

## REPEATER DESCRIPTION

### T1 AND T1/OS DIGITAL LINES

### DIGITAL TRANSMISSION SYSTEMS

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**1. GENERAL**

**1.01** The T1 and T1 Outstate (T1/OS) Carrier System repeaters are used to regenerate pulse code modulation (PCM) signals received from the preceding line section or terminal and to transmit the regenerated pulses to the next location via the following line section. These repeaters are designed for use with exchange area cable pairs. Office and line repeaters are provided for either 1- or 2-cable power looping operation. A summary of the T1 Carrier repeater codes is given in Tables A, B, and C.

**1.02** The reasons for reissuing this section are listed below. Revision arrows are used to emphasize the more significant changes.

- (1) To add the 231F bridging office repeater
- (2) To make power option corrections to Fig. 28.

**1.03** There are three categories of repeaters and one type of regenerator used for the T1 and T1/OS lines. They are office repeaters, line repeaters and regenerators, and bridging repeaters. These repeaters can be grouped according to circuitry: those having integrated circuits [Table A (office repeaters) and Table B (line repeaters)], and the older ones having nonintegrated circuits (Table C). The integrated circuit-type repeaters and 7A regenerator are immune to free-running oscillation when not driven by a signal and operate over a wider temperature range (Table D). Integrated circuit repeaters and 7A regenerators also incorporate automatic line buildout (ALBO) which eliminates the need for 836-type line buildout (LBO) networks required in all nonintegrated circuit-type repeaters.

**1.04** A general description of the repeaters and the 7A regenerator used for T1 and T1/OS digital lines is contained in this section. For a detailed description refer to the schematics and circuit descriptions listed in Part 5.

**1.05** Office and line repeaters are provided for the following modes of cable repeater operation:

- (1) One cable using bidirectional line repeaters
- (2) One cable using unidirectional line repeaters
- (3) Two cables using bidirectional line repeaters
- (4) Two cables using unidirectional line repeaters.

Both directions of transmission are carried in a single cable sheath in modes 1 and 2, while each direction of transmission is carried in a separate cable sheath in modes 3 and 4. Modes 1 and 4 are used more widely than the others and were formerly called one-cable and two-cable operation (see Section 365-200-100).

**1.06** The 7A regenerators are required as line repeaters for T1/OS lines on T2 cable. This re-

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generator, designed to fit into a 473-type (T2) apparatus case slot, is roughly the equivalent of half a 209-type repeater with additional circuitry to prevent interaction of T1 and T2 signals. At T1/OS span-terminating positions, the 236N repeater is required to match the LOCAP\* cable impedance.

**1.07** Office repeaters (Fig. 1 through 5), except the bridging type, consist of circuits carrying two separate directions of transmission (transmit and receive). The transmit path is passive and includes line attenuation (artificial line or flat-loss network), secondary lightning protection, and a transformer for simplexing power to the line. In addition, jack access to the transmit path is provided on some of these repeaters. Block diagrams of the integrated and nonintegrated circuit-type line powering repeaters are shown in Fig. 6 through Fig. 9. Diagrams of the integrated and nonintegrated circuit-type power looping repeaters are shown in Fig. 10 through Fig. 13. The bridging repeaters (Fig. 14) are used to provide signals to the maintenance line and to minimize transmission interruption during in-service repeatered line patching.

**1.08** Line repeaters (Fig. 15 through 18) include two complete regenerators in one housing to provide pulse regeneration for both directions of transmission. This applies for one system for bidirectional operation or for one direction of transmission for two systems for unidirectional operation. The two regenerators are referred to as side 1 and side 2 for convenience of identification (see Fig. 19 through 22). Both sides of these repeaters are powered from the same power supply. Through or looped line-powering arrangements are built into the 201- and 205-type and 208 and 209 single-letter code integrated circuit repeaters (Fig. 19 and 20), whereas a plug-in switch is provided in the 238- and 239-type and 208 and 209 double-letter code repeaters (Fig. 21) for selecting the powering arrangements. Option screws are provided in the 201- and 205-type nonintegrated circuit repeaters (Fig. 22) for through and loop line powering. A plug-in switch for selecting separate or common fault-locate outputs (options S and V) is provided in the 238- and 239-type and 208 and 209 double-letter code bidirectional repeaters. Separate fault-locate outputs are built into the 205M, 205N, 208E, 208F, 209E, and 209F repeaters (options U and V). The separate fault-locate outputs are used to permit single-end fault locating of the T1/OS lines. The 205-

209-, and 239-type repeaters contain secondary surge protection, which is the only difference between them and the 201-, 208-, and 238-type repeaters, respectively.

**1.09** The 7A regenerator (Fig. 23 and Fig. 24) consists of one complete regenerator to provide pulse regeneration in one direction of transmission. The single fault-locate output must be fault located from both ends of the span of the T1/OS lines. The 7A regenerator also contains secondary surge protection.

**1.10** The regenerator is used to regenerate a 1.544 Mb/s pulse stream for one direction of transmission. The pulse stream consists of the presence or absence of a pulse. The format of the pulse stream is bipolar (alternate positive and negative pulses). Distorted and attenuated pulses from the previous repeater regenerator or terminal are received at the input of the regenerator or repeater (see Note).

**Note:** If for some reason no input pulses are received at the input to the nonintegrated circuit-type repeater, the repeaters may go into self-oscillation at approximately 10 kHz. Another phenomenon that may take place with these repeaters if no input signal is present is the generation of an eight-out-of-eight output pulse train. Self-oscillation may possibly cause interference to other working systems in the same apparatus case.

These pulses are coupled to the preamplifier through the input transformer and buildout networks (ALBO or LBO). In the case of office repeaters, an artificial line or pad provides proper line termination and buildout of line loss. Several codes of LBO networks are provided for use in the nonintegrated circuit-type repeaters. These networks and their losses are shown in Table E. The ALBO network is used in all integrated circuit-type repeaters and 7A regenerators to automatically build the cable section out to the correct loss at 772 kHz.

**1.11** The preamplifier is a shaped feedback amplifier equalized to make the overall characteristic of the cable and preamplifier uniform. The gain characteristic of the preamplifier is optimized for cable losses of approximately 31 dB by the fixed feedback network. When the cable section loss preceding the amplifier of an integrated circuit repeater or 7A regenerator is less than 31 dB, the regulator circuit

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detects the reduced cable loss and provides a control signal to the ALBO network. The ALBO network inserts the proper amount of shaped loss in the input to the preamplifier, thus making the overall characteristic of the cable and the amplifier uniform again. When the cable section loss preceding the amplifier of a nonintegrated circuit type repeater is less than 31 dB, the additional loss required is obtained by inserting the proper LBO (Table E). Optimal repeater and regenerator performance over a range of cable loss from approximately 7.5 dB to 35 dB, as measured at 772 kHz, is provided by the ALBO network or by selecting and installing the proper LBO network.

**1.12** The output of the preamplifier is applied to the clock extraction circuit and also to the pulse regenerator. The signals applied to the clock extraction circuit are rectified and then applied to a hi-Q resonant circuit. This resonant circuit extracts a 1.544-MHz frequency component from the applied signal. The extracted signal is first amplified and then used to control the time at which the input signals of the pulse regenerator are sampled. The extracted signal also controls the width of the regenerated pulse. This regenerated pulse is, in turn, applied to a transistor switch which drives the next section of cable.

**1.13** Span line powering (nominal 60- or 140-mA for line repeaters and 80 mA for the 7A regenerator) is supplied from the office battery via the office repeater using a combination of ground and -48, -130, and +130 volt office battery. In the 201-type office repeater, the line current is manually set by means of a resistor and may vary from 130 to 200 mA as the line temperature and/or office battery vary. However, it must be maintained within 130 to 150 mA. In the 206-, 221-, 231-, and 236-type office repeaters, the line current is held to nominal values by means of automatic line current regulators contained in the line powering repeaters (Fig. 6 through 9). In addition to its primary use for powering the line repeaters, the line current also serves as a sealing current for unsoldered splices.

**1.14** Two types of line current regulators (Fig. 25 and 26) are used in the 206-type repeater (-48 volt and +130 volt). The +130 volt regulator is powered from the +130 volt office battery and either ground, -48 volt, or -130 volt office battery. The -48 volt regulator is powered from -48 volt office battery and ground only. A single line current regulator (Fig. 27 and 28) is used in the 221-, 231-, and 236-type re-

peater which is powered from the various combinations of office battery and ground (-48 volts and ground, +130 volts and ground, +130 volts and -48 volts, and +130 volts and -130 volts). These combinations provide for optional power loop voltages of 48, 130, 178, or 260 volts. The power loop voltage used, and thus the code of repeater used, will depend on the cable gauge, cable length, and the number of repeaters in the power loop. The desired power loop voltage is obtained by strapping options on the fuse and alarm panel in the 206 office repeater bay or by selecting options on the regulator in the 221- and 231-type repeaters (Fig. 27 and 28). In addition to a full voltage range capability ( $\pm 130$  volt and -48 volt, selected switch options), the 221-type and some codes of 231 and 236 repeaters also have a line current option which will permit the powering of standard T1 lines (140 mA) or low power T1 lines (60 mA).

**1.15** Four test points are provided on office repeaters equipped with regulators and two are provided on office repeaters which are used to loop the line current. These test points permit measuring the current and voltage to establish that the power loop is being powered properly and that the regulator is operating within its regulating range. The + test point (206- and 236-type repeaters) or the -V test point (221- and 231-type repeaters) is used in conjunction with the other three test points as follows:

#### **206- and 236-Type Repeaters**

- + with -I: measuring line current. The voltage at these test points indicates 1.4 volts when the line current is 140 mA, 0.6 volts when the line current is 60 mA, and 0.8 volts when the line current is 80 mA (236N repeater).
- + with -V: measuring line voltage. The line voltage is the sum of the voltage drops across each repeater in the line and the cable resistance.
- + with REG: measuring regulator voltage. This measurement is used to determine the operating point of the current regulator.

#### **221- and 231-Type Repeaters**

- -V with -I: measuring line current. The voltage at these test points indicates 1.4 volts when the line current is 140 mA and 0.6 volts when the line current is 60 mA.

- -V with +V: measuring line voltage. The line voltage is the sum of the voltage drops across each repeater in the line and the cable resistance.
- -V with REG: measuring regulator voltage. This measurement is used to determine the operating point of the current regulator.

**1.16** The -48 volt regulator which is provided in the 206-type repeater uses a single fuse in the minus line, and the +130 volt regulator uses two fuses, one in the minus line and one in the +130 volt line. The current regulator in the 221-, 231-, and 236-type repeaters uses two fuses, one in the minus line and one in the plus line. These fuses, if blown, provide an alarm indication on the fuse and alarm panel in the office repeater bay (ORB). Depending on the line-powering voltage combination used, these fuses may be replaced with dummy fuses. More details about the nominal line current, dummy fuse, and option switch are provided in Fig. 25 through 28.

**1.17** Nominal line current is simplexed over the cable pairs via the power option block, switch S101 (Fig. 29), and the center taps of the input and output transformers. The dc power is extracted at each line repeater by means of a series diode regulator which provides dc voltages to both sides of the repeater.

## 2. REPEATER ADJUSTMENTS AND REPAIRS

**2.01** The repeaters described in this section do not require field adjustment, except for selecting the powering options (and FL options on some codes) and installing equalizers into the 206- and 236-type extended cross-connect package (EXCP) repeaters. All nonintegrated circuit-type repeaters require that 836-type LBO networks be inserted. Selecting the options, installing equalizers, and inserting LBO networks is only required during initial installation or when a repeater is used to replace a defective one taken out of service for repair.

**2.02** Assembly and adjustment of the T1 repeaters require special test equipment; therefore, repairs should not be attempted in the field. If failure should occur, the defective repeater should be replaced and returned to a repair center equipped to service these units.

## 3. INTEGRATED CIRCUIT-TYPE REPEATERS

### A. Office Repeaters

**3.01** The different codes of integrated circuit-type repeaters, provided for use in the office, are listed in Table A and are shown in Fig. 1 through 4.

**3.02** The 201K repeater, rated manufacture discontinued (Mfr Disc), is used as an office repeater or as a line repeater. The 208D and 208AB line repeaters may also be used as an office repeater in the 201-type office repeater bay by use of 215A adapters.

**3.03** A single office repeater can be used in a terminal office or two repeaters can be used back-to-back in a through office to provide both directions of transmission for one system in one cable sheath. These arrangements are shown in Fig. 30 and 31, respectively. Powering options must be set as required for the particular installation.

**3.04** Two office repeaters can be used in a terminal office or four repeaters can be used in a dual back-to-back arrangement in a through office to provide both directions of transmission for two systems in two cable sheaths. These arrangements are shown in Fig. 32 and 33, respectively. Powering options must be set as required for the particular installation.

### 206 Integrated Circuit-Type Repeaters

**3.05** These repeaters (Fig. 1 and Table A) include a regenerator and a simplexing transformer in both sides. Some 206-type repeaters also contain access jacks (Fig. 6). Pulse regeneration is provided in one direction (receiving) whereas the other direction (transmitting) is passive. In addition, a built-in 7.5-dB artificial line network or 3-dB pad (see Note) and secondary lightning protection are provided in both incoming and outgoing lines.

**Note:** When near-end crosstalk or end section loss is the limiting factor, an office repeater equipped with a 3-dB pad instead of a 7.5-dB artificial line may be used.

The active side of the 206-type repeater is powered by the built-in voltage regulator circuit. The power option block (Fig. 29) permits the power for the voltage regulator to be obtained either in series with the span line power loop or directly from office battery. In either case, the span line will be powered by the automatic line current regulator.

**3.06** The 206H, 206J, and 206K repeaters are identical except for the following:

- The 206H contains a -48 volt current regulator for powering short lines.
- The 206J contains a +130 volt current regulator for powering longer lines.
- The 206K contains no current regulator and thus is not used for powering the line. This repeater is used for looping the power at a through or terminal office, and it obtains power from the local office battery or the power loop.

**3.07** The 206L, 206M, and 206N repeaters are identical to the 206H, J, and K, respectively, except that they contain a 3-dB pad instead of a 7.5-dB artificial line.

**3.08** When using T1 repeaters which have a 3-volt base-to-peak output, the office repeater bay (ORB) to digital cross-connect (DSX) cabling restriction is 85 feet of ABAM cable or 0.4 dB of loss at 772 kHz. The 206T, U, W, Y, AA, and AB repeaters, which are part of the EXCP, are provided to significantly increase the flexibility and growth potential of the DSX-1. These repeaters have a 6-volt base-to-peak output which is 6 dB higher in output power than a standard DS1 signal. This higher amplitude is preequalized by a 983-type equalizer which is mounted on the repeater frame. When using a 206 EXCP repeater with a 983-type equalizer, cabling between the ORB and DSX-1 may consist of up to 655 feet (3 dB) of ABAM cable (see Table F).

**3.09** The 206 EXCP repeaters have powering and artificial line options which are respectively equivalent to the 206H through N repeaters. However, due to the 3-dB additional cable loss in the transmit path, the transmit interface networks in the EXCP repeaters are reduced in loss by 3 dB. In addition, to accommodate both standard and low current lines, the regulating EXCP repeaters have a screw switch standard/low line current option. When operating at low (60 mA) line current, the office repeater must be powered from local office battery. The 206 EXCP repeaters have no input, output, or monitor jacks since these functions are provided by the DSX-1. Table G summarizes the relationships between the 206 EXCP repeaters and other 206 codes.

