L3 CARRIER

DESCRIPTION

REPEATERS

CONTENTS — PAGE

1. GENERAL

1.01 This section describes the following repeaters, which are used in the L3 carrier system high-frequency lines.

(a) Auxiliary repeaters

(b) Equalizing auxiliary repeaters

(c) Equalizing main repeaters

(d) Switching main repeaters

(e) Terminal main repeaters

1.02 This section is reissued to include information on Performance Evaluation at Remote Locations (PEARL). This equipment is added to each repeater in the L3 line.

1.03 In this section, all-message system applications are covered in detail. Combined message and television arrangements are covered in general terms since only limited use of such systems is expected. Because of the customized nature of these applications, installations for combined system use will continue to be handled on a job-engineered basis with the recommendations of the Bell Telephone Laboratories.

1.04 In the L3 system, the medium of transmission between terminals is the high-frequency line consisting of a coaxial conductor, associated repeaters, and connecting equipment. Separate high-frequency lines are used for the two directions of transmission on a 4-wire circuit.

1.05 Coaxial conductors attenuate the transmission of the carrier-frequency currents. The attenuation varies with frequency, temperature, and other causes. In a 4000-mile L3 coaxial system, the accumulated gain distortion of the cable over the frequency band of 300 to 8350 kHz could be as much as 40,000 dB. In the L3 system, repeaters located at 4-mile intervals along the line provide amplification, equalization, and regulation required to maintain the desired transmission level.

1.06 The word repeater as used in this section is an all-inclusive term embracing the components installed at any one location necessary to provide satisfactory transmission of the frequencies (300 to 8350 kHz) over the high-frequency line. A repeater and its preceding 4-mile section of coaxial cable are known as a repeater section.

1.07 The basic function of a repeater is to provide 2-way amplification and regulation which produces, and maintains with changing conditions, a gain-frequency characteristic over the frequency band of 300 to 8350 kHz. This gain-frequency characteristic is closely equal to the loss-frequency characteristic of 4 miles of 0.375-inch or 2.87 miles of 0.27-inch polyethylene-insulated coaxial cable, or up to 2.80 miles of 0.27-inch rubber-insulated coaxial cable.

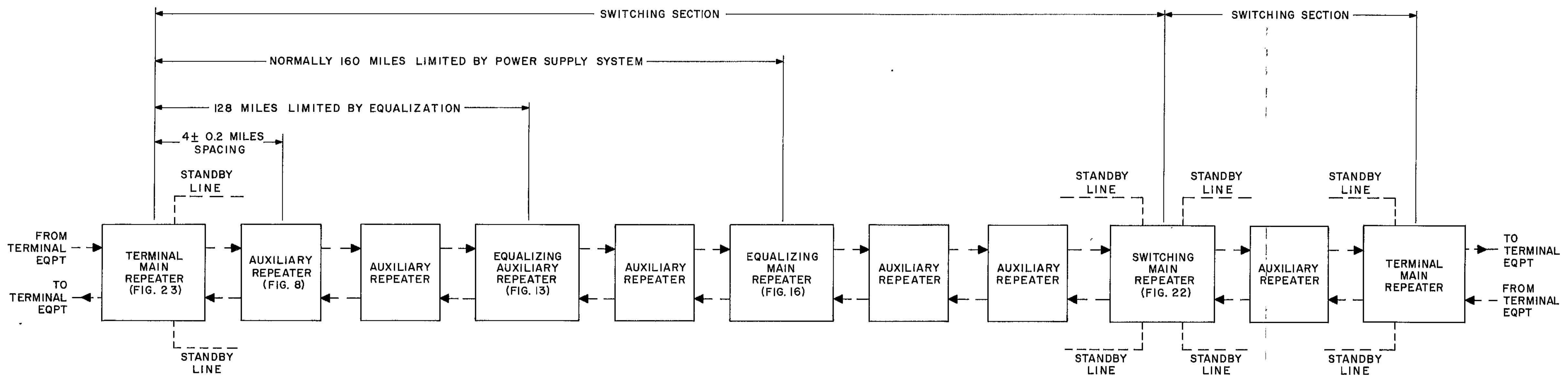
1.08 Figure 1 illustrates the L3 high-frequency line from terminal repeater to terminal repeater with a brief description of the individual repeater functions. The high-frequency line is composed of switching sections, so called because such a section is backed up by a standby line which is switched into service automatically on the failure of any one of the regular lines. A switching section consists of switching facilities at each end connected by means of a number of auxiliary repeater sections operating between intervening equalizing auxiliary or equalizing main repeaters as required.

1.09 Table A lists the transmission equipment used at the different repeaters. This table shows that the number of components and the complexity of the repeater increase with the functions performed. A functional description of these components is included in this section in the individual repeater descriptions.

1.10 Repeaters used in the L3 system can be divided into two general groups, those that receive power from the cable and those that obtain power locally. The first group normally includes the auxiliary and equalizing auxiliary repeaters, which operate from a constant current fed to them over the center conductors of the two associated coaxial cables. The other group includes the equalizing main, the switching main, and the terminal main repeaters which normally operate on power fed directly from a local 230-volt regulated source. Switching and terminal main repeaters may also be arranged to receive power over the coaxial cables in the same manner as the auxiliary and equalizing auxiliary repeaters. Those repeaters which are fed from one power source together with the two associated coaxial lines constitute a power section. Each power section is supplied from a 505D power plant located at an equalizing main, a switching main, or a terminal main repeater.

1.11 Figure 2 illustrates, in simplified form, a power section including two auxiliary repeaters. One is an intermediate repeater and the other is a junction repeater where adjacent power sections are looped. The power control circuit operates on 230 volts from the 505D power plant and steps up the voltage to the value necessary to drive the constant line current through the impedance of a power section. The line current is transmitted to the center conductors of a pair of coaxial lines through power separation filters (PSF) shown in simplified form in Fig. 2. Transmission and power currents make common use of these center conductors until the first auxiliary repeater from the supply point is reached; there they are separated by the power separation filters and are passed to their own portions of the repeater circuit. The inductors designated "L" are power circuit loading coils used to maintain uniform line current. Coils identified as "T" are primaries of two power transformers, with three secondary windings of each being omitted. Normally, two power sections are used between adjacent main stations. Both power sections terminate at the same repeater, called a junction repeater. At a junction repeater, a connection is made between the ends of the transformer primary windings to close one power loop. The adjacent power section, which is fed from the opposite direction, is looped through a looping coil designated "PL" or through a power transfer circuit.

1.12 Power sections may be arranged for operation in either of two power systems, known as PS1 or PS2. The earlier standard power supply arrangements used at the repeaters have been designated as PS1. An improved power supply designated PS2 was developed for use in power sections including repeater equipment at underground repeater locations; however, it may be used in



TERMINAL MAIN REPEATER

Transmitting — Receives transmission frequencies from terminal equipment. Introduces pilots and raises the level of the entire frequency band 312 to 8320 kc for transmission over the line.

Receiving — Raises the level of the incoming frequency band 312 to 8320 kc. Provides equalization and regulation.

Line Connecting — Provides means of bridging, blocking, and dropping transmission frequencies. Removes pilots and connects transmission frequencies to terminal equipment.

Switching — Automatically switches a standby line in place of any regular line in case of failure.

Power — Furnishes power to approximately 22 auxiliary repeaters or receives power from the cable.

AUXILIARY REPEATER

Transmission — Provides amplification and regulation through the medium of a line amplifier to match the loss characteristics of 4 miles of 0.375-inch coaxial cable.

Two types: (a) Pilot controlled.

(b) Thermometer controlled.

Power — Powered from cable.

EQUALIZING AUXILIARY REPEATER

Transmission — Same transmission functions as an auxiliary repeater; also provides additional equalization and regulation to overcome accumulated deviations of a number of auxiliary repeaters.

Power — Powered from cable.

EQUALIZING MAIN REPEATER

Transmission — Provides same transmission functions as an equalizing auxiliary repeater.

Power — Supplies power to local equipment plus approximately 22 repeaters in each direction.

SWITCHING MAIN REPEATERS

Transmission — Same functions as equalizing auxiliary or equalizing main repeater; also provides additional equalization and regulation to make all lines electrically equal so that a line can be switched automatically to a standby line without detriment to service.

Line Connecting — Provides for bridging, blocking, and dropping of certain mastergroup or supergroup frequencies.

Switching — Automatically switches a standby line in place of a regular line in case of transmission failure on regular line.

Power — Supplies power to local equipment plus approximately 22 auxiliary repeaters in each direction, or receives power from the cable.

Fig. 1 — L3 High-Frequency Line — General Layout of Repeaters and Summary of Their Functions

TABLE A

TRANSMISSION EQUIPMENT AT L3 REPEATER STATIONS (BASED ON ALL-MESSAGE SYSTEM)

EQUIPMENT UNITS	TYPE OF REPEATER				
	AUXILIARY	EQUALIZING AUXILIARY	EQUALIZING MAIN	SWITCHING MAIN	TERMINAL MAIN
Passive Elements:					
Power Separation Filter	4	4	4	4	4
Artificial Line	As Reqd	As Reqd	As Reqd	As Reqd	As Reqd
Basic Equalizer	2	2	2	2	1
Amplifiers:					
LINE AMPL	2	2	2	2	1
FLAT AMPL A	–	2	2	2	1
FLAT AMPL B	–	2	2	2	1
FLAT AMPL C	–	–	–	2	–
FLAT AMPL D	–	–	–	2	1
FLAT AMPL T	–	–	–	2	1
Equalizers:					
Low-Frequency Equalizer	–	–	–	2	1
A2 Equalizer	–	2	2	2	1
A1 Equalizer	–	2	2	2	1
B1 Equalizer	–	–	–	2	1
B2 Equalizer	–	–	–	2	1
Adjustable Phase Equalizer	–	–	–	2	1
556-kHz Equalizer	–	–	–	2	1
308-kHz Equalizer	–	–	–	2	1
3096-kHz Equalizer	–	–	–	2	1
8320-kHz Equalizer	–	–	–	2	1
Regulators:					
308 kHz	–	–	–	2	1
556 kHz	–	–	–	2	1
2064 kHz	–	2	2	2	1
3096 kHz	–	2	2	2	1
7266 kHz	–	2	2	2	1
8320 kHz	–	–	–	2	1
Auxiliary or Thermometer	2	–	–	–	–
Computers:					
3-Pilot Type	–	2	2	–	–
6-Pilot Type	–	–	–	2	1
Pearl:					
J68818C Tone and Balancing Unit	1	–	–	–	–
J68818D Tone and Balancing Unit	–	2	2	–	–

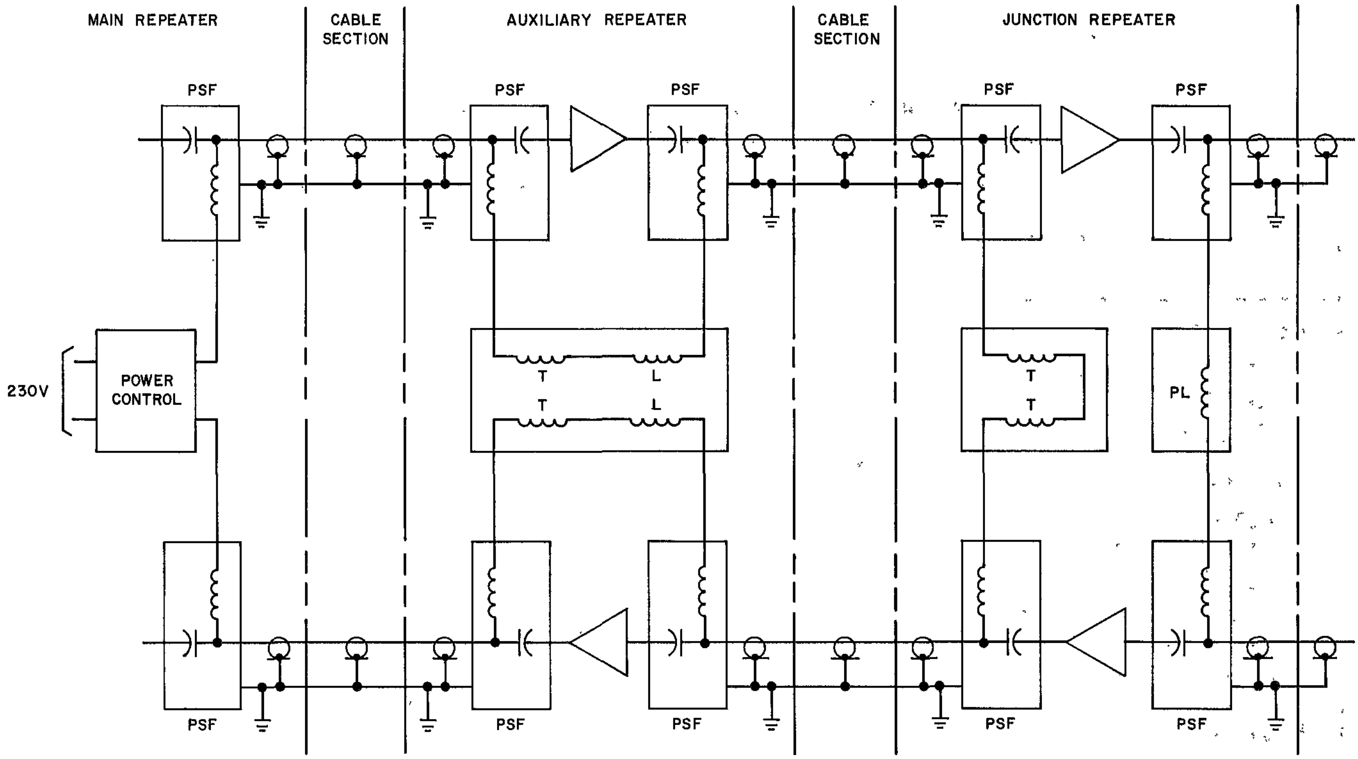


Fig. 2—Power Section—Simplified Schematic Diagram

other power sections. The PS2 power supply requires a constant line current of 1.55 amperes, as compared with the PS1 line current of 1.35 amperes. Thus, the two supplies are not interchangeable and any one power section must use the same type of power supply at each repeater. The PS2 power supply provides improved rectification through the use of silicon rectifiers in place of the selenium stacks used in the PS1 power supply, reduced harmonic distortion in the line current, and reduction of operating voltages to more nearly their nominal values. Section 359-010-120 includes the details of repeater power arrangements.

