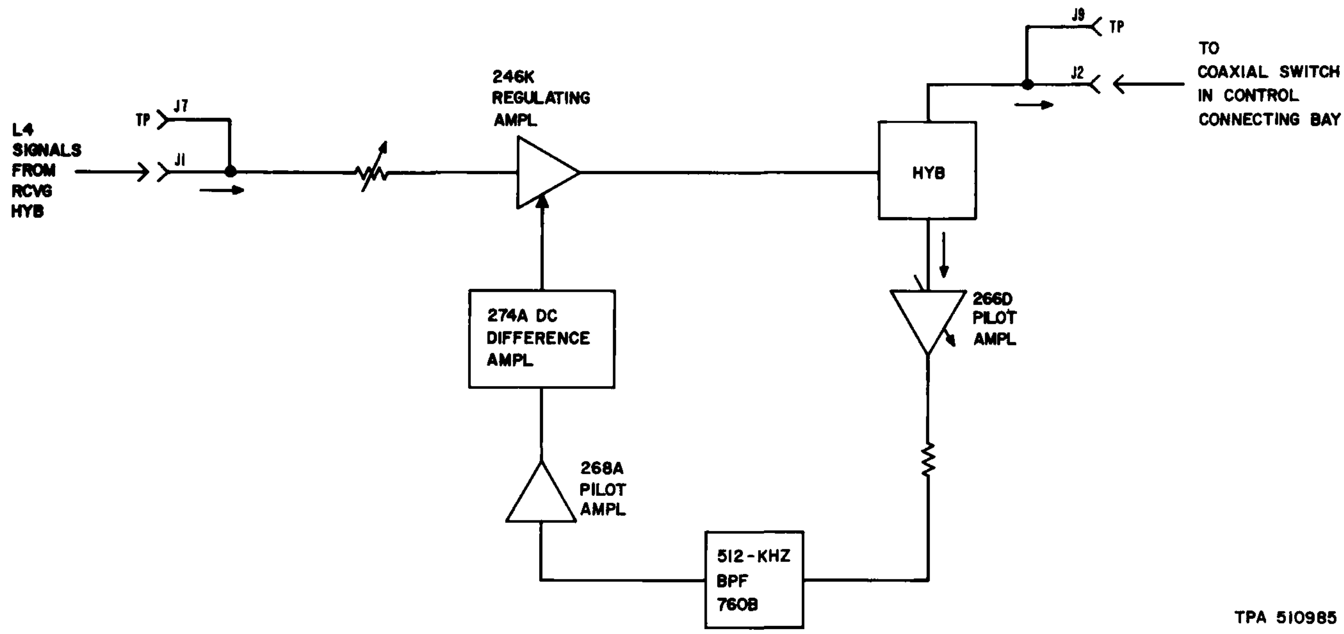

Fig. 21—512-kHz Band-edge Regulator—Block Diagram

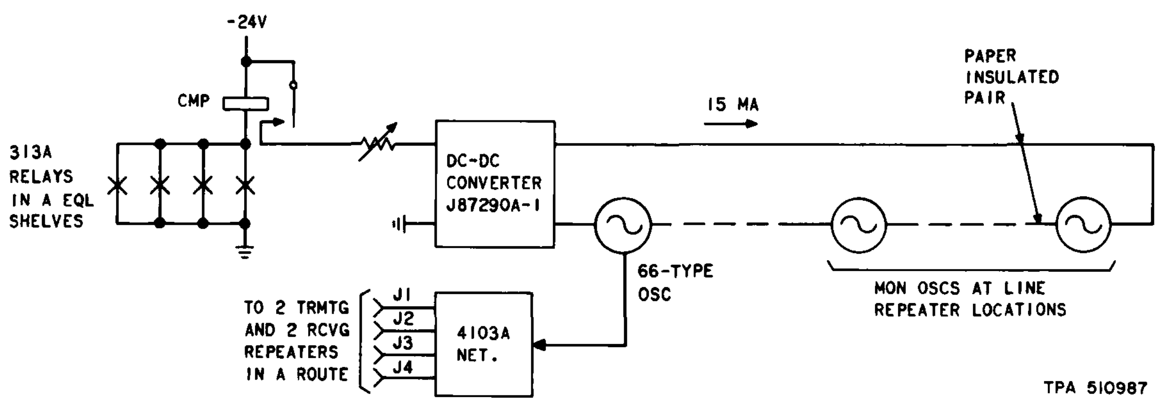