**3.10** The 206R and 206S bridging repeaters are used to minimize transmission interruptions

during in-service patching and to provide signals to the maintenance line. Both repeaters perform the same bridging functions. The two codes differ in that the 206S is intended for use in offices which have DSX-1 bays. Therefore, the 206S has no input or output jacks since these access points are provided by the DSX-1. In addition, bridging resistors are not provided in the 206S since they are provided at the DSX-1. These repeaters operate with a nominal input at the DS1 monitor level (ie, a DS1 level signal reduced 20 dB in amplitude by 430-ohm resistors in series with tip and ring). An ALBO has been incorporated into the design so that monitored signals passing through up to 3 dB of cable loss (at 772 kHz) will be correctly regenerated. This corresponds to the maximum ORB-to-DSX-1 ABAM cable length of 655 feet.

**3.11** These bridging repeaters have no power options and are always powered from the -48 volt office battery. Office battery input to the bridging repeaters is in series with a current-limiting resistor which is part of the ORB.

**3.12** The 206R and 206S bridging repeaters are completely interchangeable with the 206C and 206P nonintegrated circuit bridging repeaters and with the 236P low-power bridging repeaters.

**3.13** The 206-type repeater uses a 1-piece cast aluminum frame on which is mounted a circuit board and, on some codes, larger parts such as fuse holders, jacks, current regulator transistors, and a molded 21-pin connector. The entire unit plugs into a slot in an office repeater bay (ORB), line terminating unit (LTU), or span-terminating module (STM). A quick-release spring catch on the lower front of these repeaters is used to hold it in place but permits it to be removed easily. Identification information such as repeater code, series number, and date of manufacture is located on the front of these repeaters. On some repeater codes the front panel also mounts access jacks, fuses, and test points. The overall length of the 206-type repeater is approximately 10 inches, the height is 8-5/8 inches, and the width is 1-9/16 inches.

**3.14** Jack protectors to replace the 8A designation strip are provided for the 206-type repeaters which have access jacks. This new hinged designation card holder assembly (Fig. 34) is shipped with all new repeaters, or it may be ordered from the Western Electric Company. System identification (such as the

example of Fig. 34) can be marked directly on the jack covers with washable ink. This holder will also accommodate the redesigned TSPS designation card, KS-20954, List 1.

### 221-Type Repeaters

**3.15** The 221A, B, and C repeaters (Table A) are similar in function to some of the 206-type repeaters. They are physically and electrically compatible with the J98725 T1C/T1 office repeater bay (ORB). There are no signal path access (patching) jacks on these repeaters since this function is provided by a DSX-1 (preferably) or an optional patch and cross-connect field in the ORB. A typical 221-type repeater is shown in Fig. 2.

**3.16** The 221-type repeater family may be used in T1 lines which would call for the 206H, J, K, T, U, W, R, and S repeaters. Therefore, fewer codes of these repeaters are required since three 221-type repeaters replace eight 206-type repeaters. The 221A and 221B repeaters have 7.5-dB artificial lines in the receive path and 4.5-dB artificial lines in the transmit path. Due to the resulting incompatibility with T1C end-section engineering rules, 3-dB pad repeaters are not provided in the 221-type family. The lower transmit path loss allows for up to 3 dB of loss at 772 kHz (655 feet of ABAM cable) between the ORB and DSX-1. The output of the 221-type repeaters is 6 volts base to peak, which is 6 dB higher in output power than a standard DS1 signal. This higher signal level allows for equalization in the transmit path between the repeater and cross-connect point. ED-3C585-30 (T1C/T1 DSX optional) and ED-3C765-30 (T1C/T1 DSX dedicated), 61, 62, or 63 equalizers (Table H) is plug-in mounted on the back of the ORB and is electrically located between the regenerator output and cross-connect point.

**3.17** A line current regulator is used in the 221A repeater and is powered from the various combinations of office battery and ground. In this repeater, switch options are used to select both the required power loop voltage (48, 130, 178, or 260 volts) and the required line current (60 or 140 mA). The 221B repeater contains no current regulator and is used for looping power. Since powering of 221-type repeaters requires 140 mA of current, they cannot be powered in series with a low power (60 mA) line. The 221A and 221B repeaters can only be powered in series with a standard power (140 mA) line or can be powered locally from the -48 volt office battery.

**3.18** The 221C bridging repeater is used for patching. This repeater, like all bridging repeaters,

is always powered from the -48 volt office battery. Input, output, and monitor jacks are *not* provided in this repeater since jack access is provided at the DSX-1 (preferably) or an optional jack field. On the ORB when a DSX-1 is used, the input to this repeater is obtained at the maintenance line input jack at the DSX-1. The bridging repeater is cross-connected to the maintenance line at the ORB. Like the 221A and B, the output level of the 221C is 6 dB above the nominal DS1 level. An ED-3C585-30, G1 (0-220 feet) equalizer should always be provided at the ORB for 221C repeaters.

**3.19** The following listing summarizes the applications of the 221-type repeaters and also includes information pertaining to the 206-type repeaters, which are used in similar applications:

- **221A**—Pulse regenerator, transmit power simplex, line current regulator with all voltage options, and standard/low line current option. Similar use as 206H, J, T, and U.
- **221B**—Pulse regenerator, power-looping circuitry. Similar use as 206K and W.
- **221C**—Bridging office repeater. Similar use as 206R and S.

**3.20** The 221-type repeater, which is approximately 10-1/2 inches long, 6 inches high, and 1-1/2 inches wide, plugs into a slot in the T1C/T1 ORB shelf. A quick-release spring catch on the lower front of these repeaters is used to hold them in place but permits easy removal. Identification information, such as repeater code, series number, and date of manufacture, is located on the front of these repeaters. Two fuses and test points are mounted on the front of some codes of these repeaters.

### 231-Type Repeaters

**3.21** The 231-type repeaters supersede the 221-type repeaters (Table A). They are physically and electrically compatible with the T1C/T1 office repeater bay. There are no signal path access (patching) jacks on these repeaters since this function is provided by a DSX-1 (preferable) or an optional jack field mounted in the ORB. A typical 231-type repeater is shown in Fig. 3.

**3.22** The 231-type repeater is fully standard/low power compatible. The regenerator portion of

the 231-type requires 60 mA of current and may be powered from local office battery or in series with either a 60-mA or 140-mA line.

**3.23** Two additional codes of 231-type repeaters are provided which were not available in the 221-type repeaters. The two additional repeaters which are coded 231D and 231E are used with Metropolitan Area Trunk (MAT®) trunk cable.

**3.24** The following listing summarizes the applications of the 231-type repeaters and also includes the 221-type that they supersede:

- **231A**—Pulse regeneration, power simplexing, line current regulator with all voltage options, standard/low line current option. Supersedes 221A.
- **231B**—Pulse regeneration, power-looping circuitry. Supersedes 221B.
- **231C**—Bridging office repeater (Mfr Disc). Supersedes 221C.
- **231D**—Pulse regeneration, power simplexing, line current regulator with all voltage options, 60-mA operation only. For use with MAT trunk cable; not available in 221-type.
- **231E**—Pulse regeneration with power-looping circuit. For use with MAT trunk cable; not available in 221-type.
- **231F**—Bridging office repeater. Supersedes 231C.

### 236-Type Repeaters

**3.25** The 236-type repeaters supersede the 206-type repeaters (paragraphs 3.05 through 3.14) and can generally be used in applications where 206-type repeaters are used (Table A). These repeaters are intended for use in the J98710 206 office repeater bay (206 ORB) or in other miscellaneous mountings intended for 206-type repeaters. A typical 236-type repeater is shown in Fig. 4.

**3.26** All options provided by the 206-type repeaters such as +130 volt regulator, -48 volt regulator, power looping, 7.5-dB artificial line, 3-dB pad, EXCP (Table F), and bridging are provided in the

236-type repeater family. In addition, some 236-type repeaters operate at 60 mA or 140 mA and some have a 60-mA/140-mA line current selector for powering both standard current and low current T1 lines. See Table A.

**3.27** Fewer codes of 236-type repeaters are required to provide the same functions as the various 206-type repeaters. This code reduction is achieved with the use of a single regulator for both +130 volt and -48 volt applications and with the elimination of two bridging repeater codes through the use of a craft-selected LOCAL/DSX option. Additional codes of 236-type repeaters are provided for MAT trunk cable and LOCAP cable applications (see Table A) which were not provided in the 206 codes.

**3.28** The 206-type repeaters can be replaced by 236-type repeaters as shown in Table A.

**3.29** The following listing summarizes the 236-type repeaters:

- Provides all the features of the 206-type repeaters.
- All codes have low-power regenerator circuitry capable of operating on 60-mA or 140-mA currents.
- Some codes have a line current regulator with standard (140 mA) or low (60 mA) line current option. This regulator is capable of operation from all combinations of office battery via craft options.
- Some codes are provided for use with MAT trunk cable and LOCAP cable.

**3.30** The 236-type repeater uses a 1-piece cast aluminum frame on which are mounted a circuit board and, on some codes, larger parts such as fuse holders, jacks, and equalizers. The unit plugs into a slot in an ORB, LTU, or STM. A quick-release spring catch on the lower front of these repeaters is used to hold them in place but permits easy removal. Identification information, such as repeater code, series number, and date of manufacture, is located on the faceplate of these repeaters. On some codes, access jacks, fuses, and test points are mounted on the faceplate. The overall length of the 236-type repeater is approximately 10 inches, the height is 8-5/8 inches, and the width is 1-9/16 inches. A typical 236-type repeater is shown in Fig. 4.

**3.31** Jack protectors to replace the 8A designation strip are provided for the 236-type repeaters which have access jacks. This new hinged designation card holder assembly (Fig. 34) is shipped with all new repeaters, or it may be ordered from the Western Electric Company. System identification (such as the example of Fig. 34) can be marked directly on the jack covers with washable ink. This holder will also accommodate the redesigned TSPS designation card KS-20924, List 1.

#### **B. Line Repeater**

**3.32** A number of integrated circuit line repeater codes are provided for the various applications of the T1 and T1/OS digital lines. They are 201-, 205-, 208-, 209-, 238-, and 239-types (see Table B). Typical line repeaters are shown in Fig. 15 through 17.

**3.33** Line repeaters include two complete regenerators in one housing to provide pulse regeneration for both directions of transmission of one system for bidirectional operation (Fig. 35) or for one direction of transmission of two systems for unidirectional operation (Fig. 36). The two regenerators are referred to as side 1 and side 2 for convenience of identification. Both sides of these repeaters are powered from the same power supply (see Fig. 19 through 21). Through or looped powering arrangements are built into the integrated circuit 201-, 205-, 208-, and 209-type repeaters (single-letter codes). Whereas an option switch for selecting through or looped powering is provided in the double-letter codes of 208 and 209 and in the 238- and 239-type repeaters. The 205-, 209-, and 239-type repeaters contain secondary surge protection, which is the only difference between them and the 201-, 208-, and 238-type repeaters, respectively. Block diagrams of these repeaters are shown in Fig. 19 through 21 to illustrate the applicable features.

**3.34** The 201G and H, 208A, B, and AA, and the 238A repeaters are used only for bidirectional operation. The two sides of these repeaters provide pulse regeneration in opposite directions; therefore, one of these repeaters is used to provide both directions of transmission for one system in one cable sheath. The 201J and K, 208C, D, and AB, and the 238B repeaters are used for unidirectional operation. The two sides of these repeaters provide pulse regeneration in the same direction; therefore, one of these repeaters provides one direction of transmission for two systems in one cable and a second repeater pro-

vides the other direction of transmission for two systems in another cable. The 238C and D repeaters, which are used for MAT trunk cable applications, provide the same functions as the 238A and B. The 205-, 209-, and 239-type repeaters are electrically identical to the 201-, 208-, and 238-type but are provided with surge protection.

**3.35** The 205M and N, 208E and F, and the 209E and F repeaters are electrically equivalent to the 205G and H, 208A and B, and the 209A and B repeaters except that separate fault-locate outputs are provided for side 1 and side 2. An option switch is provided on all double-lettered codes of 208 and 209 bidirectional type and all 238 and 239 bidirectional codes which allows selection of a common fault-locate output or separate fault-locate outputs. This separate fault-locate output feature is intended for use in the T1/OS. When used in conjunction with special fault-locating equipment and apparatus cases, single-ended fault location of T1 lines using these bidirectional repeaters is possible.

**3.36** T1 line repeaters are intended for use in remote locations such as manholes or utility poles. However, some T1 line repeaters may also be mounted in express office repeater panels (EORP) located at intermediate offices. Table B lists the apparatus cases and EORPs which house the T1 line repeaters.

**3.37** The entire 201-type repeater structure is enclosed in an aluminum housing that is held in place with two screws. The faceplate bears the repeater code, series number, and manufacture date. These repeaters are approximately 6 inches long, 4-3/16 inches high, and 1-1/8 inches wide. The 205-type repeater is similar in appearance to the 201 except it is about 2 inches longer than the 201-type. The 208-, 209-, 238-, and 239-type repeaters are enclosed in an aluminum housing that is held in place with one screw. These repeaters are approximately 2-1/2 inches high and 3/4 inches wide. The 208- and 238-types are approximately 5 inches long, whereas the 209- and 239-types are approximately 6-1/2 inches in length.

#### **C. 7A Regenerator**

**3.38** The 7A regenerator (Fig. 23) consists of a single regenerator, power supply, surge protection network, and isolation network. These networks are required to minimize interference in T2 systems

which will be operating in the same apparatus case with the T1/OS. Digital signal paths and powering terminals on the 7A regenerator are pin compatible with 1-type regenerators (T2) so that the apparatus case wiring need not be changed for the different systems. The fault-locate output of the 7A regenerator appears on a different pin from the T2. This allows separation of the T1 and T2 maintenance systems.

**3.39** The circuitry used in the 7A regenerator is similar to that used in the 209-type T1 repeater except that the circuit is implemented using dual-in-line packaged circuits and discrete components rather than a hybrid integrated circuit (HIC). (See paragraphs 3.33 through 3.37)

**3.40** The 7A regenerator structure is enclosed in an aluminum housing that is held in place with the five screws. The faceplate bears the repeater code, series number, and manufacture date. This regenerator provides pulse regeneration in one direction of transmission of one system (Fig. 37). It is used in T1/OS digital lines on LOCAP cable with T2. The plug-ins are designed for use in remote locations where they are mounted in 473-type apparatus cases. The repeaters are physically compatible with T2 regenerators housed in the same apparatus case. There are no craft options on the plug-in. These regenerators are approximately 7-3/4 inches long, 6-3/8 inches high, and 1 inch wide.

#### **4. NONINTEGRATED CIRCUIT REPEATERS (MFR DISC)**

##### **A. Detailed Circuit Description**

**4.01** The detailed circuit description in paragraphs 4.02 through 4.45 applies to the nonintegrated circuit repeaters only. For a complete circuit description of the integrated circuit repeaters, refer to the schematics and circuit descriptions listed in Part 5.

**4.02** Coded information is transmitted over a T1 carrier facility by the presence or absence of pulses in specific time slots. The absence of a pulse is equally as important as the presence of one. T1 repeaters must therefore faithfully duplicate all pulses that appear at their input without inserting a pulse into any empty slot.

**4.03** Bipolar pulse transmission (ie, transmission of alternately positive and negative pulses) is used on the digital line to remove the dc component from the unipolar PCM pulse train generated in the

channel bank equipment and to reduce the principal energy component to one-half (see Fig. 38). Since the pulse repetition rate is  $1.544 \times 10^6$  pps, the principal energy component is reduced from 1.544 MHz to 772 kHz; and the digital line bandwidth requirement is reduced from approximately 3.088 to 1.544 MHz. The absence of a dc component in the bipolar pulse train permits the repeater to be transformer-coupled to the line and helps to prevent shifting of the regenerator firing level with variation in input pulse density.