2. AUXILIARY REPEATER

2.01 Located at 4-mile intervals along the high-frequency line is the auxiliary repeater, which is the basic unit of the L3 repeater system. It provides 2-way amplification and regulation which produces a gain-frequency characteristic over the frequency band (300 to 8350 kHz) closely equal to the loss-frequency characteristic of 4 miles of 0.375-inch or 2.87 miles of 0.27-inch polyethylene-insulated coaxial cable, or 2.80 miles of 0.27-inch rubber-insulated coaxial cable.

A. Equipment Arrangements

2.02 In the aboveground routes, auxiliary repeaters are normally housed in 6-foot by 9-foot aboveground, unheated, insulated, concrete block structures. On underground hardened routes, the repeater is housed in underground leakproof structures with transmission equipment mounted on shock-resistant bays.

2.03 A typical layout of an aboveground auxiliary repeater station is illustrated in Fig. 3. Auxiliary repeater transmission bays, either J68819A (see Fig. 5) for PS1 power system or J68819G (see Fig. 6) for the PS2 power system, are located parallel with, or adjacent to, building walls. Associated cable terminals may be mounted between bays as shown, or attached to the bays or wall as desired. They may also be mounted on the ceiling above and in front of the bays. In this case, the bays may be located adjacent to one another. The J68815L maintenance power unit, if required, may be mounted on the left-hand side of the bay as shown. The bays are floor-supported without shock mounting.

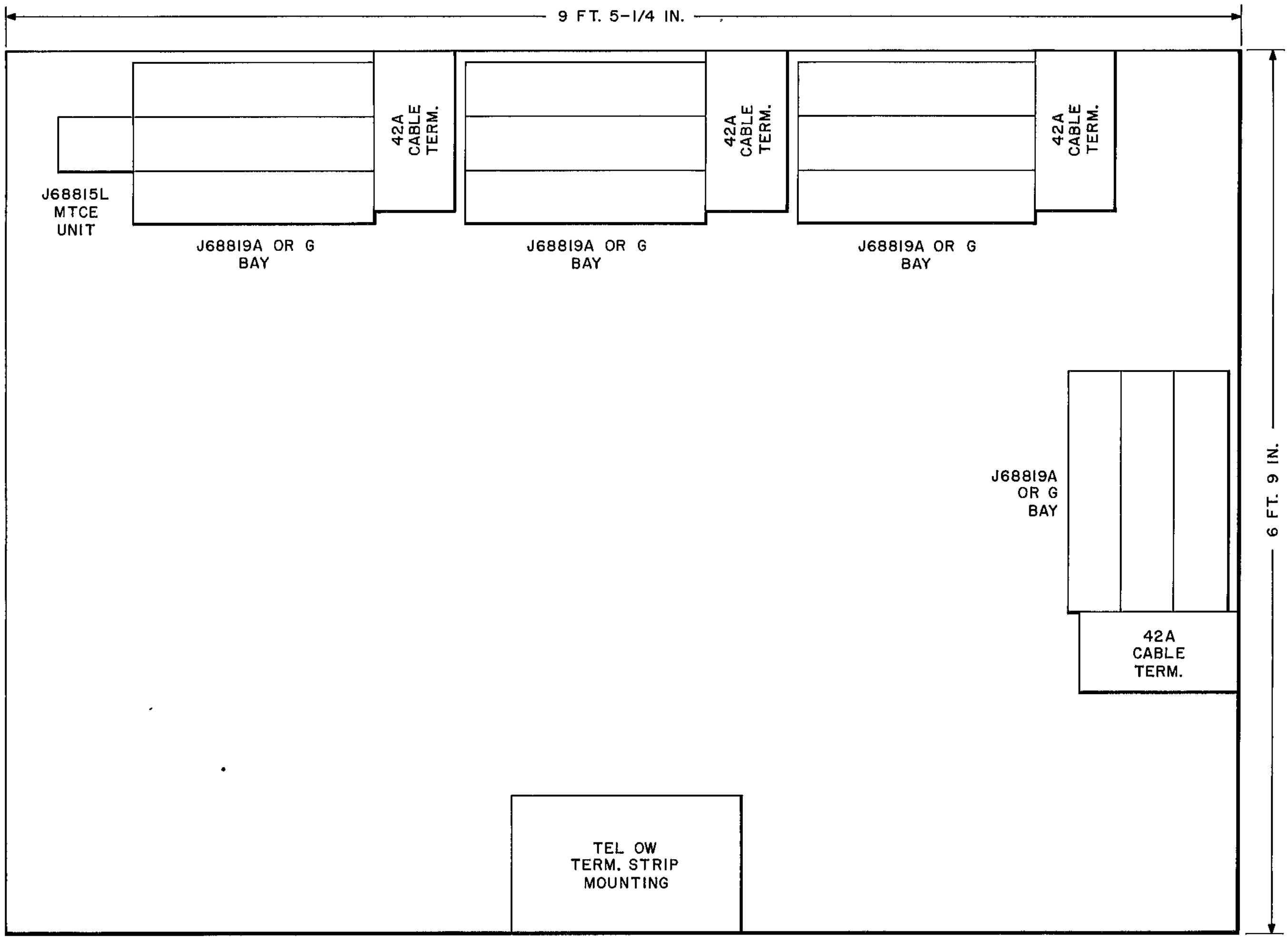


Fig. 3—Typical Layout of Aboveground Auxiliary Repeater Station

2.04 A typical layout of a hardened route underground auxiliary repeater station is illustrated in Fig. 4. Shock-mounted J68819G transmission bays are located in line, parallel to and at least 6 inches from the wall. Cable terminals are located on the ceiling immediately in front of the associated bays. Terminal strip and telephone order-wire equipment is located on or adjacent to the wall without shock mountings.

2.05 The J68819A auxiliary repeater bay illustrated in Fig. 5 includes transmission and power equipment for two coaxial lines arranged for the PS1 power system for use in aboveground stations. The arrangement, as shown, is for 6-foot, floor-supported bays. In addition, 7-foot or 11-foot 6-inch bays are also available. ➧The PEARL panel is located at the top of the bay.➧ The transmission panels for the odd and even directions of transmission are mounted near the top of the bays. Three power panels comprising the PS1 power supply are mounted below the transmission equipment. The line loading panel and power transfer unit, when used, are installed at the bottom of the bay.

2.06 The J68819G auxiliary repeater bay (see Fig. 6) includes transmission and power equipment for two coaxial lines arranged for the PS2 power system either for use above or below ground. The transmission equipment is mounted in a 6-foot bay equipped with shock isolators for attachment to the ceiling in an underground structure with 8-foot 6-inch ceiling height. The shock isolators are omitted in aboveground installations and the

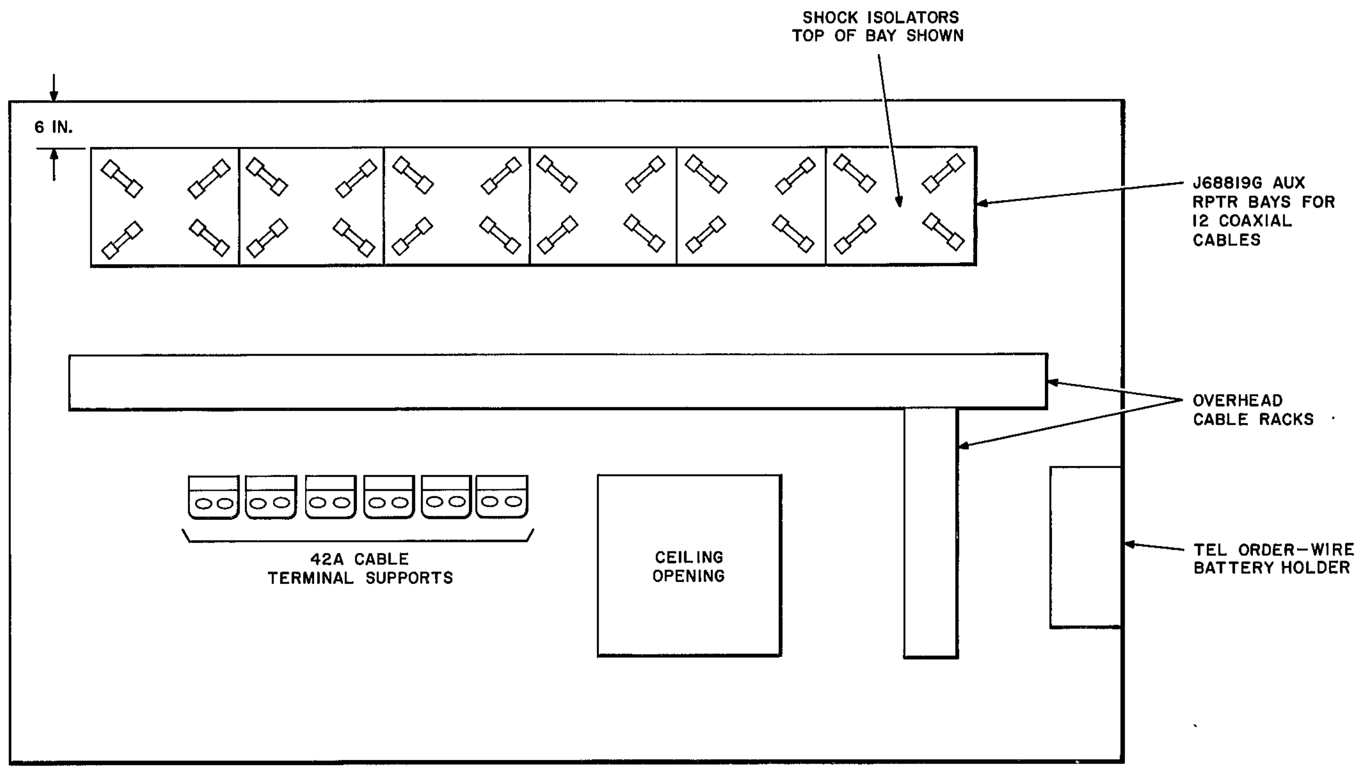


Fig. 4—Typical Layout of Underground Auxiliary Repeater Station

bays are floor mounted. In this bay the main power and auxiliary power units are mounted above the transmission panels. The high-voltage line loading or power transfer units are mounted below the transmission units. Connections for aboveground monitoring of the amplifiers are illustrated in Fig. 6.

2.07 The front and end views of the transmission panel are illustrated in Fig. 7. The demountable amplifiers and regulators are easily removed from the front of the panel. Parallel slots on the units slide over guide strips on the transmission panel. Gravity-operated catches on the guide strips hold the amplifiers and regulators in place. Power connections are made after the unit is locked in place. The regulator is mounted above the amplifier with its connector mounting surface facing a similar surface on the amplifier, so that plug-in connections for the two units occupy as little vertical space as possible. The cables and plugs by which power and transmission connections are made to the amplifier and regulator are located between their mounting positions, together with the jack equipment for in-service amplifier testing and switching. Separate control panels are provided for, and mounted below, each transmission panel. The control panels include filament activity switches, voltage test (VTST) jacks, filament chokes, and the power and control connections. On the rear of the transmission unit, passive elements of the transmission and power circuits are mounted. These include the power separation filters, artificial lines, and basic equalizers.

2.08 Communication at an auxiliary repeater is provided by a telephone set bridged across a local order wire running between adjacent main repeaters. The telephone set is mounted in a cabinet in aboveground auxiliary repeaters and is mounted either in a cabinet or a bay in underground auxiliary repeater sites. Only outgoing dc signaling is provided. All order and alarm and control circuit pairs contained in the cable are terminated on a terminal strip mounted either in the cabinet, in a

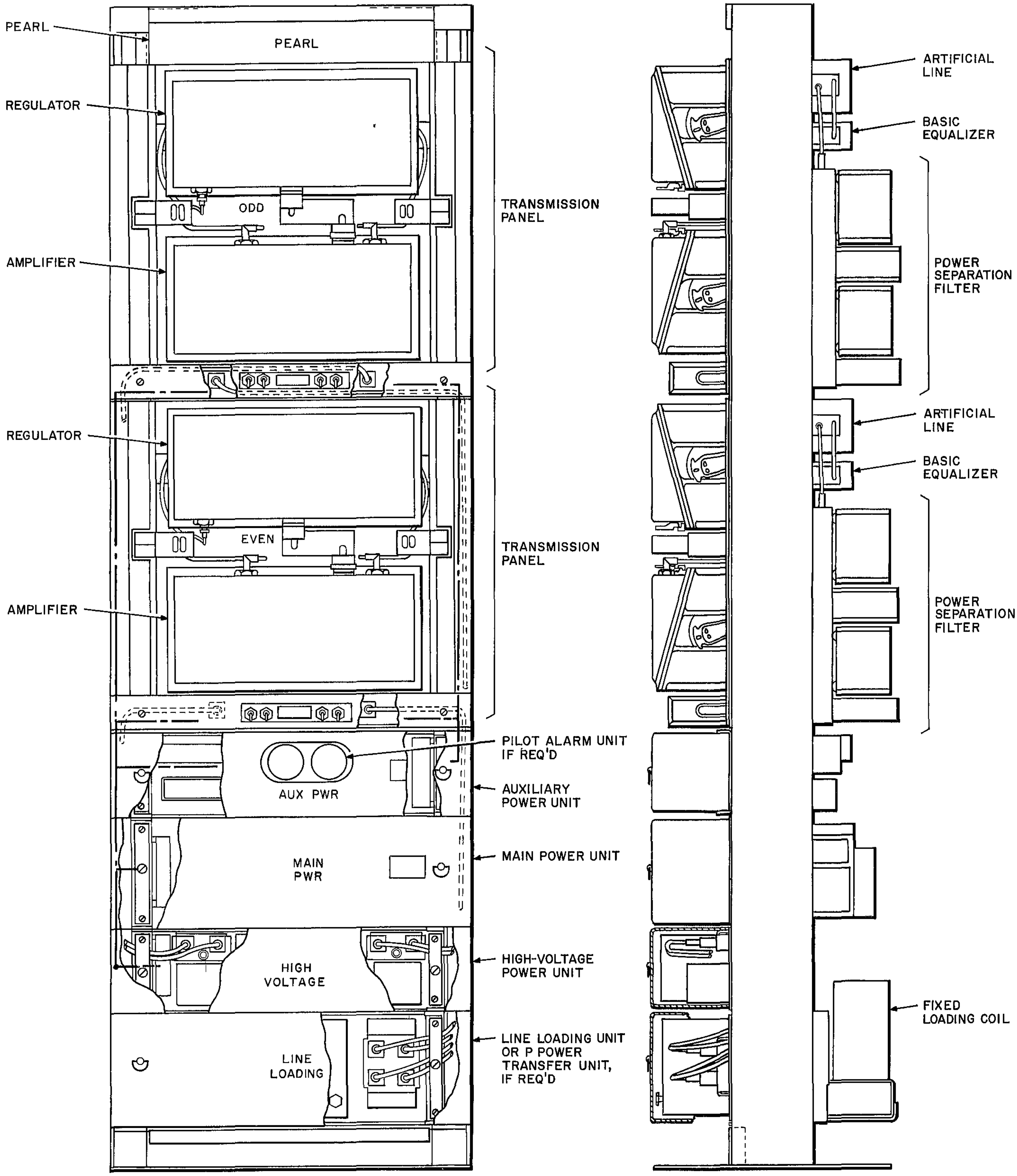


Fig. 5—J68819A Auxiliary Repeater on 6-Foot Bay

bay, or on a wall. Provisions for cross-connections between pilot alarm pairs and the repeater, or between the repeater and the 154-type regulator buried with the cable, are provided as required. On hardened routes with repeaters located underground, access to the order circuit and monitor jacks for aboveground monitoring of the 7266-kHz line pilot are provided as illustrated in Fig. 8. The additional aboveground telephone set allows signaling and talking with the attending repeater, and the monitor jacks allow monitoring of transmission levels from aboveground without entering the