Fig. 22—Monitoring Oscillator Arrangement—Block Diagram

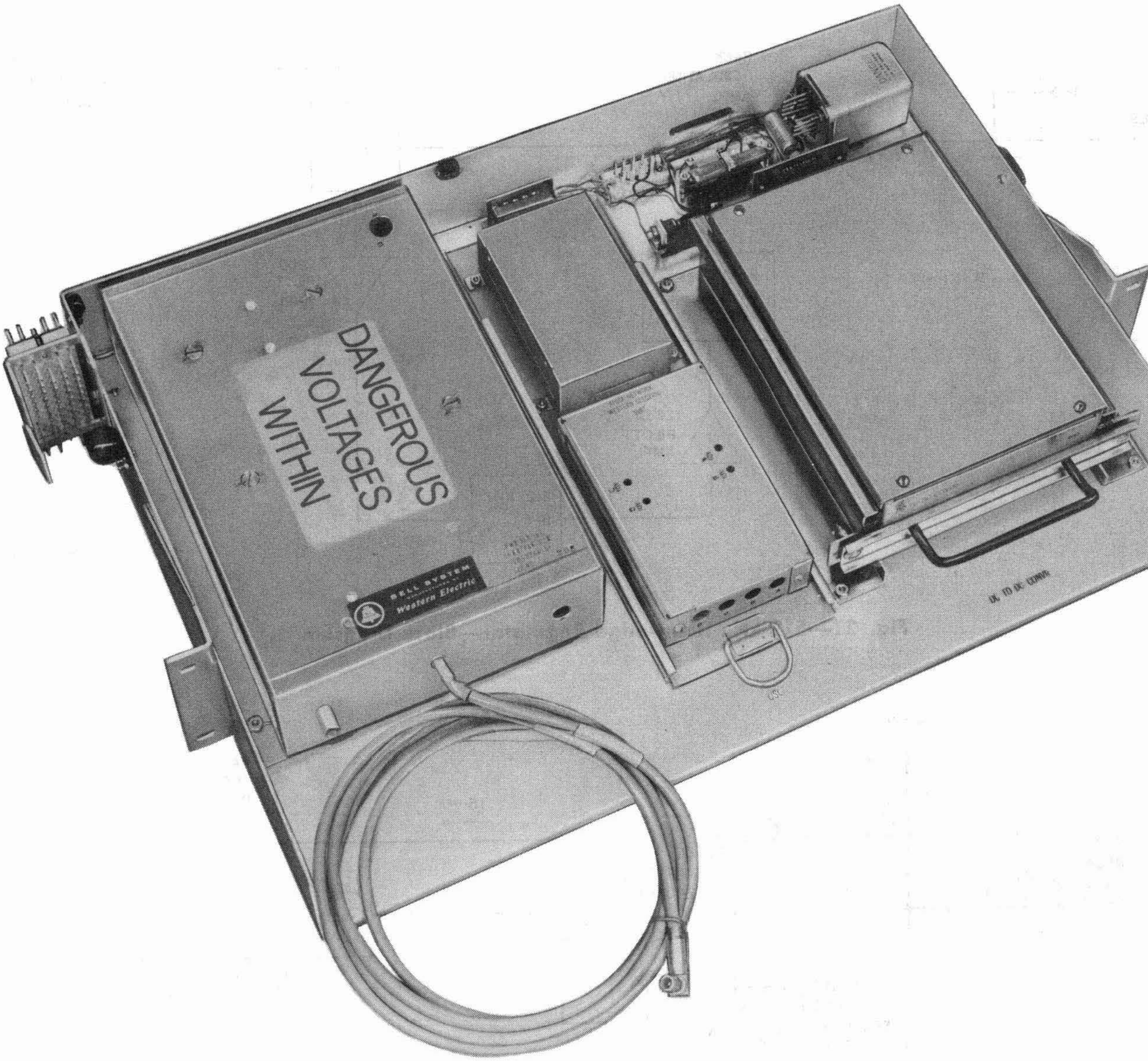

Fig. 23—Power Separation Filter and Monitoring Oscillator Shelf