**4.04** Figure 39 is a block diagram of one side of the basic nonintegrated circuit repeater used in the T1 Carrier System. The other side is identical (that is, there are two regenerators per repeater) except in the case of 206-type office repeaters. In this case, the repeater has a single regenerator on the receiving side plus a circuit consisting of a power simplifying transformer, access jacks, artificial line, and lightning protection network on the transmit side.

**4.05** Distorted, attenuated bipolar pulses from the preceding line section are applied to the repeater input. These pulses are coupled to the regenerator through networks (the LBO network in the line repeaters and, in the case of office repeaters, an artificial line or 3-dB pad) that provide proper line termination and buildout of line loss to a standard value. The artificial line network or 3-dB pad may be built in the repeater, or it may be separate (in the 201 ORB), depending on the repeater type used (see paragraph 4.15).

**4.06** After leaving the input networks, the bipolar pulse train enters the repeater circuits which generate a new pulse for each input pulse. The pulse train first goes to the preamplifier where it is amplified and reshaped to reduce pulse dispersion into adjacent time slots. Waveforms at the preamplifier input and output and at other points in both the line and repeater are shown in Fig. 40.

**4.07** The reshaped and amplified bipolar pulse train is coupled from the preamplifier to both the converter and gate circuits. The converter changes the bipolar pulse train to a unipolar pulse train and applies it to the clock circuit in order to produce highly accurate timing pulses. These timing pulses are applied to the two gate circuits.

**4.08** Since it is desirable to prevent operation of the pulse regenerator by any signal except the

pulses of a PCM train, the threshold control circuit is provided to automatically hold the gates closed to all input pulses below a certain level. This prevents pulse regeneration by most noise, crosstalk, and other undesirable pulses that may be on the line; but it permits the desired PCM pulse train to operate the gates and thus be regenerated and applied to the following section of line.

**4.09** The simultaneous occurrence of PCM and clock timing pulses at the inputs of the AND 1 or 2 gate will cause its associated blocking oscillator to output a pulse. Since the PCM input pulses are bipolar (alternating positive and negative pulses), the simultaneous occurrence of a PCM input and a clock timing pulse will alternate between the AND 1 and 2 gates. This will cause alternate operation of the blocking oscillators, which produce new positive and negative pulses. These new pulses are of the same shape and amplitude as the original pulses; therefore, the resultant output from the pulse regenerator is a duplicate of the bipolar pulse train that originated at the distant end of the line.

**4.10** The T1 Carrier System is designed to provide optimum performance when using a digital line of 22-gauge twisted pair cable with a nominal repeater spacing of 6000 feet. Where the length of any 22-gauge line section is less than this value, the line must be built out to the equivalent of 6000 feet ( $31 \pm 1.2$  dB) by inserting into the repeater input an amount of loss equal to the amount that the line is deficient. Since the impulse noise level is normally high in the vicinity of the central office, the spacing between the central office and the first line repeater must be no greater than 4500 feet of 22-gauge cable in order to keep the average PCM signal level at least twice as great as the noise level at any point on this line section; therefore, these end sections must also be built out to the equivalent of 6000 feet for optimum repeater performance.

**4.11** The most significant frequency in the transmission of T1 Carrier line signals is 772 kHz; therefore, repeater spacing and LBO requirements may be described in terms of insertion loss at 772 kHz. In these terms, the nominal loss of an aerial line section is 31.1 dB at 55°F and the nominal loss of an underground line section is 32.2 dB at 55°F. If the loss is less than 29.8 dB, building out is required.

**4.12** The basic circuit and the loss-versus-frequency characteristic of a typical LBO net-

work is shown in Fig. 41. This circuit simulates the line loss over the applicable frequency range by use of a flat low-frequency loss combined with a rising loss of 6 dB per octave above a certain break frequency. The low-frequency loss and the break frequency depend on the line length represented by the network.

**4.13** Two types of networks are used in the repeaters. These are the 100-ohm artificial line and the 400-ohm LBO network. The 400-ohm unit, designated 836-type LBO network, uses the circuit shown in Fig. 41. This network is used in the input of both line and office nonintegrated circuit repeaters to build out the preceding line section to a nominal 6000 feet. The 100-ohm artificial line network permits the 836-type network to be used to build out an end section of any minimum length of 4500 feet or less.

**4.14** Several codes of the 836-type LBO network are provided to compensate for a wide range of line lengths. These networks and their losses are shown in Table E. The LBO networks (see Fig. 42) are provided with screw terminals which engage contacting slots in the printed wiring boards in the repeaters. This arrangement permits removal and insertion of the build-out networks with a minimum of effort. One network is required for each regenerator used in a repeater, and it will be assigned on the basis of transmission measurements made immediately after the repeater apparatus cases have been installed.

**4.15** The 100-ohm artificial line network is used with office repeaters to permit end sections of 0 to 4500 feet to be used. It provides proper termination for the associated end sections. This network has an impedance of 100 ohms, a loss-versus-frequency characteristic similar to that shown in Fig. 41 and about 7.5-dB loss at 772 kHz. This unit is built into the 206A, B, D repeaters. It is used as a separate part, designated ED-97079-30, G5 network, that may replace the ED-97079-30, G4 3-dB span pads in the 201 ORB. The circuit for the 100-ohm LBO network used in the incoming line of the 206-type repeater is shown in Fig. 43. The resistive, capacitive, and inductive components of this network provide the required shaped loss. A built-in 3-dB pad is used in the 206E, F, and G repeaters instead of the 100-ohm artificial line. The secondary lightning protection network is also shown in Fig. 43. This network is built in the 206-type repeater and is located in the control unit of the 201 ORB. The varistor string, RV101 through RV104, provides lightning protection by reducing metallic

surges. The lightning-protection networks for incoming and outgoing lines are identical, except that four varistors are used in the incoming line and eight varistors are used in the outgoing line to avoid clipping the higher level regenerated output pulses.

**4.16** The preamplifier is a 2-transistor feedback amplifier that provides shaped compensation for losses in the preceding section of cable. It is designed to compensate for a 6000-foot section of 22-gauge cable. The circuit diagram is shown in Fig. 44.

**4.17** In order to compensate for the increasing cable loss at higher frequencies, the preamplifier has a rising-gain characteristic of 6 dB per octave above 100 kHz. This characteristic is controlled by the ac feedback through R5 in combination with C1. At 1.5 MHz the rising-gain characteristic is checked and a falling-gain characteristic is introduced by the L1 and R2 combination and by the network between the Q2 collector and Q1 emitter, thus setting the upper bandwidth limits. In addition, a sharp null in the preamplifier gain is introduced at 2.25 MHz by the resonant effect of C2 and L2 to meet repeater timing circuit requirements; and the gain above 2.25 MHz is further suppressed by the combined effect of C3 and L3.

**4.18** A sharp drop in the preamplifier gain below 2 kHz is provided by the combined effect of input transformer T1, output transformer T2, and bypass capacitors C4 and C5. The large amount of low-frequency feedback, caused by the decreasing bypass action of these capacitors plus the feedback through R5, provides a large reduction in output impedance in order to provide linear response when the preamplifier is driving its nonlinear load. Gain stability of the preamplifier is obtained by feeding a portion of the Q2 emitter voltage back to the base of Q1.

**4.19** A curve of the preamplifier gain versus frequency is shown in Fig. 45, and the overall response of the preamplifier combined with 6000 feet of 22-gauge cable is shown in Fig. 46. This overall gain characteristic provides adequate bandwidth (approximately 1.5 MHz) for bipolar pulse transmission, and yet the bandwidth is sufficiently narrow that the system is not excessively sensitive to crosstalk.

**4.20** Single bipolar input pulses that have been equalized and amplified appear at the pream-

plifier output as shown in Fig. 47. However, if the preamplifier input pulse pattern is random, which is the usual case, the eye pattern shown in Fig. 48 will appear at the preamplifier output. (Also see the oscilloscope patterns of typical preamplifier input and output waveforms in Fig. 40). The eye portion of this pattern represents the region to which operation of the regenerator gates must be confined in order for a PCM pulse to be regenerated. From Fig. 49 it can be seen that when interference is severe, the eye shrinks to a very small portion of the signal; therefore, in order to obtain accurate PCM pulse regeneration under a wide range of adverse conditions, the operating level and timing region of the regenerator gates are confined to the upper half of the eye by means of automatic threshold control and narrow, accurate timing pulses.

**4.21** The timing circuit is used to generate narrow, accurate pulses for timing the operation of the regenerator gates. These timing pulses prevent partial pulsing, optimize crosstalk performance, reduce pulse instability, thus aiding in producing stable bipolar output pulses that accurately duplicate the original.

**4.22** The bipolar signal at the preamplifier output is converted to a unipolar signal, and as a result, the principal energy component of the pulse train is changed from 772 kHz to 1.544 MHz. The conversion is accomplished by using a full-wave rectifier, CR2 and CR3, to rectify the positive pulses alternately appearing across the 3-4 and 4-5 windings of transformer T2 in Fig. 50.

**4.23** The unipolar signal is fed from the converter to C10 and L4 in the clock circuit (see Fig. 51) to force this tuned circuit to ring at its resonant frequency of 1.544 MHz. The effective Q of this circuit must be high enough for ringing to be maintained with a minimum pulse density of 2 pulses in each of the 16 consecutive pulse positions, and so that the phase of the resultant clock sine wave (see Fig. 40) will not jitter with variations in the PCM pulse pattern. However, the Q of the resonant circuit must not be so high that aging and temperature variations can mistune the clock frequency. An air core inductor with an adjustable iron slug and a temperature-compensated, preaged capacitor is used for this circuit. By driving the resonant circuit with an emitter-follower stage (Q4) and removing the signal at a low impedance point on L4, a Q of approximately 85 is maintained.

**4.24** Transistor Q5 is an amplifier having a low-Q collector lead circuit (C13 and L6) that is also

tuned to 1.544 MHz for further shaping of the clock sine wave. Inductor L5 in the emitter provides an advance of about 90 degrees in the clock sine wave for proper positioning of the clock output pulse (spike). Diodes CR4 and CR5 are used to limit the sine wave symmetrically with respect to ground, and thus to minimize the effect of variation in the level and density of the preamplifier output pulse train. The gain of Q5 is such that at the minimum expected pulse level and density, the clock signal amplitude will almost reach the limiting level. In Fig. 52, several different levels of clock signal, ranging from minimum to full limiting, are superimposed on each other to show that the only point on the curve that does not vary with changes in level or density is where the signal level crosses the zero-volts line. Therefore, it can be seen that a high degree of phase stability in the timing pulses can be obtained by limiting the clock signal level and then using only the portion where it makes a zero crossing.

**4.25** To obtain use of the required portion of the clock sine wave, diode CR6 in series with L7 is used to hold the Q6 base voltage at the cutoff point with no input signal. When the fast-rising positive half of the clock signal is applied to CR6, this diode allows the Q6 base voltage to rise suddenly. This causes the Q6 collector voltage to drop suddenly to form the negative clock output pulse. The base current is determined by R16 and is now sufficient to hold Q6 in saturation during the positive half of the input signal. Next, the clipped clock signal suddenly changes from positive to negative, and Q6 conduction is suddenly cut off as its base voltage reaches approximately zero. However, the low inductance of the T3 primary winding (about 60 mH) causes a large positive overshoot in the collector voltage when the transistor is cut off. This positive overshoot in the clock output voltage is the positive pulse used for timing the operation of the regenerator gates, and the negative pulse is used for cutting off the gates. The resultant waveform at the secondary of transformer T3 is shown in Fig. 53. Since one positive and negative timing pulse pair will be generated for each pulse in the unipolar clock input train, there will be one such timing pulse pair generated for each positive pulse and one for each negative pulse in the bipolar PCM pulse train.

**4.26** Since transistors will have wide differences in gain and storage time and the regulated dc supply voltage will differ from repeater to repeater, the base current of Q6 is adjusted to the optimum

value by selecting R16 at the time of shop test. In addition, resistor R17 in series with the primary winding of T3 is used to limit the Q6 collector current to a maximum of 20 mA.

**4.27** The pulse regenerator (Fig. 54) is used to produce bipolar pulses that duplicate those that originated at the distant end of the preceding cable. It applies the resultant new bipolar pulse train to the following line section for transmission to the next repeater location or to the channel bank at the terminating office.

**4.28** The pulse regenerator consists of two blocking oscillators, Q7 and Q8, connected in a push-pull configuration. One provides the positive pulses and the other provides the negative pulses of the outgoing bipolar pulse train. Diodes CR7 and CR9 form the gate for Q7; CR8 and CR10 form the gate for Q8. Positive pulses must be simultaneously applied to **both** diodes of an unoperated gate for that gate to operate, and a negative pulse must be applied to **either** diode of an operated gate to cut off that gate. Resistors R19 and R20, respectively, determine the base current for Q7 and Q8 when their corresponding gates are operated. In order to obtain a balanced output from the pulse regenerator, the RC constant of the two blocking-oscillator input circuits must be the same; however, these resistors will normally be of a different value since the inner and outer windings of T4 to which they are connected will have different values of capacitance.

**4.29** The pulse regenerator circuit operates as follows: Preamplifier output transformer T2 (Fig. 44) simultaneously applies bipolar PCM pulses of opposite phase to gate diodes CR7 and CR8 (Fig. 54). At the same time, clock circuit output transformer T3 (Fig. 51) applies positive timing pulses (Fig. 53) to gate diodes CR9 and CR10. Since each gate (CR7, CR9 or CR8, CR10) operates only with the simultaneous application of a positive PCM pulse and a positive timing pulse to its input, the two gates operate alternately. Thus they alternately apply positive pulses to the input of their respective blocking oscillators. Application of a positive pulse to the base of either blocking-oscillator transistor, through the corresponding winding of T4, causes that transistor to very rapidly start to conduct and thus generate a negative-going voltage at its collector. Such a negative impulse at the collector of Q7 appears as a positive-going voltage at the secondary of T4. When a negative timing pulse arrives at the gates, the con-

ducting transistor is very rapidly cut off and the first positive output pulse is completed. Operation of the other blocking oscillator is the same except that the collector of Q8 is connected to the opposite end of the T4 primary; thus a negative pulse at the collector of Q8 appears as a negative pulse at the secondary of T4. This means that positive and negative output pulses alternately appear at the secondary of T4. Since the timing, shape, and amplitude of these pulses are very accurately controlled, the resultant bipolar pulse train at the repeater output accurately duplicates the input train at the distant end of the incoming line. However, any bipolar errors (two or more successive pulses of the same polarity) appearing at the input of any repeater are duplicated locally and at each succeeding repeater location.

**4.30** Transformer T4 is used to couple the output pulses from Q7 and Q8 to the outgoing line as described in paragraph 4.29. Winding 9-11 is balanced with respect to ground (terminal 10) and provides bipolar output pulses of about 3 volts base to peak. Windings 6-7 and 1-12 are feedback windings for Q7 and Q8, respectively. Winding 5-8 is used to provide pulses for fault locating, and R21 and L8 are used for shaping the fault-locating pulses and to provide isolation between the pulse regenerator and fault-locating filter. Pulse shaping and isolation are employed to decrease overshoot, thus minimizing intersystem interference in the repeater preamplifier at the following repeater location. When a fault-locating filter is not used, terminals G and H must be connected together or the repeater will not operate correctly.