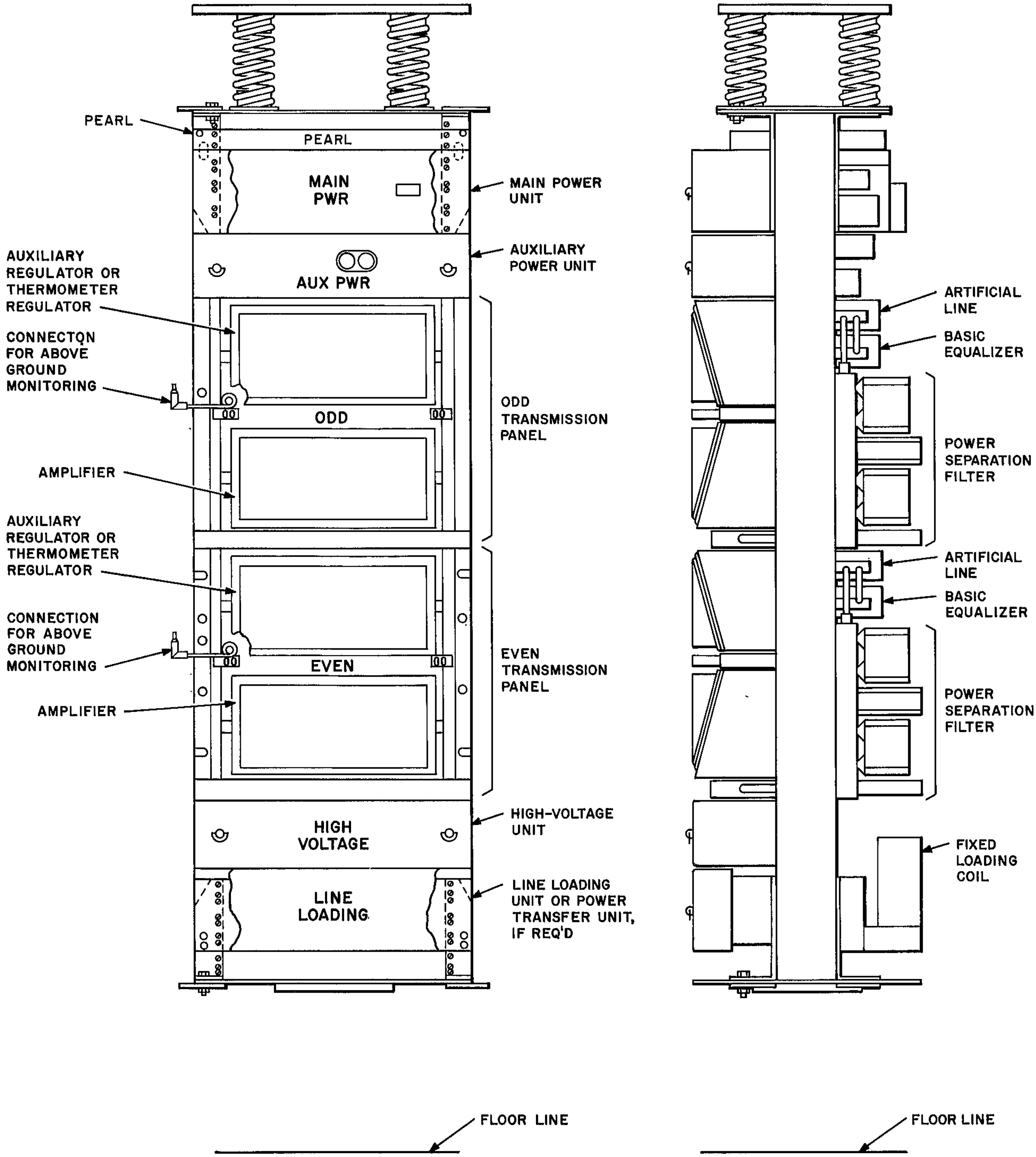


Fig. 6—J68819G Auxiliary Repeater on 6-Foot Bay—Equipped for Shock Isolation

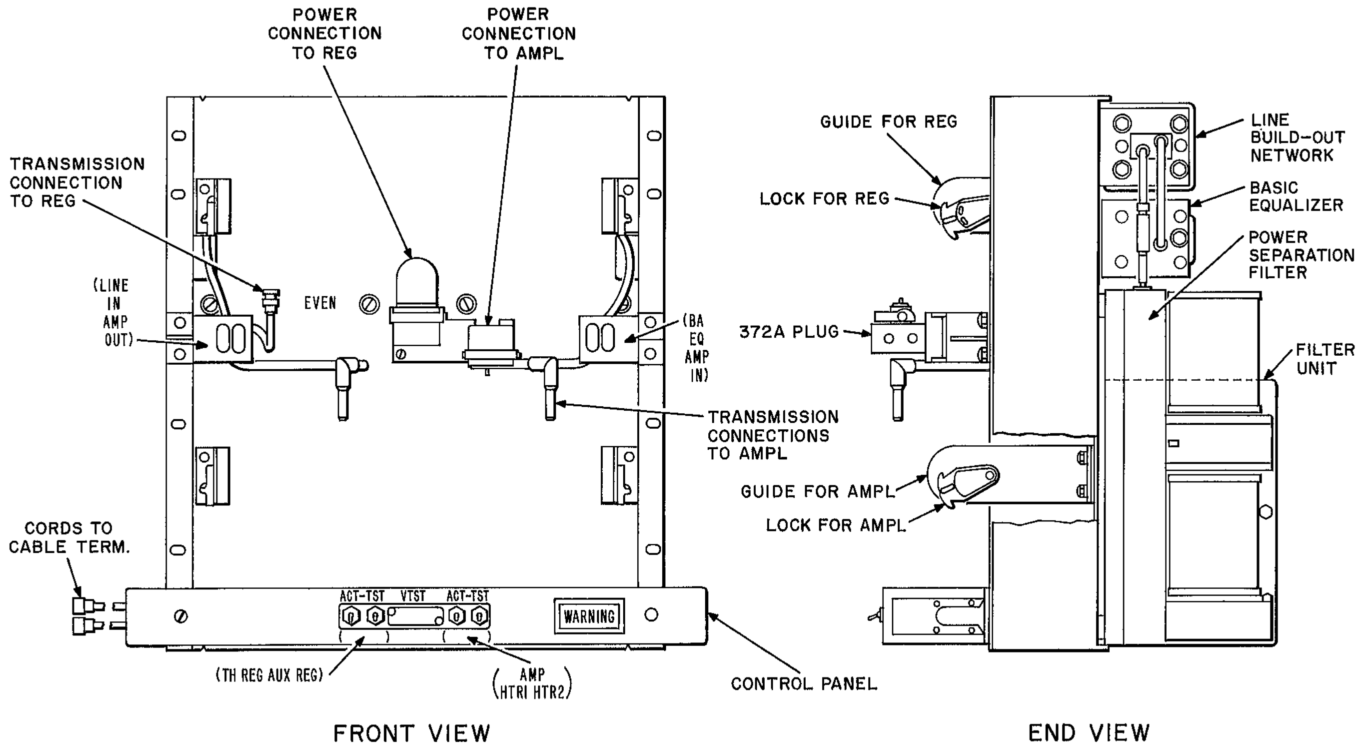


Fig. 7—Auxiliary Repeater Transmission Panel

underground repeater. Transfer circuit arrangements prevent interruption of through communication and transmission in case the aboveground facility is destroyed.

B. Transmission

2.09 Figure 8 is a block diagram of a typical underground auxiliary repeater station illustrating the equipment required for two coaxial lines with monitoring and order-wire connections above ground. A station located above ground would be similar except that the monitor jacks and one of the telephone sets would be omitted. The flexible cable shown between the cable terminals and the repeater bay is required for all underground installations but is optional in aboveground installations.

2.10 A functional description of the transmission equipment for one direction of transmission (see Fig. 8) is provided in 2.11 through 2.17. Duplicate equipment is required for the other direction of transmission.

Power Separation Filter

2.11 Power separation filters are used at each end of each section of coaxial cable. At the receiving end, the high-frequency transmission currents and the 60-Hz power currents which flow in the center conductor of the cable are separated in the power separation filter. The high-frequency transmission currents are passed to the transmission equipment and the low-frequency power currents are passed to the high-voltage unit of the repeater power supply. The high loss to the carrier frequencies in the power circuit reduces crosstalk coupling between opposite directions of transmission and feedback from amplifier output to input. At the transmission end, the power separation filter serves to combine the high-frequency transmission currents and the power currents for transmission over the line.

Artificial Line

2.12 The artificial line is used when the cable section is less than the minimum specified length. It is provided to build out the loss-frequency characteristic of the shorter cable sections to be equivalent to the loss-frequency characteristic of either 4.0 ±0.2 miles of 0.375-inch or 2.87 ±0.15 miles of 0.27-inch polyethylene-insulated cable, or 2.80 miles of 0.27-inch rubber-insulated cable at average cable temperature. Artificial line network options are provided in steps of 0.2-, 0.4-, 0.8-, and 1.2-mile equivalent lengths for maximum buildout of 2.4 miles of 0.375-inch coaxial cable. For the 0.27-inch coaxial cable, networks are provided in steps of 0.15-, 0.29-, 0.57-, and 0.86-mile equivalent lengths for a maximum buildout of 1.72 miles.

Basic Equalizer

2.13 The carrier-frequency currents pass from the power separation filter and artificial line (if required) to the basic equalizer. The basic equalizer functions to improve the match between the gain characteristic of the line amplifier and the loss characteristic of the different types of coaxial cable. For 0.27- and 0.375-inch polyethylene-insulated cables, this equalizer consists of a resistance pad. For the 0.27-inch rubber-insulated cable, a shaped network is required.

Line Amplifier

2.14 The demountable, hermetically sealed line amplifier (J68816A) is a feedback type with a nominal gain-frequency characteristic closely equivalent to the loss of 4.0 miles of 0.375-inch coaxial cable.

Regulators

2.15 The gain of the line amplifier is controlled by one of two types of demountable, hermetically sealed regulators. The J68817A auxiliary regulator continuously controls the gain of the line amplifier in accordance with the change in the magnitude of the 7266-kHz pilot transmitted along the line. The shape of the gain change must match the square root of the frequency shape of the line loss change over the transmitted frequency band. The J68817T thermometer regulator, which has the same external appearance as the auxiliary regulator, controls the gain of the line amplifier in accordance with the resistance change of a thermistor mounted in a 154-type regulator buried near the cable adjacent to the repeater station. Normally, every fourth auxiliary repeater is pilot-regulated with the intervening repeaters thermometer-regulated.

PEARL Amplifier Monitoring

2.16 ♦PEARL is designed for use with L3 carrier systems to provide remote identification and location of a failed or faulty amplifier in a switching section of a repeatered line. The basic principle of operation of PEARL requires the insertion of a distinctive tone into each of the amplifiers. The identifying tones are located just below the useable L3 frequency band and are spaced at 1-kHz intervals. The output signal of the oscillator is inserted at the output of the amplifier through a high-impedance bridging pad. The oscillator tone is also applied at the input of the amplifier through an adjustable attenuator, an adjustable phase shifter, and a high-impedance bridging pad. The attenuator and the phase shifter are adjusted so that the oscillator tone passing through the amplifier is equal to, but 180° out of phase with, the oscillator tone applied directly to the amplifier output. The two tone signals then cancel at the amplifier output. If the gain of an amplifier changes, the balance of the identifying tone will be upset and the tone from that amplifier will be transmitted over the line to the receiving main station. At the main station, the frequency of the tone identifies the amplifier experiencing the gain change and the power level of the received tone indicates the amount of gain or phase change. If an amplifier should fail, the full oscillator signal would be applied to the line to the receiving main station.♦

Pilot Alarms

2.17 At pilot-regulated auxiliary repeaters, pilot alarm units are used. Two pilot alarm units having the same external appearance are available but are not electrically interchangeable. The J68815D unit, illustrated schematically in Fig. 9, is designed for use with a single alarm pair for both directions of transmission. The J68815R unit, illustrated schematically in Fig. 10, is designed for two alarm pairs, one for each direction of transmission. Either of the alarm units monitors the power level of the 7266-kHz pilot via the auxiliary regulator. When the power level of the 7266-kHz pilot deviates above or below a predetermined limit, Sensitrols® in the alarm unit operate and send an alarm over the alarm pair or pairs to the associated main repeater. At the main repeater, in the case of the two alarm pairs, the energized pair will determine the direction of transmission causing the alarm. With the single alarm pair, alarm-locating bridge measurements will determine the direction

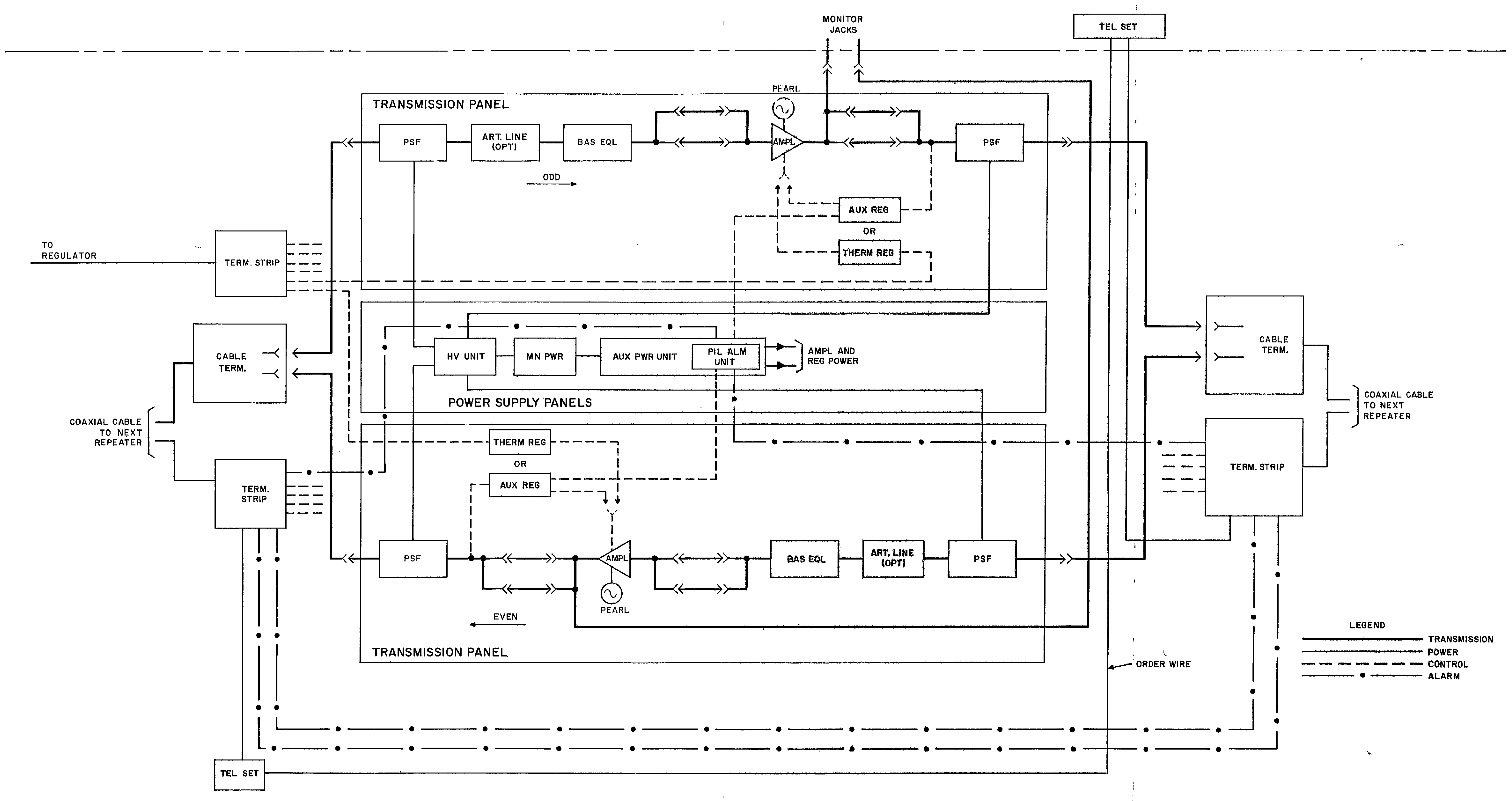


Fig. 8—Typical Auxiliary Repeater Station—Block Diagram

of transmission causing the alarm. The alarm circuit may be reset locally or from a main repeater after the failure has occurred ♦on repeatered lines equipped with PEARL. The PEARL test set can be used to identify the repeater which is causing the alarm condition.♦

supplies for the amplifiers and regulators. The line loading, power transfer, and maintenance power units are placed in the repeater as required. As mentioned in 1.12, either PS1 or PS2 power supply arrangements may be used, depending on the power system.

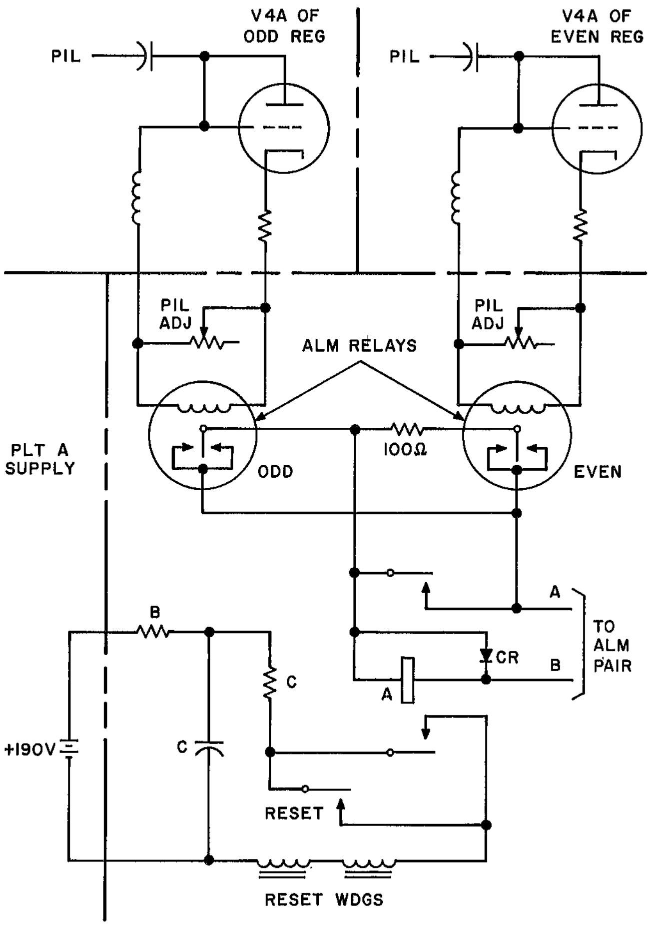


Fig. 9—Circuit of Auxiliary Pilot Alarm Unit for Use With One Alarm Pair

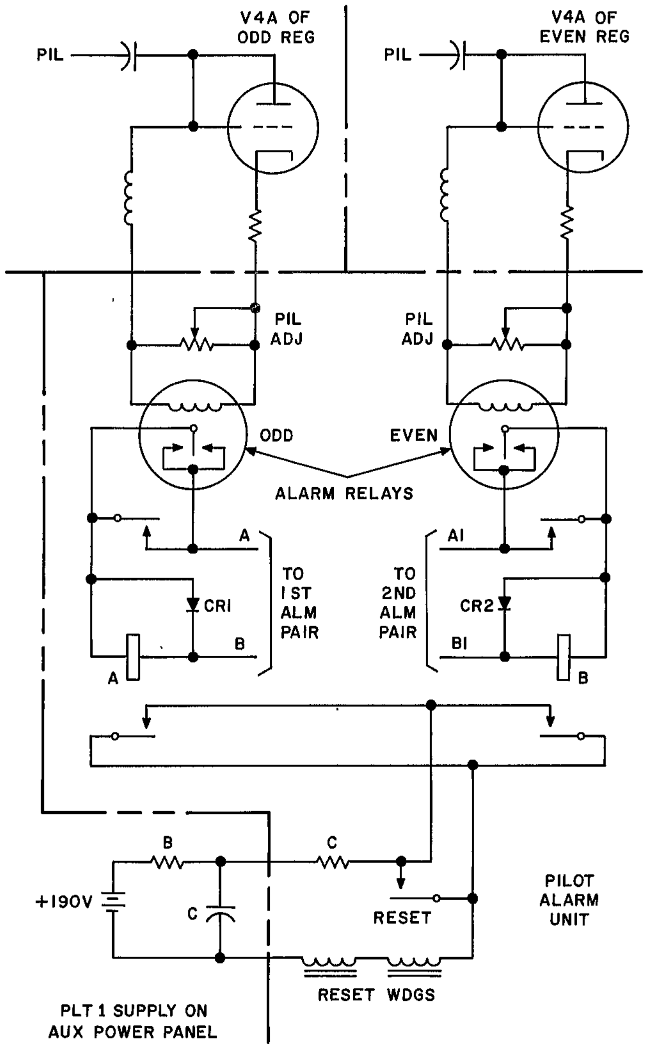


Fig. 10—Circuit of Auxiliary Pilot Alarm Unit for Use With Two Alarm Pairs

Power

2.18 Power for operation of the auxiliary repeater is supplied over the center conductor of the coaxial cable via the power separation filter to the high-voltage units. The high-voltage unit supplies 250 volts to the main power unit and provides two 6.7-volt heater supplies. The main power and the auxiliary power units provide +315 and +190 volt plate supplies and +100 and -100 volt grid

3. EQUALIZING AUXILIARY REPEATER

3.01 The equalizing auxiliary repeater performs the basic equalization and regulation functions of an auxiliary repeater. In addition, it is equipped with fixed, dynamic, and manually adjustable equalization units to compensate for accumulated unequalized deviations introduced by a number of auxiliary repeaters.

3.02 The equalizing auxiliary repeater is used at intermediate locations between main repeaters where, for administrative, power supply, economic, or other reasons, the spacing between power supply points is in excess of about 132 miles.

A. Equipment Arrangements

3.03 The following is a description of aboveground stations. There is no hardened underground version of equalizing repeaters at present. The repeater is normally housed in a 15-foot by 15-foot aboveground building. Depending on system layout, an existing K or L repeater station is sometimes used. Figure 11 illustrates a typical layout for an equalizing auxiliary repeater station. The coaxial terminals are mounted on the associated repeater bays. Terminal strips for alarm and telephone order circuits, order-wire equipment, and cabling are job engineered. Figure 12 illustrates the transmission and power equipment used in the equalizing auxiliary repeater. The J68819B equalizing auxiliary repeater transmission bay includes the transmission and part of the power equipment for one coaxial line arranged for either a PS1 or PS2 power system. The J68819C equalizing auxiliary repeater power bay, together with a rectifier located on the J68819E rectifier bay, includes the power equipment required for the two J68819B transmission bays associated with a pair of coaxial lines. The equipment as shown is mounted in 7-foot, floor-supported bays. In addition, 11-foot 6-inch bays may be provided.

3.04 Communication to and from the equalizing auxiliary is the same as at the auxiliary repeater. Order-wire and alarm circuits are common for auxiliary and equalizing auxiliary repeaters for a given coaxial line or pair of coaxial lines.

B. Transmission

3.05 The block schematic of the equalizing auxiliary repeater is illustrated in Fig. 13. The transmission circuit up through the line amplifier is identical with the auxiliary repeater. The line frequencies are amplified by the line amplifier with a gain-frequency characteristic of the amplifier compensating for the losses in the preceding section of coaxial cable, just as in the auxiliary repeater. Compensation for accumulated deviations from flatness present at the input to the equalizing auxiliary repeater is provided by equalizers A2 and A1.

Equalizers A2 and A1

3.06 Equalizers A2 and A1 consist of a combination of fixed, manual, and automatic gain-adjusting circuits. The manual sections are adjusted during periodic gain-frequency lineup and compensate for slow variations in the gain-frequency characteristic of the line. The dynamic section of equalizers A2 and A1 compensates for more rapid changes in the gain of the line. The dynamic section of equalizer A2 is under the control of the 2064-kHz regulator, and the dynamic section of equalizer A1 is under the control of the 3096-kHz regulator. Equalizer A2 contains a design deviation equalizer which corrects for the cumulative error resulting from a number of auxiliary repeaters not ideally matching the loss shape of the cable.

Regulators

3.07 The 7266-kHz, 2064-kHz, and 3096-kHz regulators continuously monitor the pilot-frequency voltages on the line and, with the computer, control the magnitude of the direct current through the thermistors in dynamic equalizers A2 and A1 and the regulating network of the line amplifier. The regulators also provide direct currents which are proportional to the pilot-frequency voltages on the line and which are measured for alarm and maintenance purposes in the pilot alarm circuit.

Computer

3.08 The computer associated with the 2064-kHz, 3096-kHz, and 7266-kHz regulators is a resistance network which translates pilot errors into shape errors and drives the appropriate dynamic equalizers by means of the associated regulators to restore the gain-frequency characteristic of the line to normal.