**4.31** If, for some reason, there are no input pulses applied to the nonintegrated circuit repeater, the pulse regenerator may go into self-oscillation. Minor disturbances on the line due to crosstalk, etc, may cause one of the blocking oscillators to fire. With no input signal, this transistor will stay on until the output transformer (T4) core saturates. At this point the blocking oscillator will start to turn off and, as it does so, will turn the other transistor on because of mutual coupling via the common core of T4. The other transistor will repeat the cycle by saturating the core and then turning itself off and the other transistor on. Oscillations of approximately 10 kHz may thus take place and will be applied to the following section of line.

**4.32** Self-oscillation of the pulse regenerator may cause it to draw excessive current from the

power source and thereby to reduce the voltage regulator diode current (paragraph 4.40) to the point where it will be below the proper operating range. As a result, regulation will be lost and the repeater supply voltage will drop. This change in voltage will have an adverse effect on the operation of the repeater.

**4.33** Another phenomenon that may take place if no input pulses are present is the generation of an eight-out-of-eight output pulse train. With no input signal, the threshold circuit (paragraphs 4.34 through 4.38) will have no control over the operating point of the regenerator gates; and crosstalk from the clock circuit on the other side of the repeater (assuming that the other side has pulse regenerator circuitry and is operating normally) can cause the clock circuit on the side that has no input to generate a timing signal. If this signal is applied to the regenerator gates having no threshold control voltage available, the blocking oscillators in that side will fire with every positive timing pulse and thus generate the eight-out-of-eight signal. Such improper operation as described here and in paragraphs 4.31 and 4.32 can be avoided by use of the bridging repeater described in paragraphs 4.51, 4.52, 4.64, and 4.65.

**4.34** The threshold control circuit is provided to prevent operation of the regenerator gates by input pulses below a certain level. However, the circuit allows operation by all pulses that are equal to or greater than this level provided that they occur simultaneously with the narrow, positive timing pulse (clock spike). This reduces the chance of regenerating noise, crosstalk, and other extraneous pulses and thus helps to keep bipolar errors at a minimum over a wide range of digital line-operating conditions.

**4.35** The threshold control circuit is shown in Fig. 55. The base-to-emitter bias voltage on blocking oscillators Q7 and Q8 is approximately the same as the forward voltage of CR7 and CR8. Without the automatic threshold control, the pulse regenerator would be operated by any positive pulse greater than 0 volts. However, in order to prevent operation by such low-level pulses, a negative bias is applied to gate diodes CR7 and CR8. With this arrangement, the amplitude of any positive pulse from T2 must be at least as great as the applied bias in order to operate either gate.

**4.36** To obtain the greatest freedom from regeneration of unwanted pulses, the operating level of the gates is set at one-half of the peak level of the

average pulse at the T2 secondary. The threshold control circuit is designed to automatically hold the gate bias at this value over a wide range of input levels. The bias ( $V_{th}$ ) and pulse ( $V_{peak}$ ) levels are illustrated in Fig. 56.

**4.37** The automatic threshold control circuit operates as follows. Winding 6-7 of transformer T2 has one-half the number of turns that windings 3-4 and 4-5 have. Thus, any negative pulses on winding 6-7 flow through diode CR1 and charge capacitor C6 with a negative dc voltage equal to one-half the peak level of the corresponding pulses appearing across windings 3-4 and 4-5. The value of C6 is large enough that the dc voltage developed across it does not decay appreciably between pulses; however, it is small enough that sudden noise bursts do not increase the dc voltage significantly. Resistor R10 and capacitor C7 are provided for filtering the pulsating dc voltage developed across C6.

**4.38** The dc voltage across C7 is coupled to the gates through common-emitter stage Q3 to provide a threshold (gate bias) voltage of  $-0.5$  to  $-3.0$  volts when the peak level of the preamplifier output pulses ranges from 1.0 to 6.0 volts. The transistor amplifier, which has a gain of approximately 20, will minimize variations that would otherwise occur in the dc voltage across C7 because of large increases in gate current requirements (up to 10 mA total) with large input signals. Resistor R9 is selected during the shop test to adjust the Q3 base bias for optimum crosstalk performance, and R22 provides automatic compensation for variations in base leakage current caused by temperature changes.

**4.39** Powering for the digital line is provided by central office battery over a simplex loop consisting of two pairs which feed through each repeater. The power can be supplied from either end by looping at the opposite end, or it can be supplied from both ends by looping at any intermediate line repeater in the string. The latter connection is illustrated in Fig. 57, where power is looped at repeater N+1. Screws for making the through or looping options are built into the nonintegrated circuit type repeaters.

**4.40** All nonintegrated circuit 201- and 205-type repeaters obtain their dc power from the voltage drop across a built-in voltage regulator circuit (Fig. 58). The total drop across the regulator is 10.6 volts and the nominal line current is 140 mA. The line

current divides between the repeater and the regulator to provide for repeater requirements and to maintain regulator diode CR30 in the breakdown condition. Regulator diode CR30 and varistors RV30 through RV34 are used to maintain the indicated repeater voltages over a wide variation in currents by absorbing any such current change across their nonlinear internal resistance. Capacitors C30 through C33 provide filtering for the regulated voltages. Option T is used for making through power connections, and option L is used for looping connections. This voltage regulator circuit is used in the nonintegrated circuit 201- and 205-type repeaters, and a similar circuit is used in the nonintegrated circuit 206-type repeater.

**4.41** Lightning protection for the voltage regulator as well as the repeater is provided at the line side of the repeater simplexing transformer, as described in paragraphs 4.15, 4.48, and 4.55. In addition, the circuits in the voltage regulator are able to withstand surges as high as 600 volts, and the regulator diode and varistors will absorb up to 50 amperes for short periods.

**4.42** Digital line powering is provided by a combination of  $-48$ ,  $-130$ , and  $+130$  volt office battery and is sufficient to provide for dc losses of the cable plus a voltage regulator loss of 10.6 volts for each repeater in the power loop. The nominal line current is 140 mA. In the 201-type office repeaters, the line current is manually set to 140 mA by means of a resistive LBO, but it may vary from 130 to 200 mA as the line temperature and office battery vary. In the 206-type office repeater bay, the line current is held to  $141 \pm 2$  mA by means of an automatic line current regulator (see Fig. 59) contained in the repeater unit. In addition to its primary use in powering the line repeaters, the line current serves as a sealing current for unsoldered splices.

**4.43** Two types of automatic line current regulators are used in the 206-type repeaters. They are the  $-48$  volt and  $+130$  volt regulators. The  $+130$  volt regulator is powered from the  $+130$  volt office battery and either of the following: ground,  $-48$  volt battery, or  $-130$  volt battery. This provides for optional power-loop voltages of 130, 178, or 260 volts. The  $-48$  volt regulator is powered from ground and  $-48$  volt battery only. The type of regulator, power-loop voltage used, and the code of 206-type repeater used will depend on the cable gauge, cable length, and the number of repeaters in the loop. The required

power-loop voltage is obtained by strapping options on the fuse and alarm panel on the 206-type repeater bay. The -48 volt regulator uses a single fuse in the minus line, and the +130 volt regulator uses two fuses, one in the minus line and one in the +130 volt line. These fuses, when blown, provide for alarm indications on the fuse and alarm panel. The -48 volt regulator is used in the 206A repeaters, and the +130 volt regulator is used in the 206B repeaters.

**4.44** The automatic line current regulator circuit shown in Fig. 59 is the basic circuit for the +130 volt unit. The -48 volt unit is essentially the same except that it uses one regulating transistor instead of two, since the collector-to-emitter voltage breakdown requirements are not as great as with the +130 volt regulator.

**4.45** The current regulator uses a temperature-compensated voltage regulator circuit (CR201, RV201, RV202, and RV203) to provide a constant input current through parallel-connected resistors R202 and R203. This current is divided between the dissipation resistors (R1A and R1B which are mounted in the +130 volt power dissipation unit at the top of the 206-type office repeater bay) and the regulating transistors (Q201 and Q202). For low values of line resistance, the dissipation resistor current will be standard and the transistor current will be low. As the line resistance increases, the transistor current increases and the dissipation resistor current decreases to maintain a constant output current over a wide range of variation in line resistance.

## B. Repeater Types

### 201-Type Repeaters

**4.46** Six codes of nonintegrated circuit 201-type repeaters are provided for the various requirements of both the office and line. They are 201A, B, C, D, E, F (see Table C). A typical 201-type repeater is shown in Fig. 18.

**Note:** The 201 nonintegrated circuit repeaters are now rated Mfr Disc.

**4.47** The 201-type repeater includes two complete regenerators in one housing to provide pulse regeneration for both directions of transmission for one system (bidirectional operation) or for one direction of transmission for two systems (unidirectional operation), depending on the repeater code used. For

convenience of identification the two regenerators are referred to as side 1 and side 2. Both sides of a 201-type repeater are powered from the same power supply. Option screws for making through (T) and looping (L) line-powering arrangements are provided on the nonintegrated circuit repeater (see paragraph 4.40). These options are made by tightening the T or L screws through the side of the case. A block diagram of the nonintegrated circuit repeater is shown in Fig. 18 to illustrate the applicable features. Since 201C and F repeaters are bridging repeaters, they do not use the LBO network nor the T and L option screws.

**4.48** A schematic diagram of the complete circuit, including the 836-type LBO network, for one side of the nonintegrated circuit repeater is shown in Fig. 60. Since the ED-97079-30, G5 artificial line and the secondary lightning protection network are not part of the 201-type repeater but are mounted separately in the office repeater bay, they are not shown in this diagram. Since no type of secondary lightning protection is included in the 201-type repeater, it should not be used as a line repeater having aerial exposure. The 205-type repeater (paragraphs 4.54, 4.55, and 4.56) should be used instead. The 4037-type network that was formerly used to provide lightning protection for the 201-type repeater is now rated Mfr Disc; however, the 201-type repeater can be converted to the 205-type by sending it to a repair center where it will be fitted with a P42H177 or P42H178 network and a longer cover.

**4.49** The 201A and D repeaters are line repeaters that are used only for bidirectional operation. The two sides of this repeater provide pulse regeneration in opposite directions; therefore, one of these repeaters is used to provide both directions of transmission for one system in one cable sheath. This type of operation is shown in Fig. 35. The through power option is shown in this diagram, but the looping option can be used instead if required.

**4.50** The 201B and E repeaters are line repeaters that are used for unidirectional operation (see Note). The two sides of these repeaters provide pulse regeneration in the same direction; therefore, one of these repeaters is used to provide one direction of transmission for two systems in one cable, and a second repeater provides the other direction of transmission for two systems in another cable sheath. This type of operation is illustrated in Fig. 36. Both through and looping power options are provided.

**Note:** The 201B and E repeaters may also be used as office repeaters.

**4.51** The 201C and F repeaters are bridging repeaters that are used in the office to minimize transmission interruptions during in-service patching of spare lines and to prevent free-running oscillation of spare lines equipped with nonintegrated circuit repeaters. By preventing such free-running oscillations, a possible source of interference with the fault-locating circuit is eliminated. The two sides of this repeater provide pulse regeneration in the same direction, as is done in the 201B and E repeaters; however, the 201C or F repeater does not use the 836-type LBO networks since each of its two inputs is bridged across a quasi-random signal source or an outgoing working line. The quasi-random signal source or working line provides the signal pulses of standard level for operating one of the 201C or F regenerators. The resultant regenerated pulses from each side are used as an input signal for an outgoing maintenance line. Since the lines using nonintegrated circuit repeaters now have a signal on them at all times, they should not oscillate. The 201C or F repeater always obtains the power for its voltage regulator circuit from the -48 volt office battery.

**4.52** An arrangement for patching a maintenance line in service without causing an interruption of service on the working line is contained in Section 365-226-500.

**4.53** The entire 201-type repeater structure is enclosed in an aluminum housing that is held in place and connected internally to the sheath ground with one screw. Access holes in the side of the cover permit tuning of the clock circuit, adjustment of the power option screws, and insertion of the 836-type LBO networks. The faceplate bears the repeater code, series number, and manufacture date. The 201-type repeater is about 6 inches long, 4-3/16 inches high, and 1-1/8 inches wide.

#### 205-Type Repeaters

**4.54** Four codes of nonintegrated circuit 205-type repeaters are provided for use in the line. They are 205A, B, D, and E (see Table C). The 205-type repeater is similar in appearance to the 201-type (see Fig. 18) except that it is about two inches longer than the 201-type.

**Note:** The 205 nonintegrated circuit repeaters are now rated Mfr Disc.

**4.55** The 205-type repeaters are electrically and physically identical to the corresponding

codes of the 201-type (paragraphs 4.46 through 4.53), except that lightning protection networks (see Fig. 61) have been added and the aluminum housing has been lengthened to accommodate them. The network provides secondary lightning protection for the repeaters in a line having aerial exposure. It consists of a series of parallel-connected, oppositely poled diode pairs (varistors) bridged across each incoming and outgoing transmission pair with a 5.6-ohm current-limiting resistor in series with each wire. This arrangement limits the maximum surge current to 50 amperes, which is within the limits that can be tolerated by the repeater.

**4.56** The 205A, B, D, and E repeaters correspond to the 201A, B, D, and E units and will be used for protected and unprotected applications, respectively. All diagrams shown for the 201-type repeater will apply to the corresponding codes of 205-type repeater.

#### 206-Type Repeaters

**4.57** Eight codes of nonintegrated circuit 206-type repeaters (see Table C) are provided for use in the office. A typical unit is shown in Fig. 5.

**Note:** The 206 nonintegrated circuit repeaters are now rated Mfr Disc.

**4.58** The 206-type repeater includes an LBO network, a regenerator, a simplexing transformer, and access jacks in one side, and a simplexing transformer and access jacks in the other side. It provides pulse regeneration in one direction (receiving) and is passive in the other direction (transmitting). In addition, a built-in 100-ohm artificial line network or 3-dB pad and secondary lightning protection (paragraphs 4.13 and 4.15) are provided in both incoming and outgoing lines of the 206-A, B, D, E, F, and G repeater codes. The active side of the 206-type repeater is powered by a built-in voltage regulator circuit. The option screws permit the power for this voltage regulator to be obtained either in series with the span line power loop or directly from local office battery. In either case, the span line will be powered by the automatic line current regulator circuit (paragraphs 4.42 through 4.45). The 206A, B, E, and F repeaters have all of these features and are illustrated in Fig. 9. The 206D and G repeaters have the same features except for the automatic current regulator and that they always loop the line current. The 206C and P repeaters do not have the power option screws,

the power simplexing arrangement, the artificial line, or the LBO network.

**4.59** Except for the 3-dB pad or 100-ohm artificial line network, the automatic line current regulator, and the access jacks, the 206-type repeater circuit is the same as the 201-type shown in Fig. 60.

**4.60** The 206A, 206B, and 206D repeaters are identical except for the following.

- (a) The 206A code contains the -48 volt current regulator for powering short lines.
- (b) The 206B code contains the +130 volt current regulator for powering longer lines.
- (c) The 206D code contains no current regulator and thus is not used for powering the line. This repeater is used for looping the power at a through or terminal office.

**4.61** The 206E, F, and G repeaters are identical to the 206A, B, and D repeaters except the 206E, F, and G contain a 3-dB pad instead of the 7.5-dB artificial line.

**4.62** A single 206-type repeater can be used in a terminal office or two repeaters can be used back to back in a through office to provide both directions of transmission for one system in one cable sheath. These arrangements are shown in Fig. 30 and 31, respectively. Powering options can be set as required for the particular installation.

**4.63** Two 206-type repeaters can be used in a terminal office or four repeaters can be used in a dual back-to-back arrangement in a through office to provide both directions of transmission for two systems in two cable sheaths. These arrangements are shown in Fig. 32 and 33, respectively. Powering options can be set as required for the particular installation.

**4.64** The 206C and 206P repeaters are bridging repeaters used in the office to minimize transmission interruptions during in-service patching of spare lines and to prevent free-running oscillation of spare lines using nonintegrated circuit 201- and 205-type line repeaters. By preventing such free-running oscillations, a possible source of interference with the fault-locating circuit is eliminated. These repeaters have only one side. They provide pulse regeneration

in the receiving direction; however, the bridging repeater does not use the artificial line or LBO networks since its input is bridged across the quasi-random signal source or outgoing working line of standard level. This quasi-random signal source or working line provides the signal pulses for operating the bridging regenerator. The resultant regenerated pulses are used as an input signal for an outgoing spare line. Since the spare line now has a signal on it at all times, it will not oscillate. The bridging repeater always obtains the power for its voltage regulator circuit from the -48 volt office battery.

**4.65** The 206-type bridging repeaters can be used for patching a spare line in service without causing an interruption of service on the working line in the same manner as described for the 201 bridging repeaters in paragraph 4.52.

**4.66** The 206-type repeater uses a 1-piece cast aluminum frame on which is mounted a circuit board and, on some codes, larger parts such as fuse holders, jacks, current regulator transistors, and a molded 21-pin connector. The entire unit plugs into a slot in the 206 ORB. A quick-release spring catch on the lower front of this repeater is used to hold it in place but permits it to be removed easily. Identification information, such as repeater code, series number, and date of manufacture is located on the front of these repeaters. On some codes the front panel also mounts access jacks, fuses, and test points. The overall length of the 206-type repeater is approximately 10 inches, the height is 8-5/8 inches, and the width is 1-9/16 inches.

## 5. REFERENCES

**5.01** The following schematic drawings (SDs) and circuit descriptions (CDs) contain detailed circuit information:

SD AND CD	TITLE
3C244-01	201 and 205 Integrated Circuit Type
97095-02	206 Integrated Circuit Type
3C098-01 and 02	208 and 209 Integrated Circuit Type
3C285-01	221 Integrated Circuit Type
3C370-01	231 Integrated Circuit Type

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**SD AND CD**

3C367-01	236 Integrated Circuit Type
3C366-01	238 and 239 Integrated Circuit Type
3C364-01	7A-Type Regenerator
97095-01	206 Nonintegrated Circuit Type.

**5.02** The 201 and 205 nonintegrated circuit-type repeaters are not covered by CDs and SDs. Therefore, a detailed circuit description for these repeaters is provided in Part 4 of this section and schematics are provided on the following A drawings:

<b>DRAWING</b>	<b>TITLE</b>
A576144	201A and 201B Nonintegrated Circuit Types
A221261	201C Nonintegrated Circuit Bridge Type
A221821	201D and 201E Nonintegrated Circuit Type
A221822	201F Nonintegrated Circuit Type
A220474	205A and 205B Nonintegrated Circuit Type
A222355	205D and 205E.

**5.03** The following equipment drawings (EDs) contain additional information:

<b>DRAWING</b>	<b>TITLE</b>
ED-3C585-30	T1 Digital Carrier Specification for Equalizing Circuit
ED-97079-30 G4	3-dB Span Pad
ED-97079-30 G5	100-ohm Artificial Line Network.

**5.04** The following Bell System Practices give additional information:

<b>SECTION</b>	<b>TITLE</b>
255-100-101	Traffic Service Position System No. 1
365-010-110	T1 Outstate (T1/OS) System—General Description
365-200-100	T1 Digital Line—General Description
365-200-105	J98710U Express Office Repeater Panel—General Description
365-226-500	T1 Digital Line Identification Plan and Line Patching Procedures Change
365-301-101	DSX, DSX-1C, and DSX-2 Patch and Cross-Connect—General Description.

TABLE A (Contd)  
INTEGRATED CIRCUIT OFFICE AND BRIDGING REPEATERS  
(SEE NOTE 1)

REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	LINE CURRENT REGULATOR	REGENERATOR CURRENT	CABLE	LINE MATCHING	EXCP
NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	T1C/T1 ORB	48V/130V	60/140 mA	60/140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING	T1C/T1 ORB	LOOP	NONE	60/140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	NONE	T1C/T1 ORB	NONE	NONE	60/140 mA	ALL	NONE	YES
NONE	LINE POWERING/ GRD/VOLTAGE	T1C/T1 ORB	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING	T1C/T1 ORB	LOOP	NONE	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	NONE	T1C/T1 ORB	NONE	NONE	60/140 mA	ALL	NONE	NO
236AA	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
236AB	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
236AC	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	PIC/PULP	ALBO/3 dB PAD	NO
236AD	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	PIC/PULP	ALBO/3 dB PAD	NO
NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP	ALBO/3 & 0.5 dB PAD	YES
NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP	ALBO/3 & 0.5 dB PAD	YES
NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 dB ART. LINE	NO
NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 dB ART. LINE	NO
NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	"MAT" TRUNK CABLE	ALBO/7.5 & 4.5 dB ART. LINE	YES
NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	80 mA	80 mA	"LOCAP" CABLE	ALBO/7.5 dB ART. LINE	YES
NONE	DSX/LOCAL	206 ORB/LTU/STM	NONE	NONE	60/140 mA	ALL	NONE	NO

TABLE A (Contd)  
INTEGRATED CIRCUIT OFFICE AND BRIDGING REPEATERS  
(SEE NOTE 1)

CODE	TYPE	REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	LINE CURRENT REGULATOR	REGENERATOR CURRENT	CABLE	LINE MATCHING	EXCP
236AA	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE/ CURRENT	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
236AB	OFFICE	NONE	LINE POWERING/ CURRENT	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
236AC	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE/ CURRENT	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
236AD	OFFICE	NONE	LINE POWERING/ CURRENT	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO

Note 1: Abbreviations used are as follows:

- STA = J98710A Span Terminating Assembly
- STM = J98728AA, AB, or AC Span Terminating Module
- LTU = J98713F Line Terminating Unit
- EXCP = Extended Cross-Connect Package (206- and 236-type repeaters require 983-type equalizers)
- 206 ORB = J98710J, K, or L Office Repeater Bay
- T1C/T1 ORB = J98725A, B, or C Office Repeater Bay
- ALBO = Automatic Line Buildout

\* The 208-type replacement repeater must be equipped with a 215A adapter.

† Manufacture discontinued (Mfr Disc).

‡ 236P must have LOCAL option selected when replacing 206R.

§ 236P must have DSX option selected when replacing 206S.

¶ 231C and 236P DSX bridging repeater can be used in a T1C/T1 bridging panel.

\*\* Can be used with or without a digital cross-connect by use of DSX/LOCAL option.

**TABLE A**  
**INTEGRATED CIRCUIT OFFICE AND BRIDGING REPEATERS**  
(SEE NOTE 1)

CODE	TYPE	REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	LINE CURRENT REGULATOR	REGENERATOR CURRENT	CABLE	LINE MATCHING	EXCP
201K*	OFFICE	208AB	NONE	STA	LOOP	NONE	140 mA	PIC/PULP	ALBO	NO
201L	BRIDGING	NONE	NONE	STA	NONE	NONE	140 mA	ALL	NONE	NO
206H†	OFFICE	236AA	LINE POWERING	206 ORB/LTU/STM	48V	140 mA	140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
206J†	OFFICE	236AA	LINE POWERING/ GRD	206 ORB/LTU/STM	130V	140 mA	140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
206K†	OFFICE	236AB	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	140 mA	PIC/PULP	ALBO/7.5 dB ART. LINE	NO
206L†	OFFICE	236AC	LINE POWERING	206 ORB/LTU/STM	48V	140 mA	140 mA	PIC/PULP	ALBO/3 dB PAD	NO
206M†	OFFICE	236AC	LINE POWERING/ GRD	206 ORB/LTU/STM	130V	140 mA	140 mA	PIC/PULP	ALBO/3 dB PAD	NO
206N†	OFFICE	236AD	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	140 mA	PIC/PULP	ALBO/3 dB PAD	NO
206R††	BRIDGING	236P	NONE	206 ORB/LTU/STM	NONE	NONE	140 mA	ALL	NONE	NO
206S§	BRIDGING- DSX	236P	NONE	206 ORB/LTU/STM	NONE	NONE	140 mA	ALL	NONE	NO
206T†	OFFICE	236E	LINE POWERING/ CURRENT	206 ORB/LTU/STM	48V	60/140 mA	140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
206U†	OFFICE	236E	LINE POWERING/ CURRENT/GRD	206 ORB/LTU/STM	130V	60/140 mA	140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
206W†	OFFICE	236F	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
206Y†	OFFICE	236G	LINE POWERING/ CURRENT	206 ORB/LTU/STM	48V	60/140 mA	140 mA	PIC/PULP	ALBO/3 & 0.5 dB PAD	YES
206AA†	OFFICE	236G	LINE POWERING/ CURRENT/GRD	206 ORB/LTU/STM	130V	60/140 mA	140 mA	PIC/PULP	ALBO/3 & 0.5 dB PAD	YES
206AB†	OFFICE	236H	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	140 mA	PIC/PULP	ALBO/3 & 0.5 dB PAD	YES
221A†	OFFICE	231A	LINE POWERING/ VOLTAGE/GRD/ CURRENT	T1C/T1 ORB	48V/130V	60/140 mA	140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
221B†	OFFICE	231B	LINE POWERING	T1C/T1 ORB	LOOP	NONE	140 mA	PIC/PULP	ALBO/7.5 & 4.5 dB ART. LINE	YES
221C†	BRIDGING	231C	NONE	T1C/T1 ORB	NONE	NONE	140 mA	ALL	NONE	YES

**TABLE A (Contd)**  
**INTEGRATED CIRCUIT OFFICE AND BRIDGING REPEATERS**  
(SEE NOTE 1)

CODE	TYPE	REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	LINE CURRENT REGULATOR	REGENERATOR CURRENT	CABLE	LINE MATCHING	EXCP
231A	OFFICE	NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	T1C/T1 ORB	48V/130V	60/140 mA	60/140 mA	PIC/PULP		
231B	OFFICE	NONE	LINE POWERING	T1C/T1 ORB	LOOP	NONE	60/140 mA	PIC/PULP		
231C¶	BRIDGING	NONE	NONE	T1C/T1 ORB	NONE	NONE	60/140 mA	ALL		
231D	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE	T1C/T1 ORB	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE		
231E	OFFICE	NONE	LINE POWERING	T1C/T1 ORB	LOOP	NONE	60 mA	"MAT" TRUNK CABLE		
231F	BRIDGING	NONE	NONE	T1C/T1 ORB	NONE	NONE	60/140 mA	ALL		
236A†	OFFICE	236AA	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	PIC/PULP		
236B†	OFFICE	236AB	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	PIC/PULP		
236C†	OFFICE	236AC	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	PIC/PULP		
236D†	OFFICE	236AD	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	PIC/PULP		
236E	OFFICE	NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP		
236F	OFFICE	NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP		
236G	OFFICE	NONE	LINE POWERING/ CURRENT/GRD/ VOLTAGE	206 ORB/LTU/STM	48V/130V	60/140 mA	60/140 mA	PIC/PULP		
236H	OFFICE	NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60/140 mA	PIC/PULP		
236J	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE		
236K	OFFICE	NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	"MAT" TRUNK CABLE		
236L	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	60 mA	60 mA	"MAT" TRUNK CABLE		
236M	OFFICE	NONE	LINE POWERING	206 ORB/LTU/STM	LOOP	NONE	60 mA	"MAT" TRUNK CABLE		
236N	OFFICE	NONE	LINE POWERING/ GRD/VOLTAGE	206 ORB/LTU/STM	48V/130V	80 mA	80 mA	"LOCAP" CABLE		
236P** ,¶	BRIDGING	NONE	DSX/LOCAL	206 ORB/LTU/STM	NONE	NONE	60/140 mA	ALL		

**TABLE B**  
**INTEGRATED CIRCUIT LINE REPEATERS**  
(SEE NOTE 1)

CODE	OPERATION	REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	NOMINAL REPEATER CURRENT	CABLE	LINE MATCHING	PROTECTED	SEPARATE FL OUTPUTS
201G†, ‡	BI	208AA	NONE	466 APP CASE	THRU	140 mA	PIC/PULP	ALBO	NO	NO
201H†, ‡	BI	208AA	NONE	466 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	NO	NO
201J†, ‡	UNI	208AB	NONE	466 APP CASE	THRU	140 mA	PIC/PULP	ALBO	NO	NO
201K†, §, ‡	UNI	208AB	NONE	466 APP CASE/STA	LOOP	140 mA	PIC/PULP	ALBO	NO	NO
205G¶, ‡	BI	209AA	NONE	468 APP CASE	THRU	140 mA	PIC/PULP	ALBO	YES	NO
205H¶, ‡	BI	209AA	NONE	468 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	YES	NO
205J¶, ‡	UNI	209AB	NONE	468 APP CASE	THRU	140 mA	PIC/PULP	ALBO	YES	NO
205K¶, ‡	UNI	209AB	NONE	468 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	YES	NO
205M¶, ‡	BI	209AA	NONE	468C6 APP CASE	THRU	140 mA	PIC/PULP	ALBO	YES	YES
205N¶, ‡	BI	209AB	NONE	468C6 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	YES	YES
208A‡	BI	208AA	NONE	475A or 818 APP CASE EORP	THRU	140 mA	PIC/PULP	ALBO	NO	NO
208B‡	BI	208AA	NONE	475A or 818 APP CASE EORP	LOOP	140 mA	PIC/PULP	ALBO	NO	NO
208C**, ‡	UNI	208AB	NONE	475A/479A or 818/819 CASE EORP	THRU	140 mA	PIC/PULP	ALBO	NO	NO
208D**, ‡	UNI	208AB	NONE	475A/479A or 818/819 CASE EORP	LOOP	140 mA	PIC/PULP	ALBO	NO	NO
208E	BI	208AA	NONE	475F or 818 APP CASE	THRU	140 mA	PIC/PULP	ALBO	NO	YES
208F	BI	208AA	NONE	475F or 818 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	NO	YES
208AA††	BI	NONE	T/L POWERING/ FL OUTPUT	475A or 818 APP CASE EORP	THRU/LOOP	140 mA	PIC/PULP	ALBO	NO	OPT
208AB**	UNI	NONE	T/L POWERING	475A/479A or 818/819 CASE EORP	THRU/LOOP	140 mA	PIC/PULP	ALBO	NO	NO
209A‡	BI	209AA	NONE	475B or 818 APP CASE EORP	THRU	140 mA	PIC/PULP	ALBO	YES	NO
209B‡	BI	209AA	NONE	475A or 818 APP CASE EORP	LOOP	140 mA	PIC/PULP	ALBO	YES	NO
209C‡†, ‡	UNI	209AB	NONE	475A/479B or 818/819 CASE EORP	THRU	140 mA	PIC/PULP	ALBO	YES	NO
209D‡†	UNI	209AB	NONE	475B/479B or 818/819 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	YES	NO
209E‡	BI	209AA	NONE	475G or 818 APP CASE	THRU	140 mA	PIC/PULP	ALBO	YES	YES
209F‡	BI	209AB	NONE	475G or 818 APP CASE	LOOP	140 mA	PIC/PULP	ALBO	YES	YES
209AA§§	BI	NONE	T/L POWERING/ FL OUTPUT	475B or 818 APP CASE	THRU/LOOP	140 mA	PIC/PULP	ALBO	YES	OPT
209AB	UNI	NONE	T/L POWERING	475B/479B or 818/819 APP CASE	THRU/LOOP	140 mA	PIC/PULP	ALBO	YES	NO