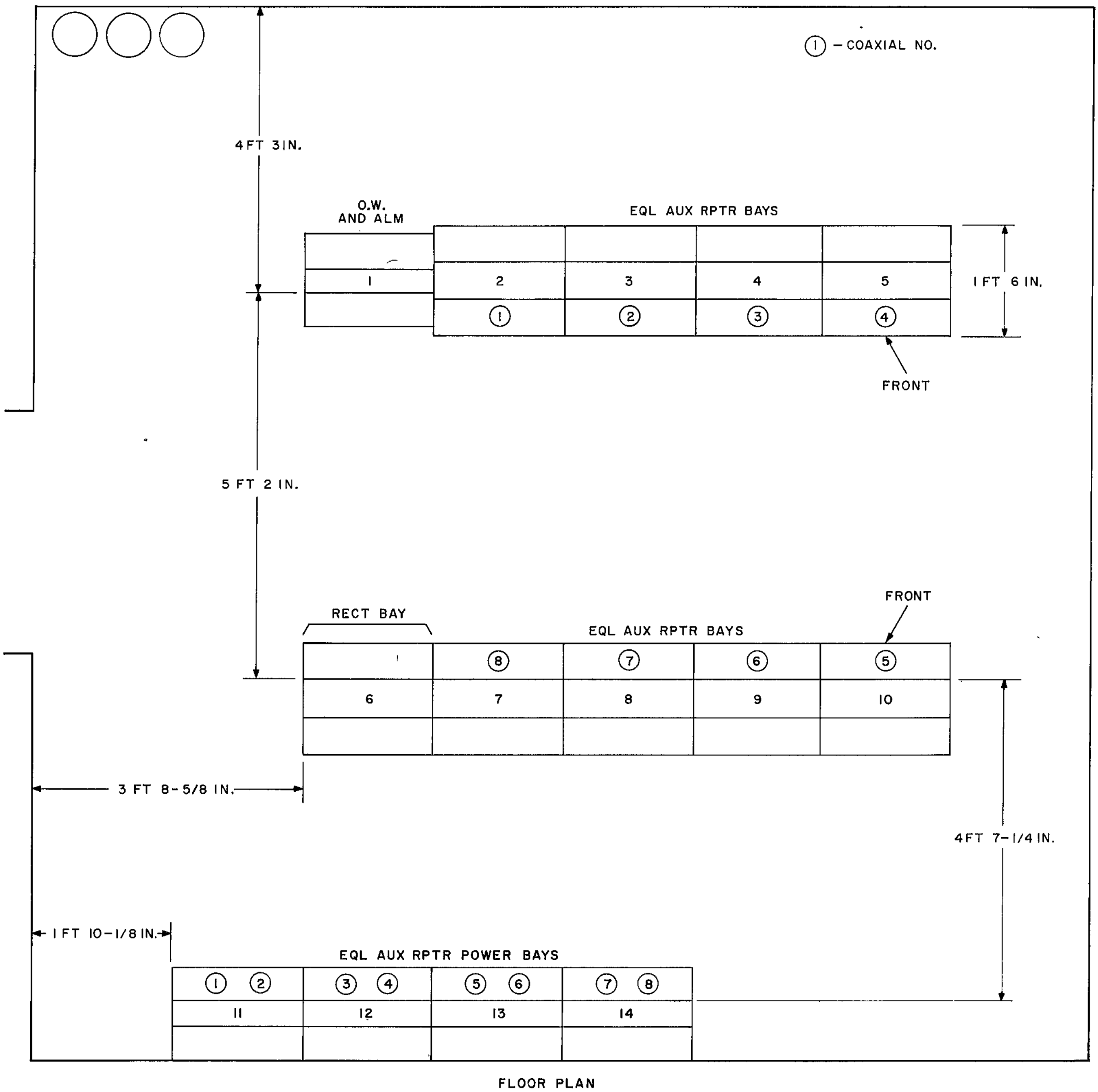


Fig. 11—Typical Layout for an Equalizing Auxiliary Repeater Station

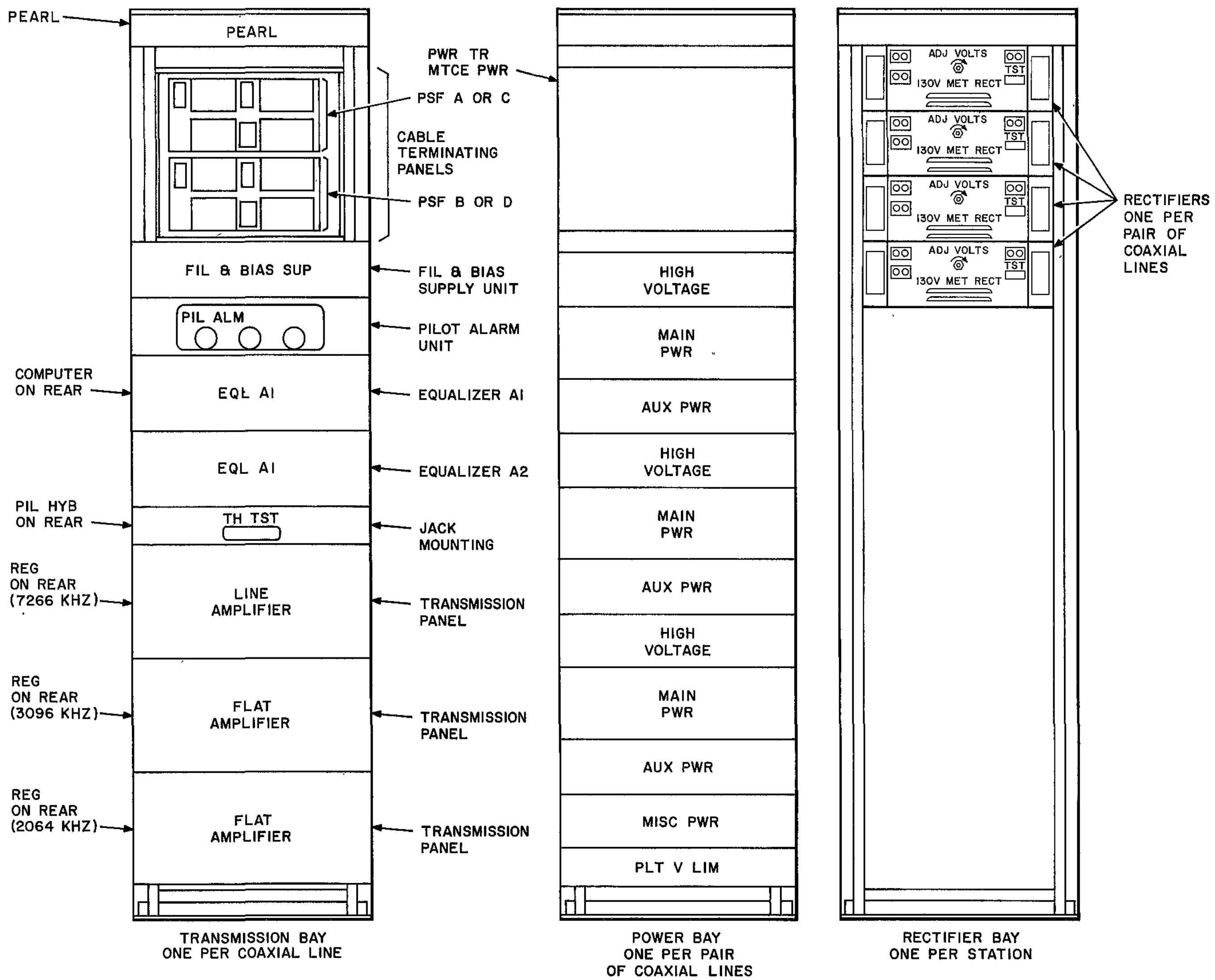


Fig. 12—Equalizing Auxiliary Repeater—Transmission and Power Equipment

Flat Amplifiers

3.09 FLAT AMP A provides the necessary gain to compensate for the flat loss of equalizer A2, and FLAT AMP B provides the necessary gain to compensate for the loss of equalizer A1.

Pilot Hybrid

3.10 A pilot hybrid provides a means for picking pilots off the line and isolates the regulator inputs from any impedance variations which may be presented at the PIL HY OUT A jack.

3.11 Thus, through the medium of the line amplifier, equalizers A2 and A1, and the associated flat amplifiers, the output of the equalizing repeater is kept approximately flat with frequency at a constant predetermined power level.

Pilot Alarms

3.12 In the equalizing auxiliary repeater, a pilot alarm unit (ODD and EVEN) is provided for each coaxial line. When only one alarm pair is provided, it is associated with a pair of coaxial lines. When two alarm pairs are provided, the pairs provide separate alarms for the two directions

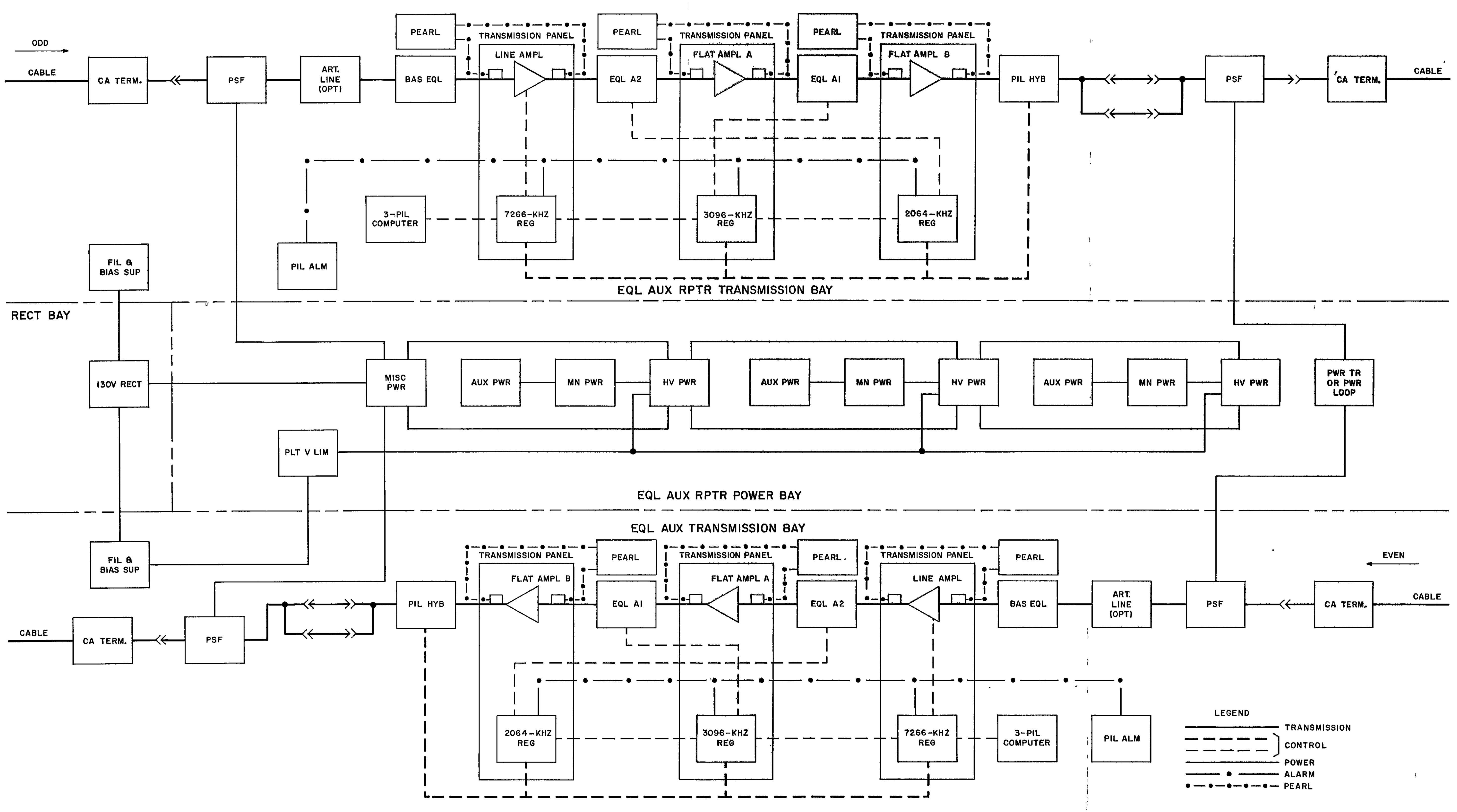


Fig. 13—Typical Equalizing Auxiliary Repeater Station—Block Schematic

of transmission. The alarm pair, or pairs, are common for an auxiliary or an equalizing repeater for a given pair of coaxial lines. The pilot alarm unit contains three Sensitrol relays which monitor the power level of the regulator control currents of the 2064-, 3096-, and 7266-kHz pilots. When any of the control currents deviates ±3 dB from a normal power level, the Sensitrol relay contacts close and cause an alarm to be operated at the attending main repeater. When two alarm pairs are used, the energized alarm pair indicates whether the failure has occurred on an ODD or EVEN coaxial line. ➧PEARL tone measurements of the repeatered line will identify the amplifier causing the alarm conditions.➧ In the case of one alarm pair, bridge measurements locate the alarming repeater and determine the direction of transmission. ➧The bridge method, however, does not assure that the repeater causing the alarm is the repeater at fault. Thermometer-regulated repeaters are not equipped with alarm tripping relays. If a thermometer-regulated repeater fails, the alarm circuit is tripped by the first pilot-operated regulator repeater. PEARL tone measurements will identify the amplifier causing the alarm condition.➧ The alarm circuit may be reset locally or from a main repeater after the failure has occurred.

Power

3.13 The equalizing auxiliary repeater receives power from the center conductor of the coaxial cable via the power separation filter, as in the auxiliary repeater. The power requirements are greater for the equalizing auxiliary repeater than for the auxiliary repeater; therefore, more units are necessary. The equalizing auxiliary power units are illustrated in Fig. 14. The equalizing auxiliary repeater may be equipped with either PS1 or PS2 power supply arrangements, depending on the power section in which it is used.

C. TV Dropping at an Equalizing Auxiliary Repeater

3.14 Optional arrangements are provided for TV dropping at an equalizing auxiliary repeater. Although rated Manufacture Discontinued, the circuit in Fig. 14 may be considered as a typical example (see 1.03). The TV transmission equipment and power supplies are mounted in separate bays from the bays that contain the high-frequency line equipment of the repeater. Power for operating the TV dropping equipment is fed from a local source. An equalizing trunk (EQG TRK) is generally provided between the high-frequency line bay and the TV bay. The trunk is used during lineup and maintenance tests and enables the attendant to place test equipment physically near the adjustable equalizers, thereby making it easier to read the meter indications.

4. EQUALIZING MAIN REPEATER

4.01 At points in a transmission line where power must be fed to the cable for operation of the auxiliary repeaters but where switching or dropping is not required, an equalizing main repeater is used. The equalizing main repeater contains the same transmission components and performs the same transmission functions as an equalizing auxiliary repeater. It differs in that it is equipped to supply power to local equipment and to coaxials emanating from the station.

A. Equipment Arrangements

4.02 Depending on system layout, the repeater is housed in a repeater office or other suitably sized building. There is no hardened version of the equalizing main repeater at present.

4.03 Equipment arrangements at an equalizing main repeater consist of a transmission bay for each through coaxial line, one rectifier bay for each pair of transmission bays, a power control bay for each power loop, and a miscellaneous bay for alarm, alarm-locating, alarm transfer, and order-wire equipment. Figure 15 illustrates the transmission equipment mounted in an 11-foot 6-inch bay. The amplifiers are mounted on the front of the bay and the regulators are mounted on the back of the bay, with dust covers being used over the transmission units. A filament and bias supply mounted in each transmission bay provides heater and bias supply voltages required for operation of the transmission equipment in the bay. The power control bay for the 505D power plant, required for each power loop, is normally mounted near the line equipment bays. The 505D power plant (or plants, depending on the number of coaxial lines being furnished power) is quite noisy and is generally separated from the transmission equipment by partitions or by other means. The equalizing