**TABLE B (Contd)**  
**INTEGRATED CIRCUIT LINE REPEATERS**  
(SEE NOTE 1)

CODE	OPERATION	REPLACE- MENT	OPTIONS	MOUNTING	LINE POWERING	NOMINAL* REPEATER CURRENT	CABLE	LINE MATCHING	PROTECTED	SEPARATE FL OUTPUTS
238A††	BI	NONE	T/L POWERING/ FL OUTPUT	475A/475F or 818/819 APP CASE EORP	THRU/LOOP	60 mA	PIC/PULP	ALBO	NO	OPT
238B**	UNI	NONE	T/L POWERING	475A/479A or 818/819 APP CASE EORP	THRU/LOOP	60 mA	PIC/PULP	ALBO	NO	NO
238C††	BI	NONE	T/L POWERING/ FL OUTPUT	475A/475F or 818/819 APP CASE EORP	THRU/LOOP	60 mA	"MAT" TRUNK CABLE/"ICOT" CABLE	ALBO	NO	OPT
238D**	UNI	NONE	T/L POWERING	475B/479A or 818/819 APP CASE EORP	THRU/LOOP	60 mA	"MAT" TRUNK CABLE/"ICOT" CABLE	ALBO	NO	NO
239A§§, ¶, ¶¶	BI	NONE	T/L POWERING/ FL OUTPUT	475B/475G or 818/819 APP CASE EORP	THRU/LOOP	60 mA	PIC/PULP	ALBO	YES	OPT
239B‡†	UNI	NONE	T/L POWERING	475B/479B or 818/819 APP CASE EORP	THRU/LOOP	60 mA	PIC/PULP	ALBO	YES	NO
239C§§	BI	NONE	T/L POWERING/ FL OUTPUT	475B/475G or 818/819 APP CASE EORP	THRU/LOOP	60 mA	"MAT" TRUNK CABLE/"ICOT" CABLE	ALBO	YES	OPT
239D‡†	UNI	NONE	T/L POWERING	475B/479B or 818/819 APP CASE EORP	THRU/LOOP	60 mA	"MAT" TRUNK CABLE/"ICOT" CABLE	ALBO	YES	NO
7A	UNI	NONE	NONE	473 TYPE APP CASE	THRU	80 mA	"LOCAP" CABLE	ALBO	YES	NO

Note 1: Abbreviations used are as follows:

- BI = Bidirectional Regenerators
- UNI = Unidirectional Regenerators
- ALBO = Automatic Line Buildout
- STA = J98710A Span Terminating Assembly
- EORP = Express Office Repeater Bay

\* Line repeaters can have a maximum line current of 150 mA.

† The 208-type replacement repeater must be equipped with a 215A adapter.

‡ Manufacture discontinued (Mfr Disc).

§ Classified as an office repeater when mounted in an STA.

¶ The 209-type replacement repeater must be equipped with a 216A adapter

\*\* Can be mounted in 479A apparatus case using a 245A adapter.

†† Must be mounted in 475F apparatus case to utilize separate FL outputs.

‡‡ Can be mounted in 479B apparatus case using a 253A adapter.

§§ Must be mounted in 475G apparatus case to utilize separate FL outputs.

¶¶ Can be mounted in 468C apparatus case using a 216A adapter.

**TABLE C**  
**NONINTEGRATED CIRCUIT REPEATERS**  
**(MANUFACTURE DISCONTINUED) (SEE NOTE 1)**

CODE	TYPE	REPLACE- MENT	OPERATION	OPTIONS	MOUNTING	LINE POWERING	NOMINAL REPEATER CURRENT	CABLE	LINE MATCHING	PROTECTED
201A†	LINE	201D 201G 201H	BI	T/L POWERING	466 APP CASE	THRU/LOOP	140 mA	PIC/PULP	836 LBO	NO
201B†, ‡	OFFICE/ LINE	201E 201J 201K	UNI	T/L POWERING	466 APP CASE/ STA	THRU/LOOP	140 mA	PIC/PULP	836 LBO	NO
201C	BRIDGING	201F 201L	UNI	NONE	STA	-	140 mA	PIC/PULP	NONE	-
201D†	LINE	201G 201H	BI	T/L POWERING	466 APP CASE	THRU/LOOP	140 mA	PIC/PULP	836 LBO	NO
201E†, ‡	OFFICE/ LINE	201J 201K	UNI	T/L POWERING	466 APP CASE/ STA	THRU/LOOP	140 mA	PIC/PULP	836 LBO	NO
201F	BRIDGING	201L	UNI	NONE	STA	-	140 mA	PIC/PULP	NONE	-
205A	LINE	205D 205G 205H	BI	T/L POWERING	468 APP CASE	THRU/LOOP	140 mA	PIC/PULP	836 LBO	YES
205B	LINE	205E 205J 205K	UNI	T/L POWERING	468 APP CASE	THRU/LOOP	140 mA	PIC/PULP	836 LBO	YES
205D	LINE	205G 205H	BI	T/L POWERING	468 APP CASE	THRU/LOOP	140 mA	PIC/PULP	NONE	YES
205E	LINE	205J 205K	UNI	T/L POWERING	468 APP CASE	THRU/LOOP	140 mA	PIC/PULP	836 LBO	YES
206A	OFFICE	206H	-	LINE POWERING	206 ORB/LTU/ STM	48V	140 mA	PIC/PULP	836 LBO/ 7.5 dB ART. LINE	YES
206B	OFFICE	206J	-	LINE POWERING/ GRD	206 ORB/LTU/ STM	130V	140 mA	PIC/PULP	836 LBO/ 7.5 dB ART. LINE	YES
206C	BRIDGING	206R	-	NONE	206 ORB/LTU/ STM	NONE	140 mA	PIC/PULP	NONE	-
206D	OFFICE	206K	-	LINE POWERING	206 ORB/LTU/ STM	LOOP	140 mA	PIC/PULP	836 LBO/ 7.5 dB ART. LINE	YES

**TABLE C (Contd)**  
**NONINTEGRATED CIRCUIT REPEATERS**  
**(MANUFACTURE DISCONTINUED) (SEE NOTE 1)**

CODE	TYPE	REPLACE- MENT	OPERATION	OPTIONS	MOUNTING	LINE POWERING	NOMINAL * REPEATER CURRENT	CABLE	LINE MATCHING	PROTECTED
206E	OFFICE	206L	-	LINE POWERING	206 ORB/LTU/ STM	48V	140 mA	PIC/PULP	836 LBO/ 3 dB PAD	YES
206F	OFFICE	206M	-	LINE POWERING	206 ORB/LTU/ STM	130V	140 mA	PIC/PULP	836 LBO/ 3 dB PAD	YES
206G	OFFICE	206N	-	LINE POWERING	206 ORB/LTU/ STM	LOOP	140 mA	PIC/PULP	836 LBO/ 3 dB PAD	YES
206P	BRIDGING- DSX	206S	-	NONE	206 ORB/LTU/ STM	NONE	140 mA	PIC/PULP	NONE	-

*Note 1:* Abbreviations used are as follows:

- BI = Bidirectional Regenerators
- UNI = Unidirectional Regenerators
- LBO = Line Buildout
- STA = J98710A Span Terminating Assembly
- 206 ORD = J98710J, K, or L Office Repeater Bay
- LTU = J98713F Line Terminating Unit
- STM = J98728AA, AB, or AC Span Terminating Module

\* Lines equipped with these repeaters can have a maximum line current of 150 mA.

† Protected if equipped with a 4037-type network and is mounted in a 468-type apparatus case.

‡ The 201J can be used as a replacement for line use only.

**TABLE D**  
**OPERATING TEMPERATURE RANGE**

REPEATER OR REGENERATOR CIRCUITRY	REPEATER OR REGENERATOR TYPE	TEMPERATURE RANGE
Integrated	201, 205, 208, and 209	-40° to +180°F
	206, 221, 231, and 236	0° to +140°F
	238, 239, and 7A	-40° to +180°F
Nonintegrated	201 and 205	-40° to +140°F
	206	0° to +140°F

**TABLE E**  
**836-TYPE LINE BUILD-OUT NETWORKS**

NETWORK	LOSS AT 772 KHZ (DB)
836A	0
836B	2.4
836C	4.8
836D	7.2
836E	9.6
836F	12.0
836G	14.4
836H	16.8
836J	19.2
836K	21.6
836L	24.0
836M	26.4

**TABLE F**  
**EQUALIZERS REQUIRED FOR 206- AND 236-EXCP REPEATERS**

ABAM CABLE LENGTH IN FEET BETWEEN ORB AND DSX-1	LOSS RANGE IN dB AT 772 KHZ	EQUALIZER CODE REQUIRED
0 to 220	0 to 1	983A
222 to 440	1 to 2	983B
440 to 655	2 to 3	983C

**TABLE G**  
**RELATIONSHIP BETWEEN THE 206 EXCP REPEATERS**  
**AND OTHER 206 CODES**

-48 VOLT REGULATOR	+130 VOLT REGULATOR	POWER LOOPING	EXCP	INTERFACE AND OUTPUT
206H	206J	206K	No	7.5 dB artificial line, -3 volt output
206T*	206U*	206W	Yes	7.5 dB/4.5 dB artificial line, -6 volt output
206L	206M	206N	No	3 dB pad, -3 volt output
206Y*	206AA*	206AB	Yes	3 dB/0.5 dB, -6 volt output

\* Has 60- and 140-mA current regulation option.

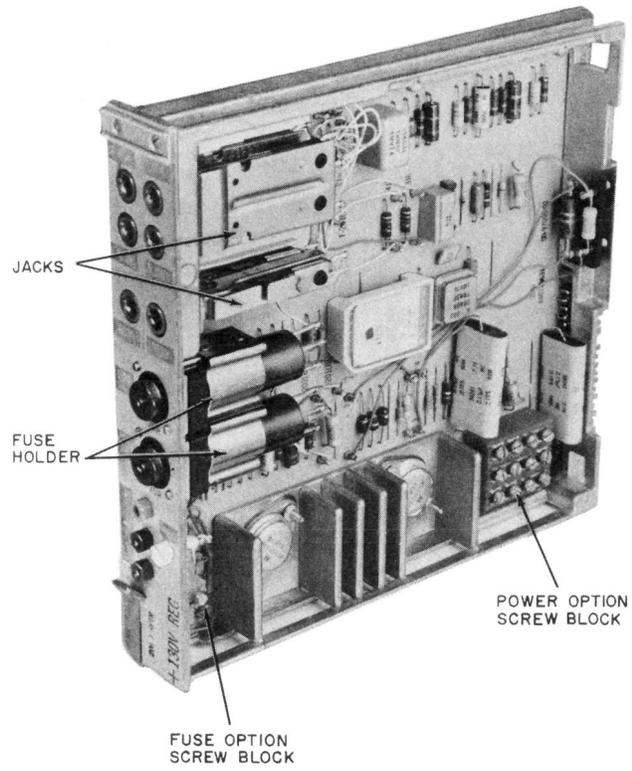
**TABLE H**  
**EQUALIZERS REQUIRED FOR 221- AND 231-TYPE REPEATERS**

ABAM CABLE LENGTH IN FEET BETWEEN ORB AND DSX-1	LOSS RANGE IN dB AT 772 KHZ	EQUALIZER CODE REQUIRED (SEE NOTES 1 AND 2)	
		T1C/T1 DSX OPTIONAL	T1C/T1 DSX DEDICATED
0 to 220	0 to 1	ED-3C585-30, G1*	ED-3C765-30, G1*
220 to 440	1 to 2	ED-3C585-30, G2	ED-3C765-30, G2
440 to 655	2 to 3	ED-3C585-30, G3	ED-3C765-30, G3

Note 1: All local cross-connect options (central offices without DSX-1 equipment) require an ED-3C585-30, G1 equalizer. All cross-connects (with or without DSX-1 equipment) to 221C and 231C bridging repeaters require ED-3C585-30, G1 equalizers.

Note 2: The T1C equalizer ED-3C655-30 and ED-3C767-30 are equivalent to and may be substituted for the ED-3C585-30 and ED-3C765-30 equalizers respectively.

\* Position 26 for bridging repeater is always equipped with a Group 1 equalizer for all cable lengths in applications with or without a DSX-1.