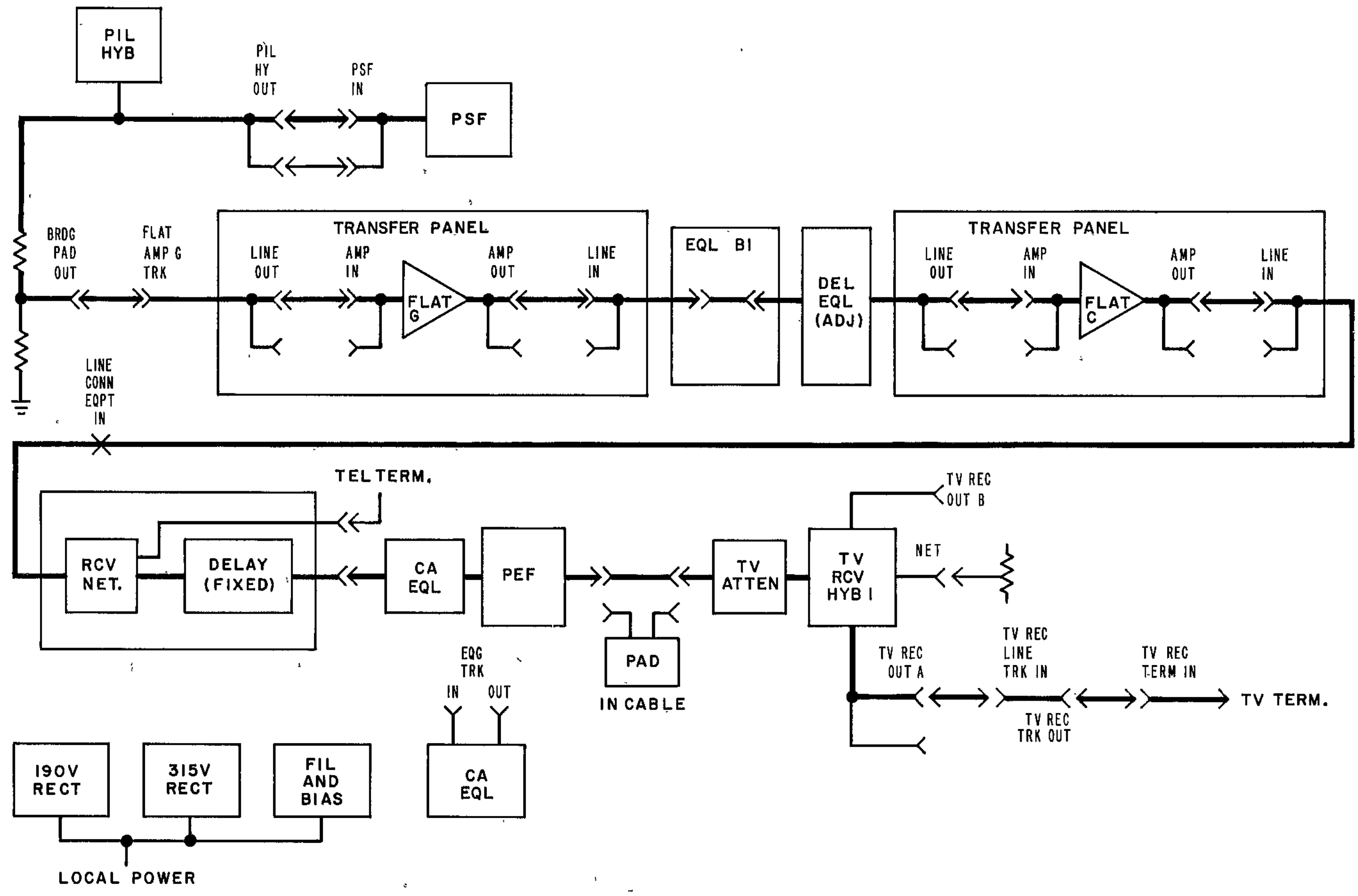


Fig. 14—Typical TV Dropping Arrangements at an Equalizing Auxiliary Repeater

main repeater may be equipped with either PS1 or PS2 power supply arrangements, depending on system use.

4.04 Order-wire facilities are located in a miscellaneous bay. In addition to the local order wire, an express order wire using selective signaling is provided for communication between main repeaters.

B. Transmission

4.05 A block schematic of the equalizing main repeater is illustrated in Fig. 16. The functions of the transmission components are the same as for the equalizing auxiliary repeater described in Part 3.

Pilot Alarms

4.06 The pilot alarm unit used at the equalizing main repeater functions in the same manner as at the equalizing auxiliary repeater. It is equipped with indicating meter and Sensitrol relays for each of the three pilots. The circuit of the unit is illustrated in Fig. 17. The ZERO and GAIN adjustment controls are mounted adjacent to the IND meter for ease in observing the adjustment of the ALM relay and IND meter.

5. SWITCHING MAIN REPEATER

5.01 The switching main repeater is used at points where circuits are dropped or terminated and where transmission on a regular line is switched to a standby line in case of failure of the regular

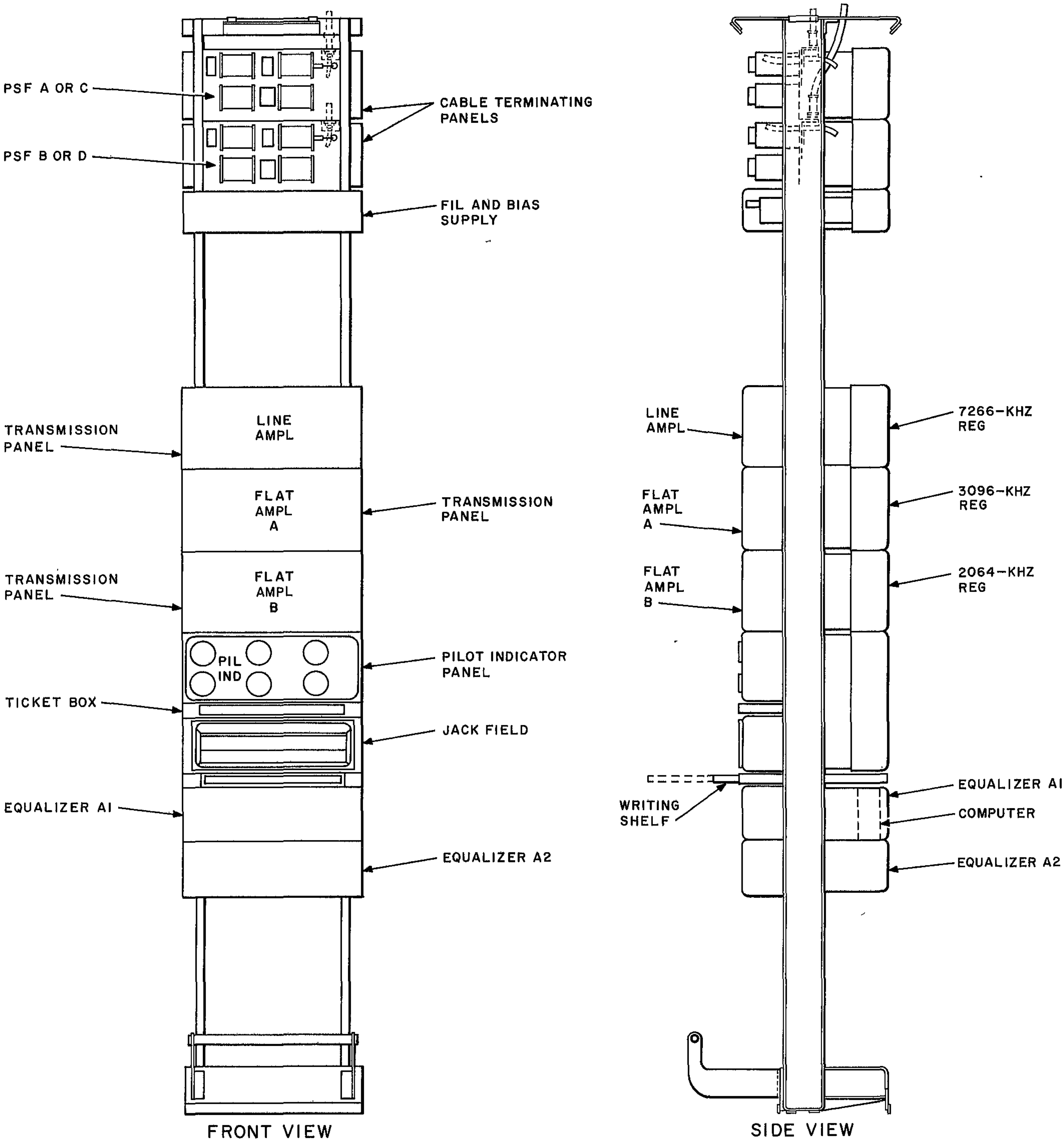


Fig. 15—Transmission Bay Arrangements at an Equalizing Main Repeater

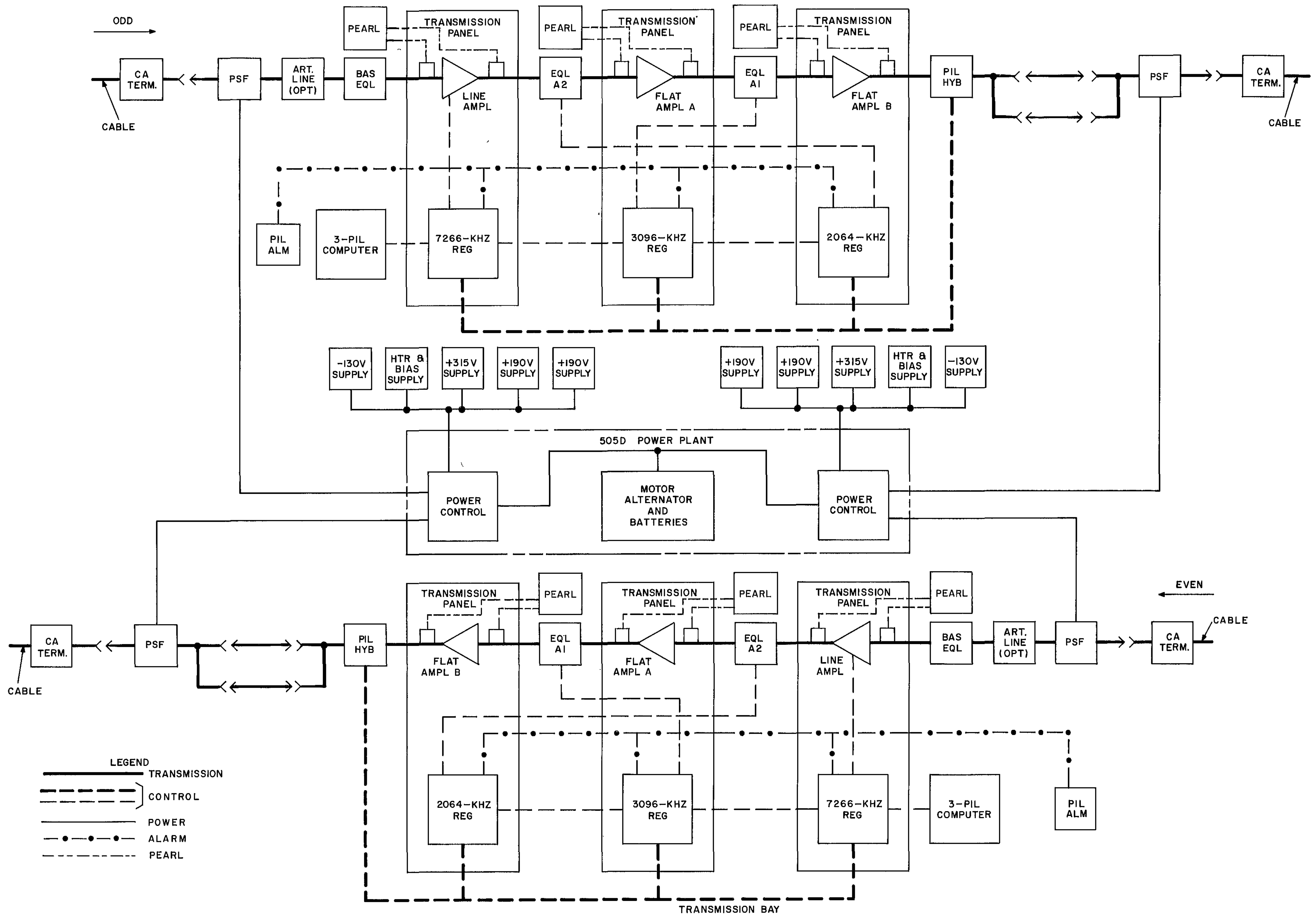


Fig. 16—Equalizing Main Repeater—Block Schematic

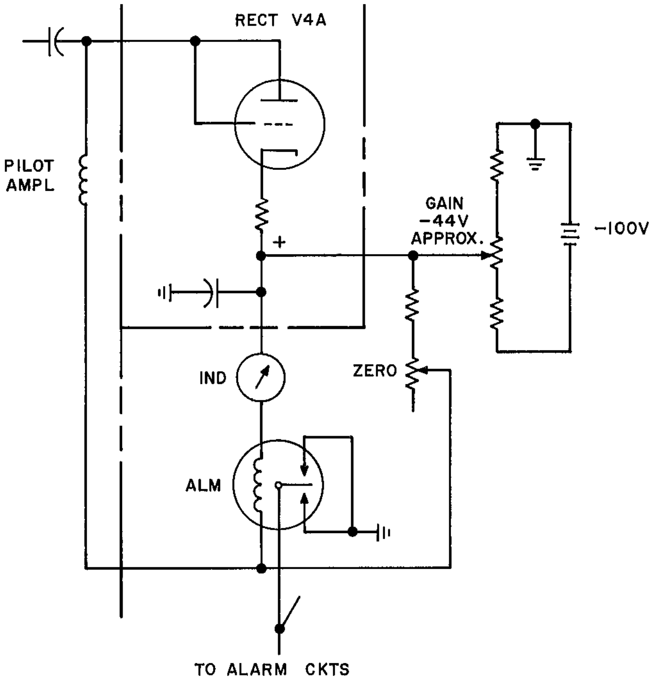


Fig. 17—Pilot Alarm Circuit at an Equalizing Main Repeater

line. At this repeater more complex, manual, and dynamic equalization is provided to make all lines as flat and as equal as possible so that a switch to a standby line is essentially hitless, thus minimizing any detriment to service.

A. Equipment Arrangements

5.02 The switching main repeater is housed in a repeater office or other suitably sized building. On hardened routes, switching main repeaters are housed in underground structures with transmission equipment mounted in shock-resistant bays.

5.03 The transmission equipment required for one through coaxial cable at a switching main repeater is mounted in a receiving bay, a transmitting bay, and part of two miscellaneous bays.

5.04 The front and side views of the receiving line bay for a switching main repeater are illustrated in Fig. 18. Each receiving bay contains the cable terminating panel, filament and bias supply, line amplifier, flat amplifiers, low-frequency equalizer and 308-kHz, 556-kHz, 3096-kHz, 8320-kHz equalizer panels, phase equalizer panel, pilot indicators, jack field, manual and dynamic equalizers, and the adjustable delay build-out network (when provided) for the receiving direction of transmission of one coaxial line. The associated regulators, transmitting line and pilot hybrid, and the computer are mounted on the rear of the same bay.

5.05 The equipment of a typical transmitting line bay at a switching main repeater is illustrated in Fig. 19. From top to bottom of the bay, a cable terminating panel, filament and bias supply, a transmission panel, a ticket box, and a jack field are installed. If the repeater is arranged for television dropping or dropping of any message facilities, the line connecting equipment (filters, equalizers, hybrids, etc.) is mounted in the transmitting line bay. Two of these bays are required for each pair of equipped coaxial lines.

5.06 The order-wire equipment and associated jack field, the alarm lamps and keys, the alarm-locating panel, the line switch unit, and switch jack field associated with one cable in one direction are mounted in a miscellaneous bay. Two of these bays are installed for each cable.

5.07 The automatic line switching equipment requires two bays for each four regular lines at a switching main repeater.

5.08 The power for the amplifiers, regulators, and line connecting equipment is supplied by the 505D power plant which also feeds power to adjacent power loops. The automatic line switching equipment is powered from local sources. The switch control bay, rectifier, and power control bays are generally mounted in a line behind the transmission bays.

B. Switching Arrangements

5.09 Protective switching arrangements at the switching main repeater provide the following:

(a) Fully automatic facilities to switch transmission from a faulty regular line to a standby line.

(b) Fully automatic facilities to restore transmission to the regular line after trouble has been cleared.

(c) Manual facilities to release a regular high-frequency line or the standby line for either corrective or preventive maintenance.

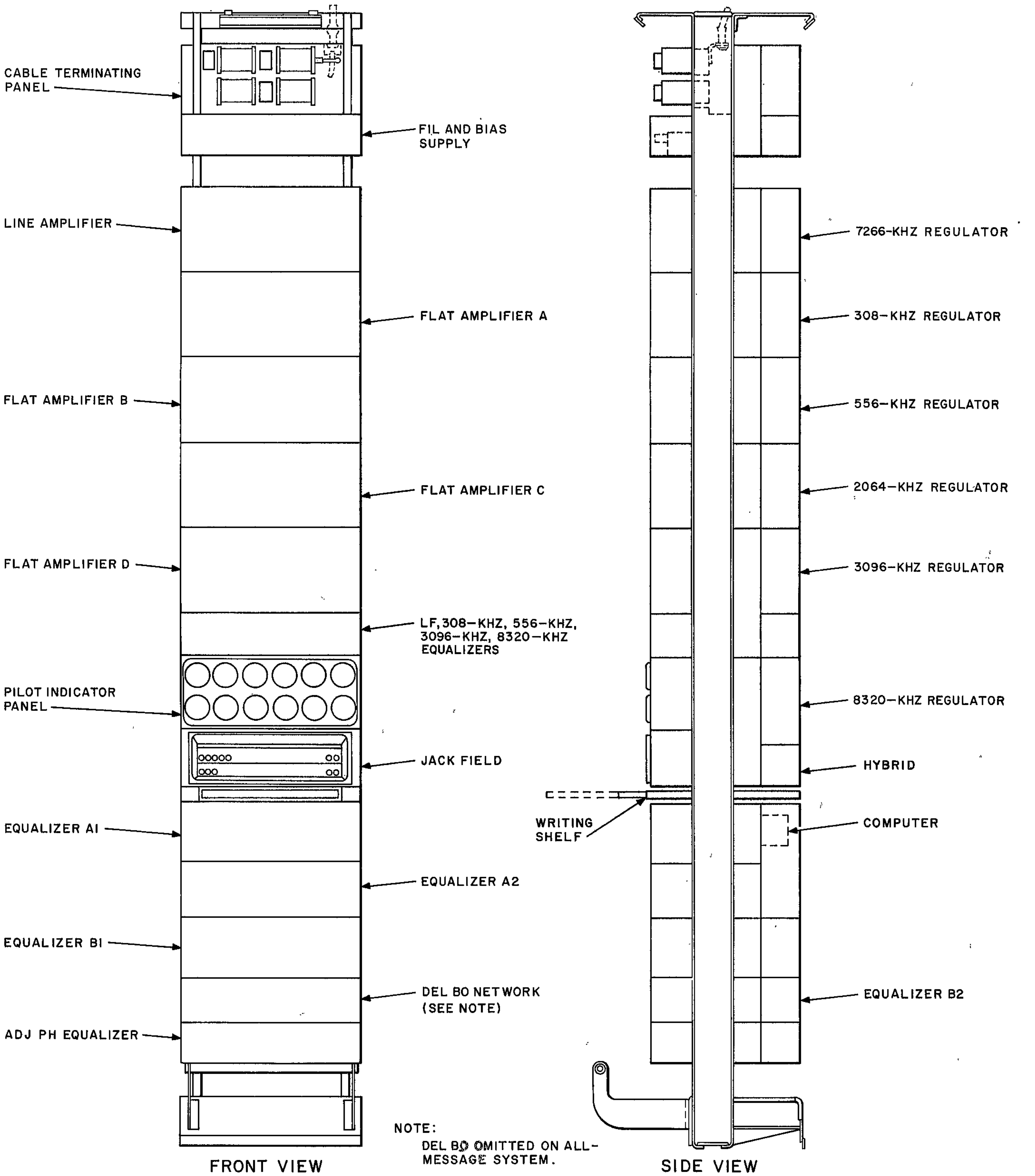


Fig. 18—Receiving Line Bay—Switching or Terminal Main Repeater

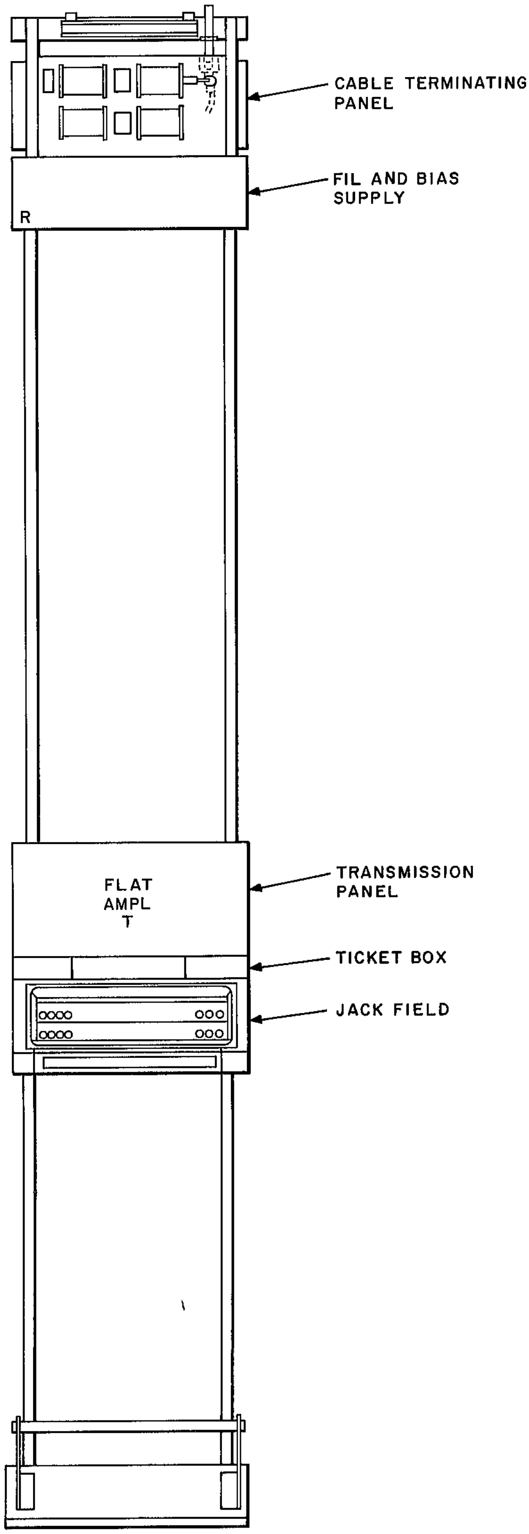


Fig. 19—Transmitting Line Bay—Switching or Terminal Main Repeater

(d) Visual and audible alarms to enable an attendant to rapidly analyze the condition of the switching circuit at an attended as well as a remote unattended repeater.

(e) Patching arrangements to facilitate the tracing of switching signals for maintenance and troubleshooting.

Three types of protective switching arrangements are provided: automatic 2-line, automatic multiline, and automatic expanded multiline. In the automatic 2-line switching arrangement, there is one standby line for each regular line. In the multiline arrangement, one standby line is used for two to four regular lines. In the automatic expanded multiline arrangement, one standby line serves from four to eight regular lines. Details of these switching arrangements are provided in Section 359-010-125.

C. Line Connecting Arrangements

5.10 Typical line connecting arrangements at a switching main repeater are illustrated schematically in Fig. 20 for an all-message system. Figure 21 is an example (see 1.03) of a combined message-television system. In an all-message system, optional facilities provide the following:

(a) Terminal only

(b) Through line only

(c) Through line with bridging

(d) Through line with mastergroup 1 blocked and terminated

(e) Through line with supergroups 112 to 118 blocked and terminated

(f) Through line with supergroups 125 to 128 blocked and terminated.

Combined message and television systems provide the same functions for the message portion of the band as in an all-message system and provide for television as in the following:

(a) Terminal only

(b) Through line only

(c) Through line with bridging received.

Details of the line connecting arrangements are covered in Section 359-010-130.

D. Transmission

5.11 The block schematic of a switching main repeater for one direction of transmission is illustrated in Fig. 22. Duplicate components are required for the other direction of transmission. The functions of the high-frequency line components through FLAT AMP A are the same as at the equalizing auxiliary and equalizing main repeaters described in Part 3. Additional manual and dynamic equalization terms necessary to make all lines as flat and equal as possible are provided by equalizers B1 and B2, a low-frequency whip equalizer pivoted at about 800 kHz, bump-shaped equalizers associated with the 308-, 556-, 3096-, and 8320-kHz pilots, and adjustable phase build-out units. With proper adjustment of these units, the gain- and phase-frequency characteristics of the lines in a given direction will be electrically similar. This allows any one of the regular lines to be interchanged with the standby line by switching without adversely affecting service. In combined message-television systems, the delay build-out (DEL BO) unit is used to equalize the delay in the lines. Additional gain and delay equalization required for television is provided in the line connecting circuits (see Fig. 21).

5.12 Received transmission signals pass through the receiving transmission equipment, pilot hybrid line switching equipment, and the line connecting equipment where various through-circuit arrangements and bridging and dropping of certain supergroups, mastergroups, or television may be made. Transmission signals and pilots to be transmitted are inserted at the transmitting hybrid and are amplified by FLAT AMP T for transmission over the line.

5.13 The transmission equipment at a switching main repeater up through FLAT AMP A is the same as used in the equalizing auxiliary repeater. The following is a functional description of the additional transmission equipment used at a switching main repeater.

Equalizers

5.14 ***Equalizers B1 and B2:*** Equalizers B1 and B2 are similar in function to equalizers A1 and A2. They supplement equalizers A1 and A2 at dropping and switching points to obtain more precise equalization. The dynamic section of equalizer B1 is controlled by the 556-kHz pilot regulator. Equalizer B2 contains two dynamic equalizing sections which are controlled by the 308- and 8320-kHz pilot regulators.

5.15 ***"Bump" Equalizers:*** The bump-shaped equalizers for the 308-, 556-, 3096-, and 8320-kHz pilot frequencies are manually adjustable units used to supplement equalizers A and B to trim the pilots to nominal power level after all other equalization of the line has been made.

5.16 ***Low-Frequency Equalizer:*** The low-frequency equalizer (LF EQ) is a manually adjustable whip equalizer pivoted at 800 kHz and is used to adjust the gain-frequency characteristic at the low end of the band.

5.17 ***Adjustable Phase Equalizer:*** The adjustable phase equalizer (PHASE BO) is a manually adjustable network used to build out the electrical length of a line equal to standby or other lines. This enables the lines to be interchanged during switching without service interruption due to phase differences. In cases where the adjustable phase equalizer is not used, a 5-dB attenuator is used.

Regulators

5.18 At the switching main repeater, regulators for each of the six pilots, 308-, 556-, 2064-, 3096-, 7266-, and 8320-kHz, are provided. These regulators are similar to those employed at an equalizing repeater. The output of all six regulators is combined in a 6-pilot computer to control the dynamic sections of equalizers A1, A2, B1, and B2 and the gain of the line amplifier.

Computer

5.19 The 6-pilot computer is a resistance network similar to but more complex than the 3-pilot computer used in the equalizing repeaters. It is provided to reduce interaction among pilot-controlled broad equalization shapes. From each regulator the computer receives a dc signal proportional to the pilot frequency voltage. With this signal information, it determines the proportional amount of equalization which should be introduced by each dynamic equalizer in the regulating network to correct for the gain distortion in a given transmission characteristic. The computer also provides the automatic line switching circuit with a direct voltage signal proportional to the level of the 7266-kHz pilot. Since the pilot indicator circuit is a relatively slow-operating device, this signal is provided so that a line switch will be initiated as soon as possible after a line failure has occurred.

Amplifiers

5.20 FLAT AMP B compensates for the losses of equalizer A1 and the low-frequency equalizer (LF EQ). FLAT AMP C compensates for the losses in equalizer B1, the attenuator or adjustable phase equalizer, and the 556-kHz equalizer. FLAT AMP D compensates for the losses of the 308-, 3096-, and 8320-kHz equalizer B2 and, when used, the delay build-out unit. The transmission amplifier FLAT AMP T amplifies the low-level transmission signals and pilots introduced at the transmitting hybrid for transmission over the line.

Delay Build-Out Network

5.21 The delay build-out network is used in combined television and message systems. The delay build-out (DEL BO) network is a manually adjustable network used in building out the delay distortion of the line in the television portion of the band.

Pilot Indicators

5.22 In the switching main repeater a pilot indicator unit, equipped with microammeters and Sensitrols for each of the six pilots, is provided. The pilot indicator unit continuously receives from the pilot regulators dc currents which are proportional to the pilot frequency voltages of the line. The current is measured and the relative magnitude is indicated on the meters. When any pilot deviates a predetermined amount from normal value, the pilot indicator circuit Sensitrol closes and applies a ground to the automatic line switching circuit which initiates a switch to a standby line. Gain controls are provided for adjustment of the pilot regulators.

6. TERMINAL MAIN REPEATER

6.01 A terminal main repeater performs the same functions as the switching main repeater, receiving in one direction and transmitting in the other. It is essentially one-half of a switching main repeater. Its principal distinguishing characteristic is that all line pilots are introduced at a terminal main repeater. At the repeater all line frequencies are modulated down to at least mastergroup frequencies (and vice versa). This repeater is generally an alarm-locating point.

A. Equipment Arrangements

6.02 The terminal main repeater is generally housed in a terminal building. On hardened routes, the repeater is located in an underground structure with transmission equipment located in shock-resistant bays.

6.03 The terminal main repeater requires one receiving bay and one transmitting bay for the line equipment per carrier system. Figures 18 and 19 illustrate the bays which are equipped the same as at the switching main repeater.

B. Transmission

6.04 The block schematic of a terminal main repeater is illustrated in Fig. 23. This illustration represents the equipment necessary for one carrier system. All line frequency components are of the same type and perform the same functions as do those in a switching main repeater. Received transmission signals are applied through the line equipment, pilot hybrid, and line switching circuit to the line connecting equipment and out to the terminal equipment. Transmission signals and pilots to be transmitted are inserted at the transmitting hybrid and are amplified by FLAT AMP T for transmission over the line.