**Fig. 1—206-Type Integrated Circuit Repeater**

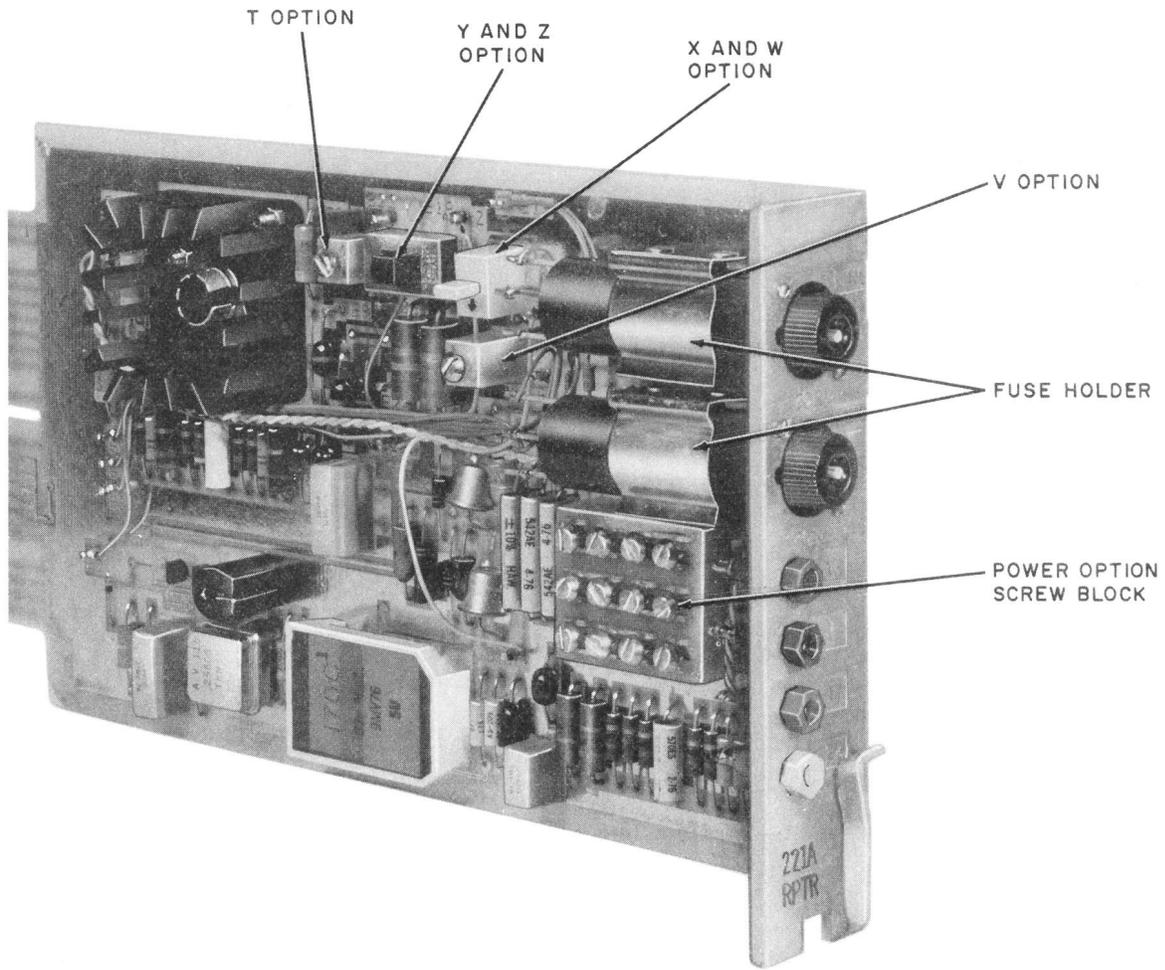


Fig. 2—221-Type Integrated Circuit Repeater

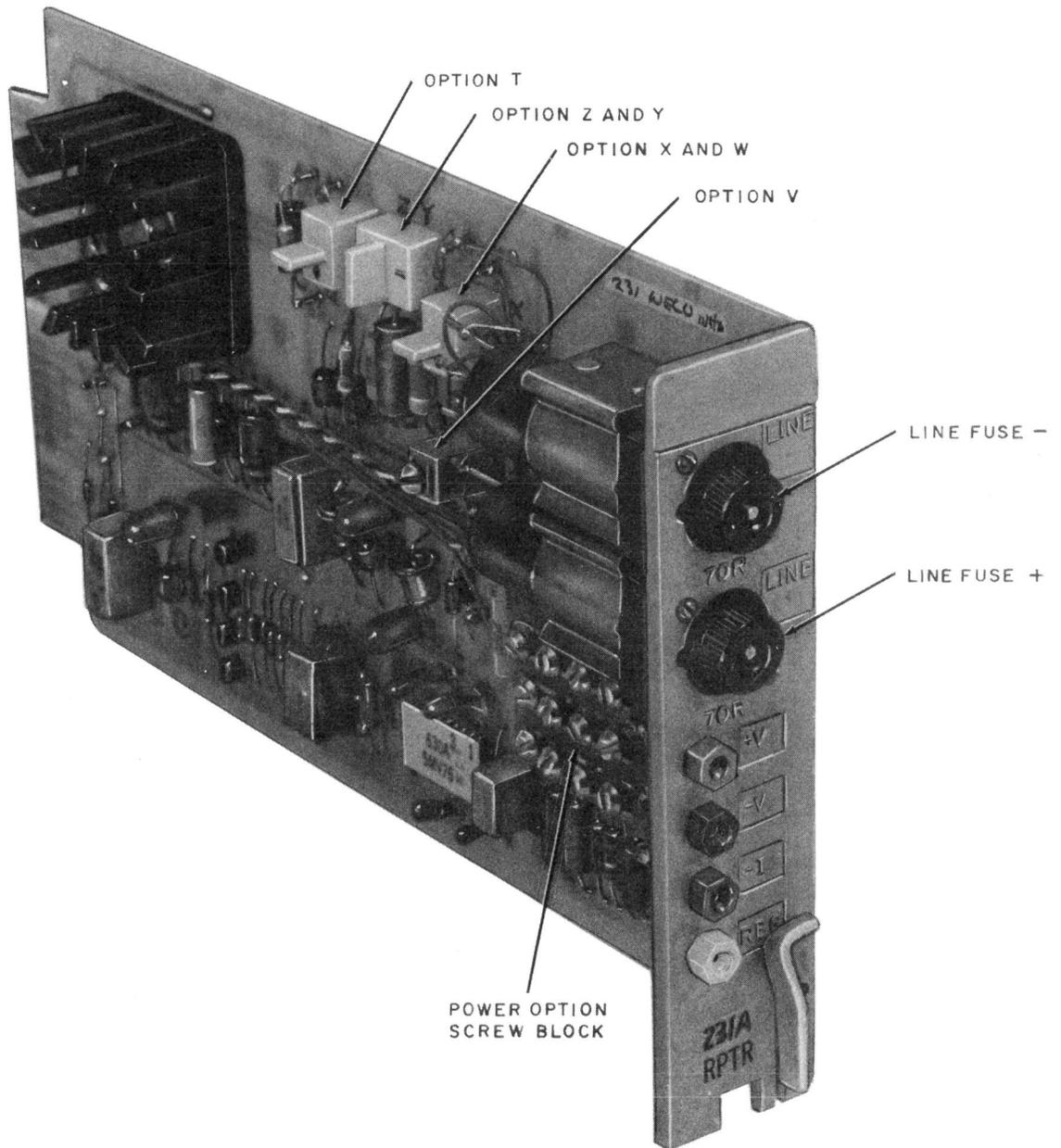


Fig. 3—231-Type Integrated Circuit Repeater

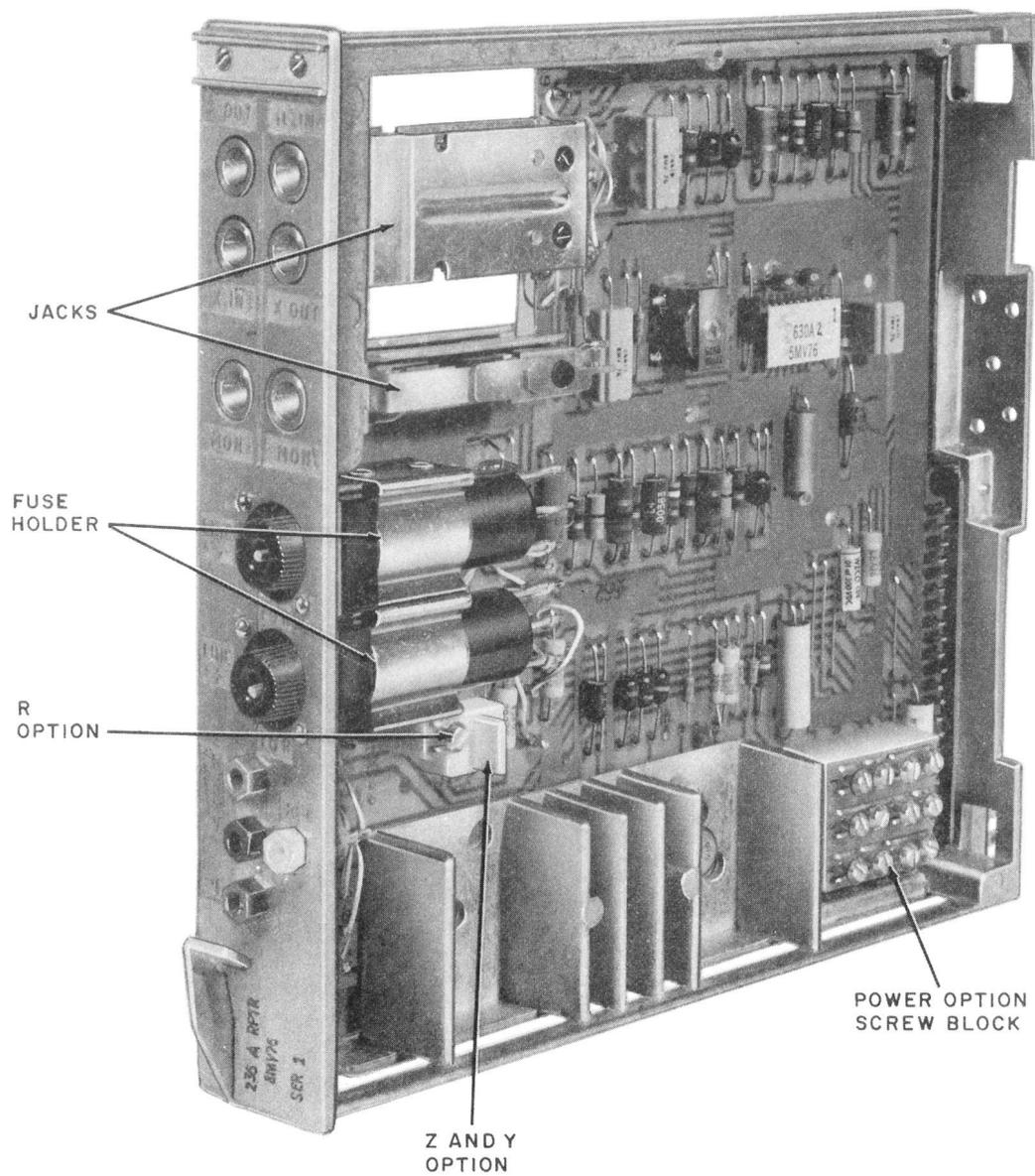


Fig. 4—236-Type Integrated Circuit Repeater

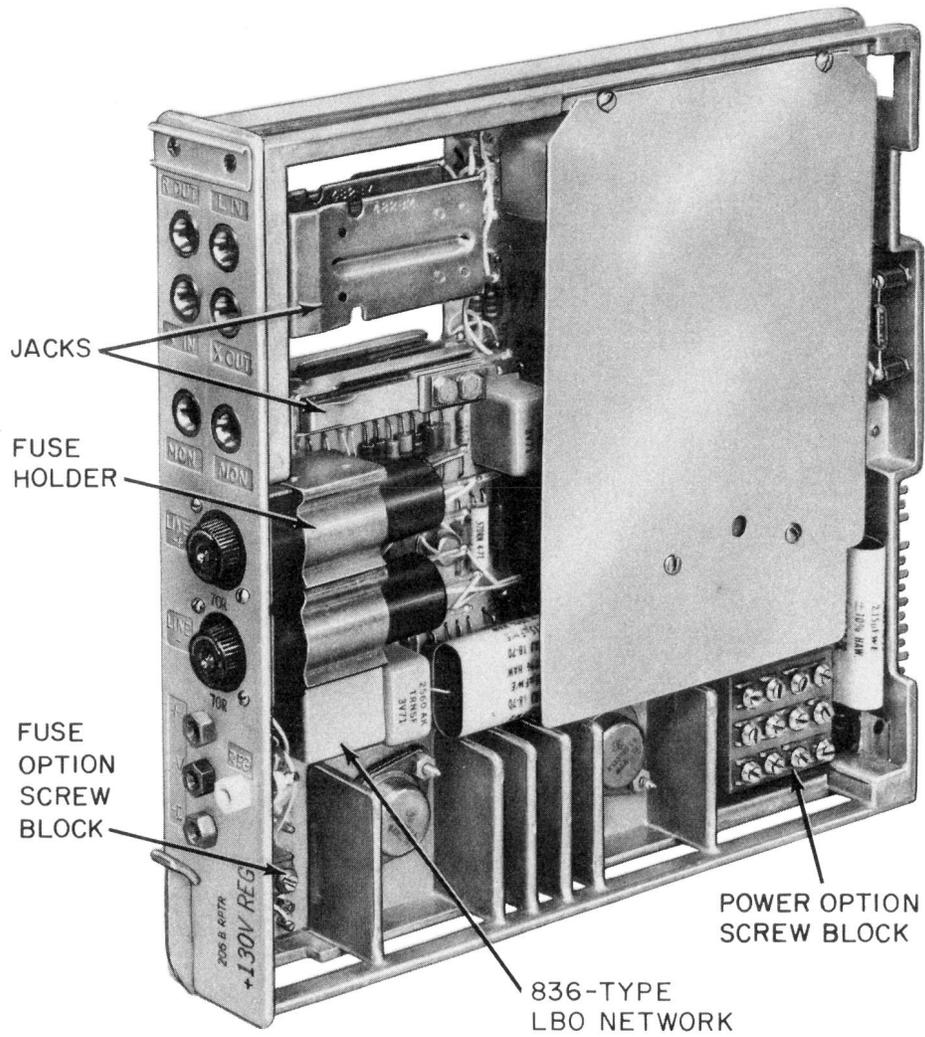


Fig. 5—206-Type Nonintegrated Circuit Repeater

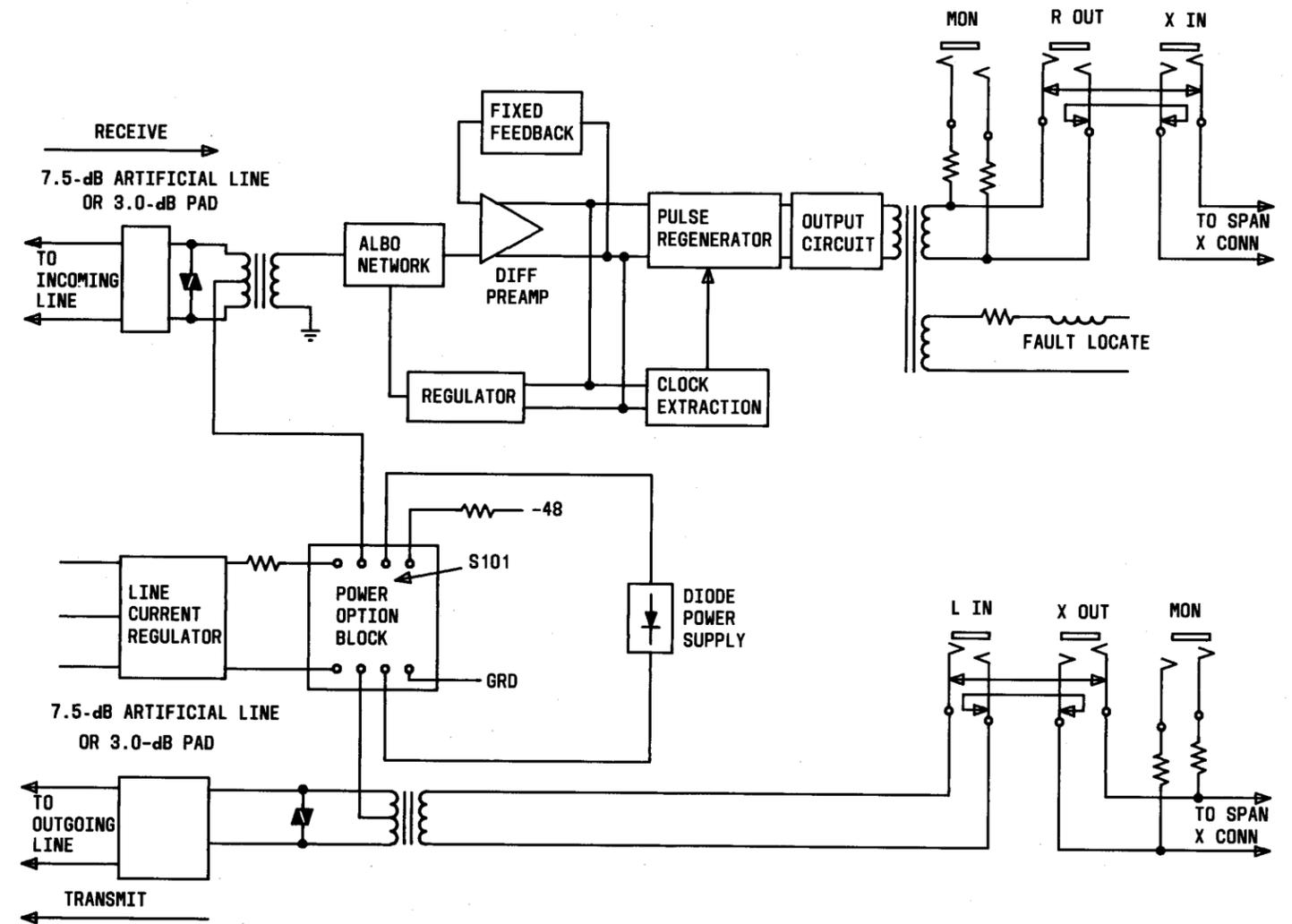


Fig. 6—Block Diagram of 206 and 236 Integrated Circuit-Type Line Powering Repeaters (Except EXCP)