6.05 Part 5 provides a functional description of the high-frequency line components.

6.06 The line switching and line connecting arrangements at the terminal main repeater are the same as at the switching main repeater. Details of these arrangements are provided in Sections 359-010-125 and 359-010-130, respectively.

Power

6.07 The terminal main repeater normally feeds power to the cable but may be arranged to receive power from the cable. In the power-received condition, the line equipment is powered from the cable and the line connecting equipment is powered from a local source. In the power-furnished condition, the power for the amplifiers, regulators, and line connecting equipment is supplied by a 505D power plant which also feeds power to the adjacent power loop. The automatic line switching equipment is powered from local sources. The switch control bays, rectifier bays, and power control bays (used when power is supplied to the cable) are generally mounted in a line behind the transmission bays.

7. DRAWINGS

7.01 The following schematic drawings (not attached) are related to this section.

SD-53206-01	L3 Carrier Amplifier Identification Tone-Balancing Circuit
SD-59449-01	L3 Carrier Auxiliary Repeater Transmission and Control Circuit
SD-59474-01	L3 Carrier—Application Schematic for Auxiliary Repeater
SD-59484-01	L3 Carrier Transmission and Control Circuit Equalizing Auxiliary and Main Repeaters
SD-59582-01	L3 Carrier—Application Schematic—Equalizing Main Repeater Transmission Circuit
SD-59607-01	L3 Carrier—Application Schematic—Equalizing Auxiliary Repeater Transmission Circuit
SD-59608-01	L3 Carrier—Application Schematic—Switching and Terminal Main Repeater Transmission Circuit
SD-59630-01	L3 Carrier—Application Schematic—Telephone Line Connecting Circuit

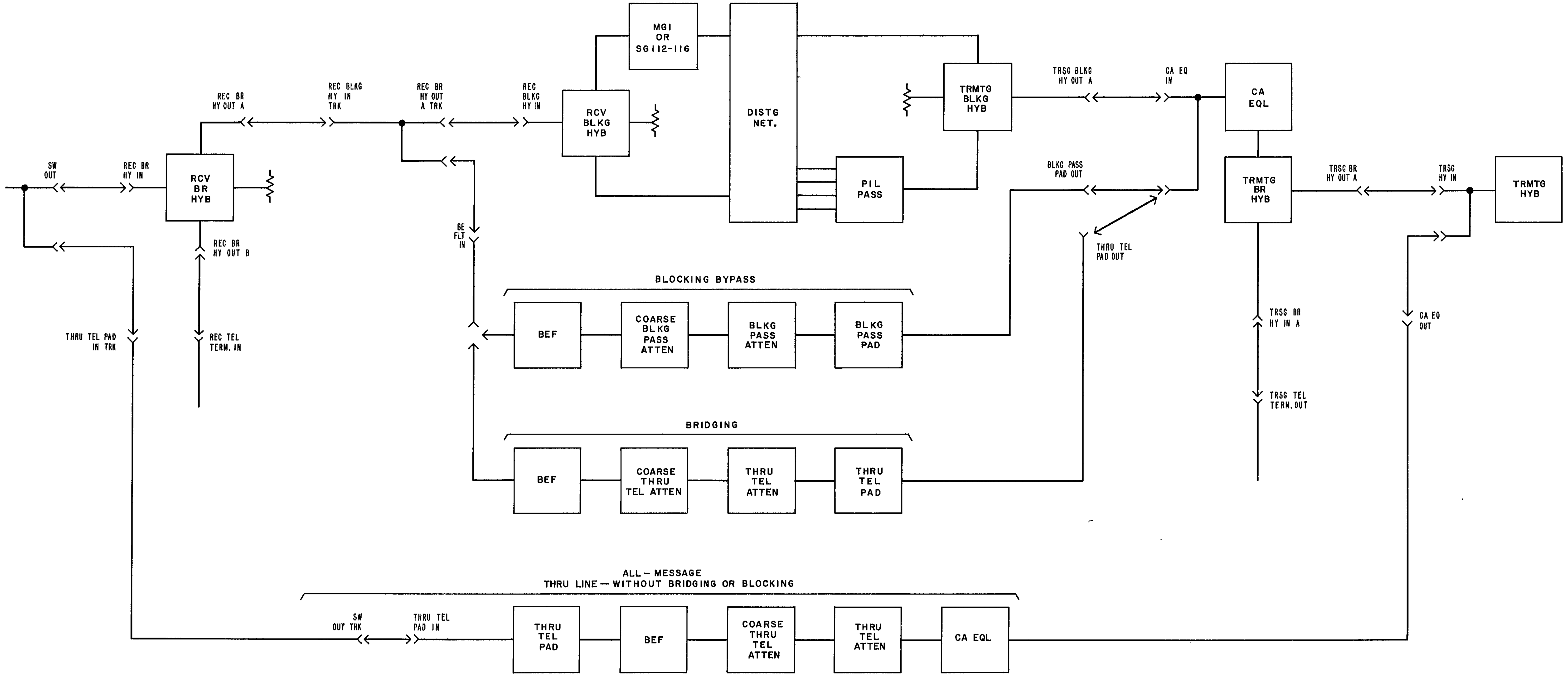


Fig. 20—Line Connecting Arrangements—All-Message System—Block Schematic

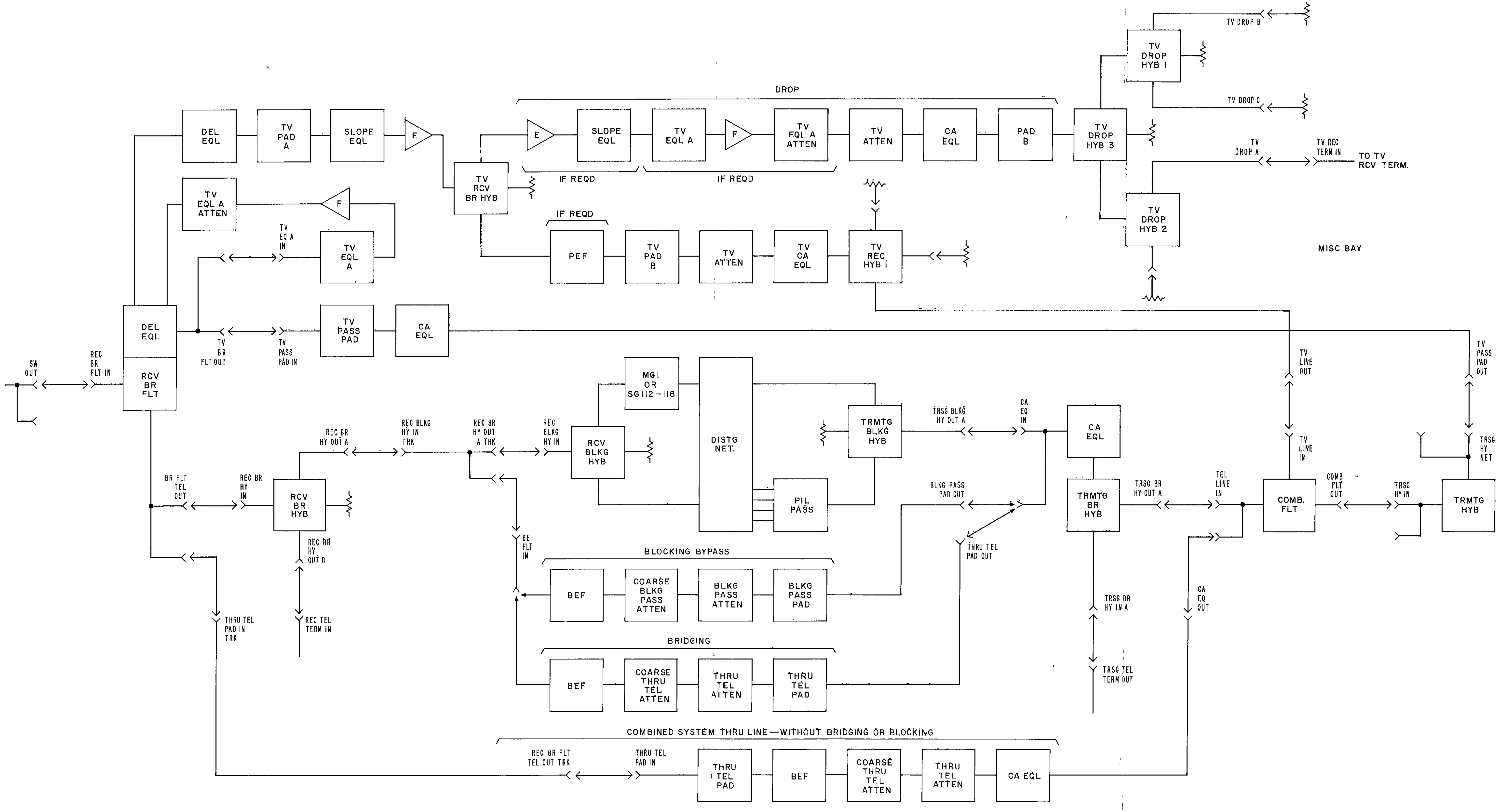
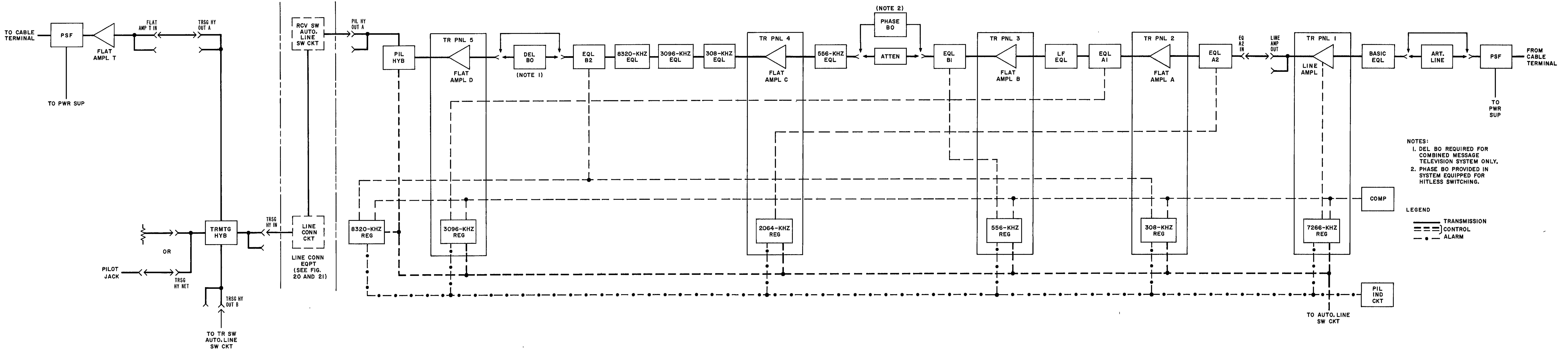


Fig. 21—Line Connecting Arrangements—Combined Message and Television—Block Schematic

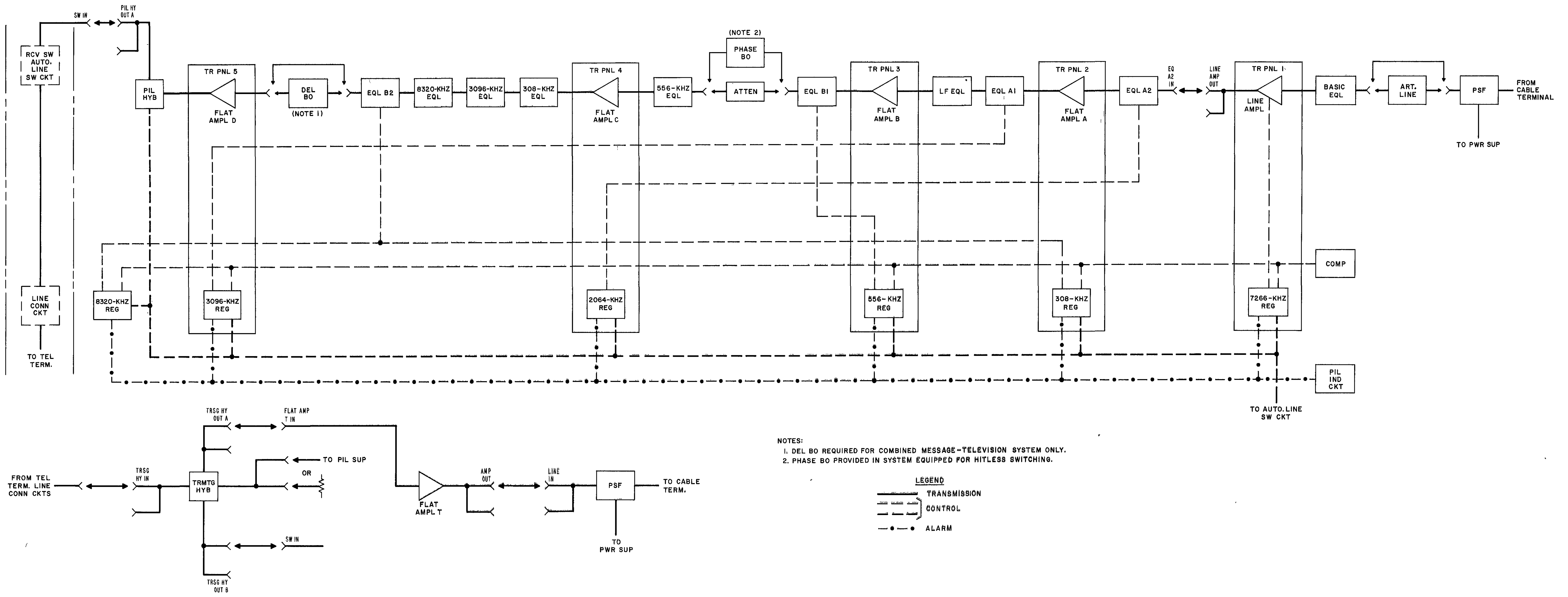


NOTES:
1. DEL BO REQUIRED FOR COMBINED MESSAGE TELEVISION SYSTEM ONLY.
2. PHASE BO PROVIDED IN SYSTEM EQUIPPED FOR HITLESS SWITCHING.

LEGEND

TRANSMISSION
CONTROL
ALARM

Fig. 22—Switching Main Repeater—Block Schematic



NOTES:
1. DEL BO REQUIRED FOR COMBINED MESSAGE-TELEVISION SYSTEM ONLY.
2. PHASE BO PROVIDED IN SYSTEM EQUIPPED FOR HITLESS SWITCHING.

Fig. 23—Terminal Repeater—Block Schematic