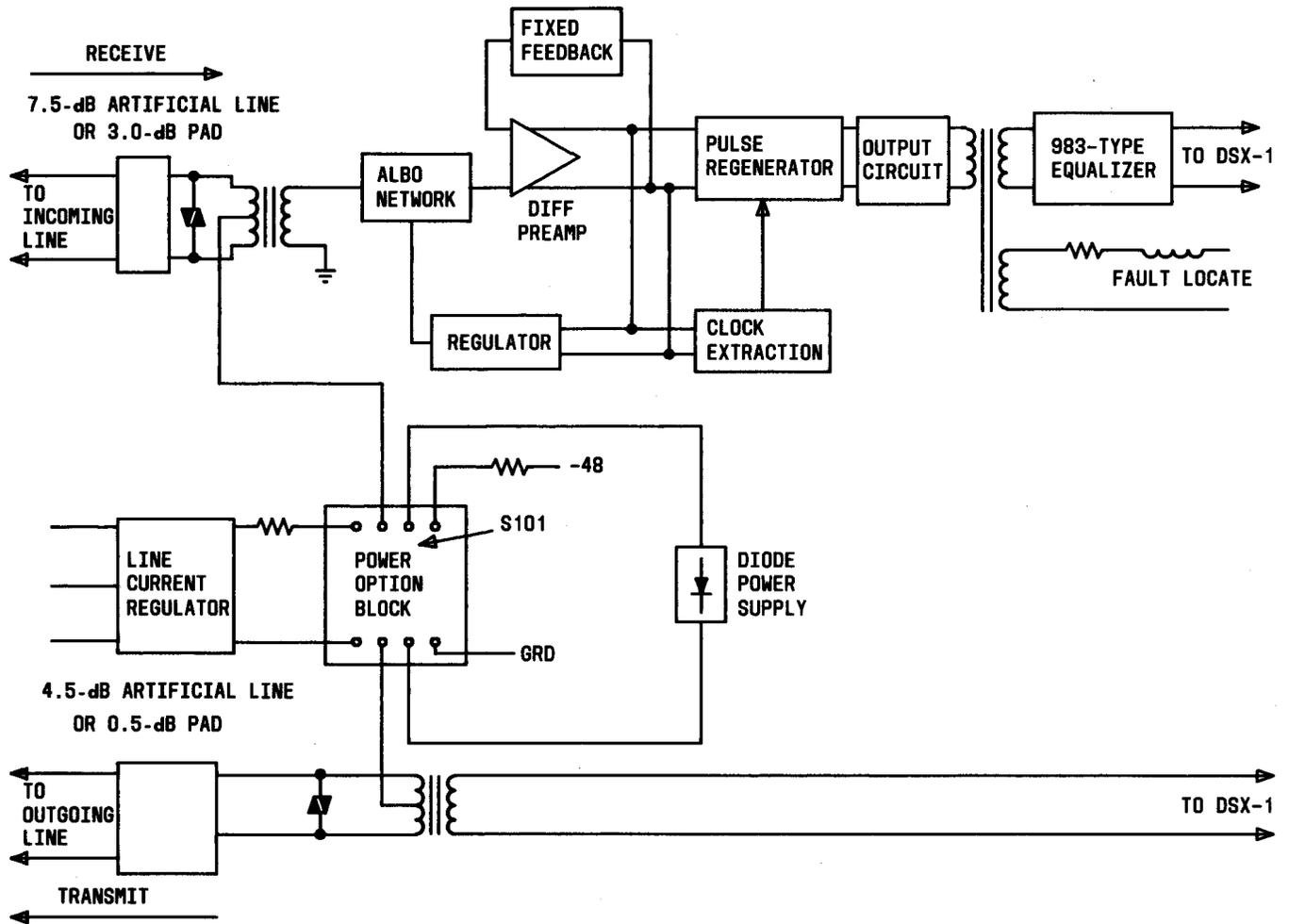


Fig. 7— Block Diagram of 206 and 236 Integrated Circuit-Type Line Powering Repeaters (EXCP)

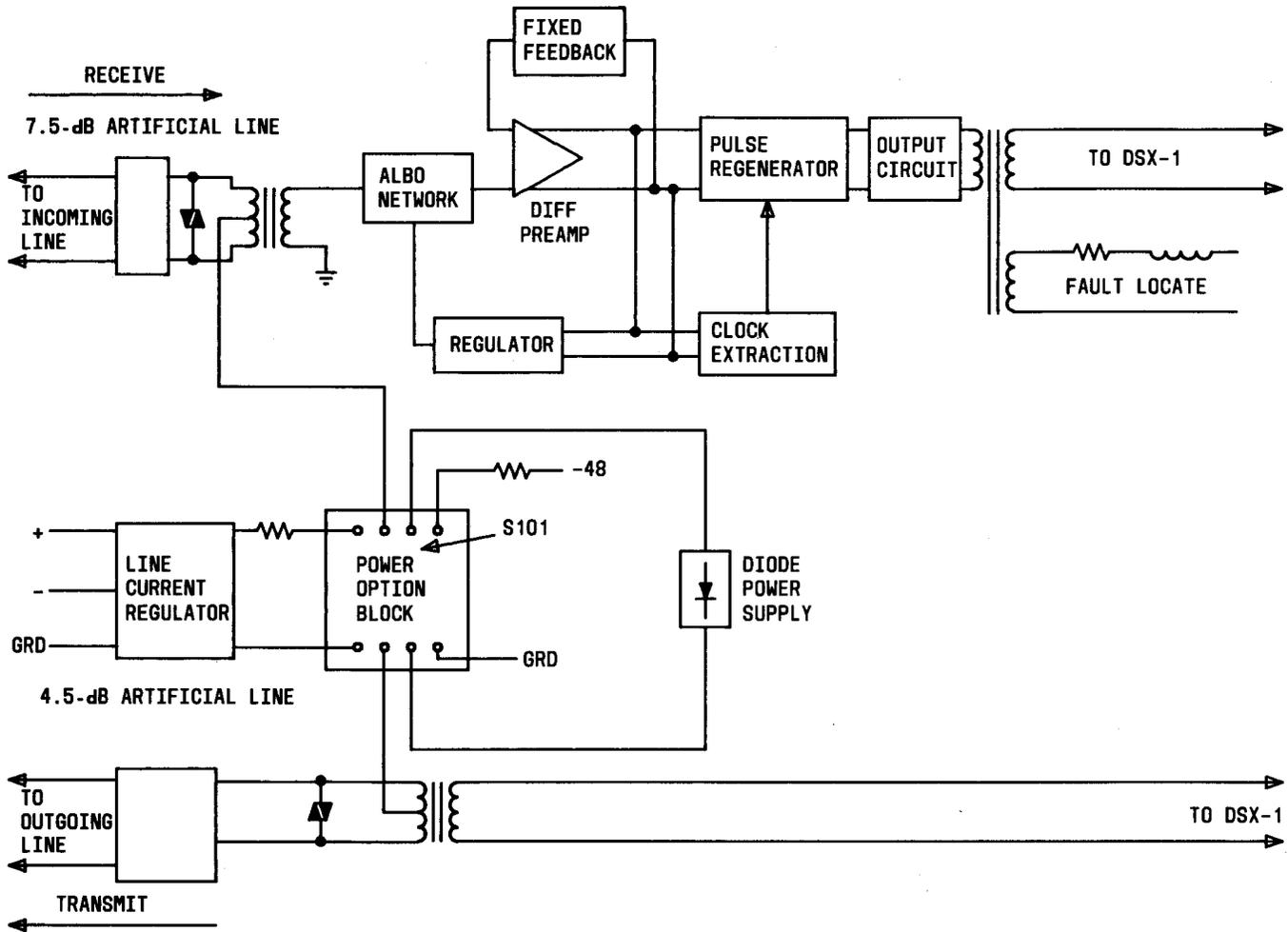
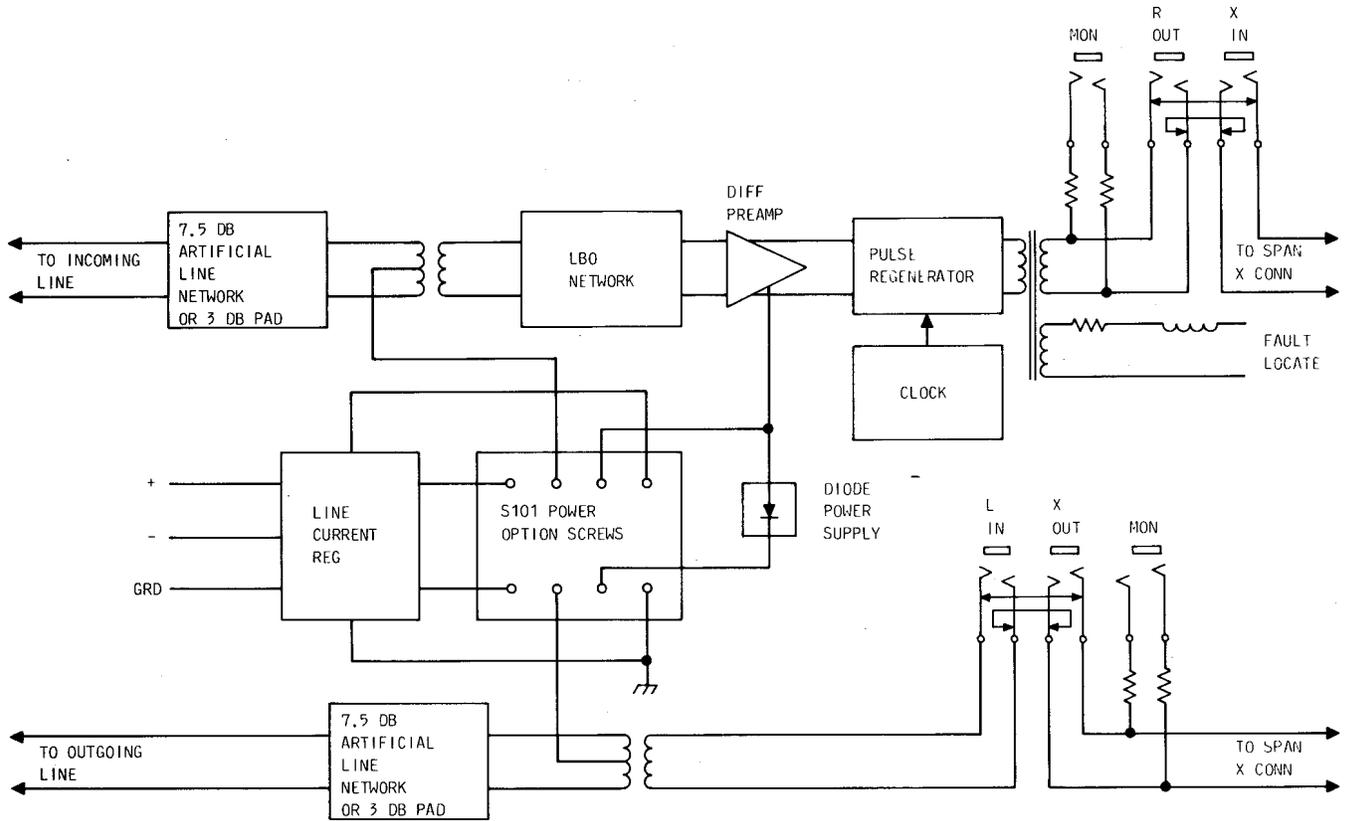


Fig. 8—Block Diagram of 221 and 231 Integrated Circuit-Type Line Powering Repeaters



**Fig. 9—Block Diagram of 206 Nonintegrated Circuit-Type Line Powering Repeater (Mfr Disc)**

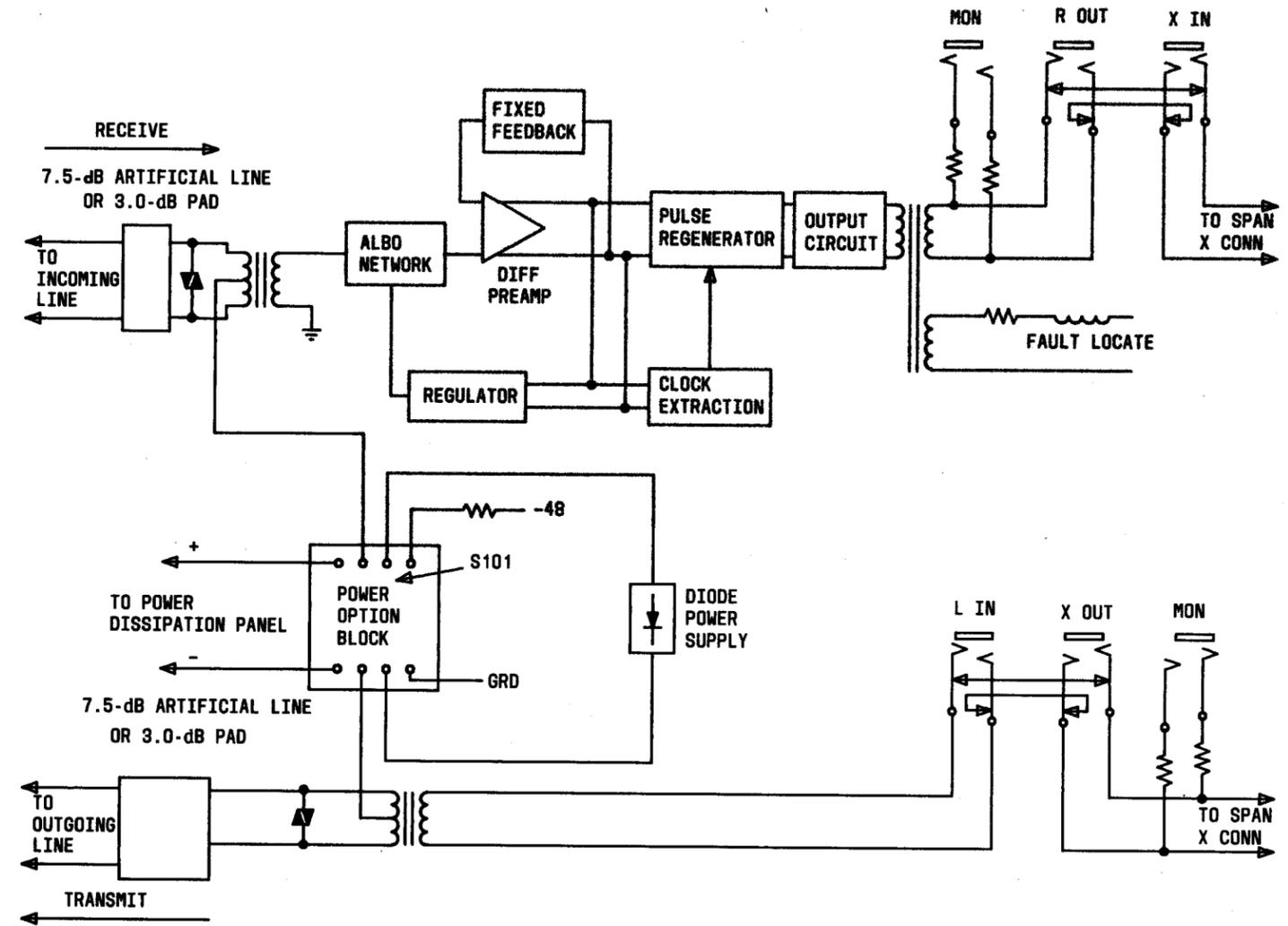


Fig. 10—Block Diagram of 206 and 236 Integrated Circuit-Type Power Looping Repeaters (Except EXCP)

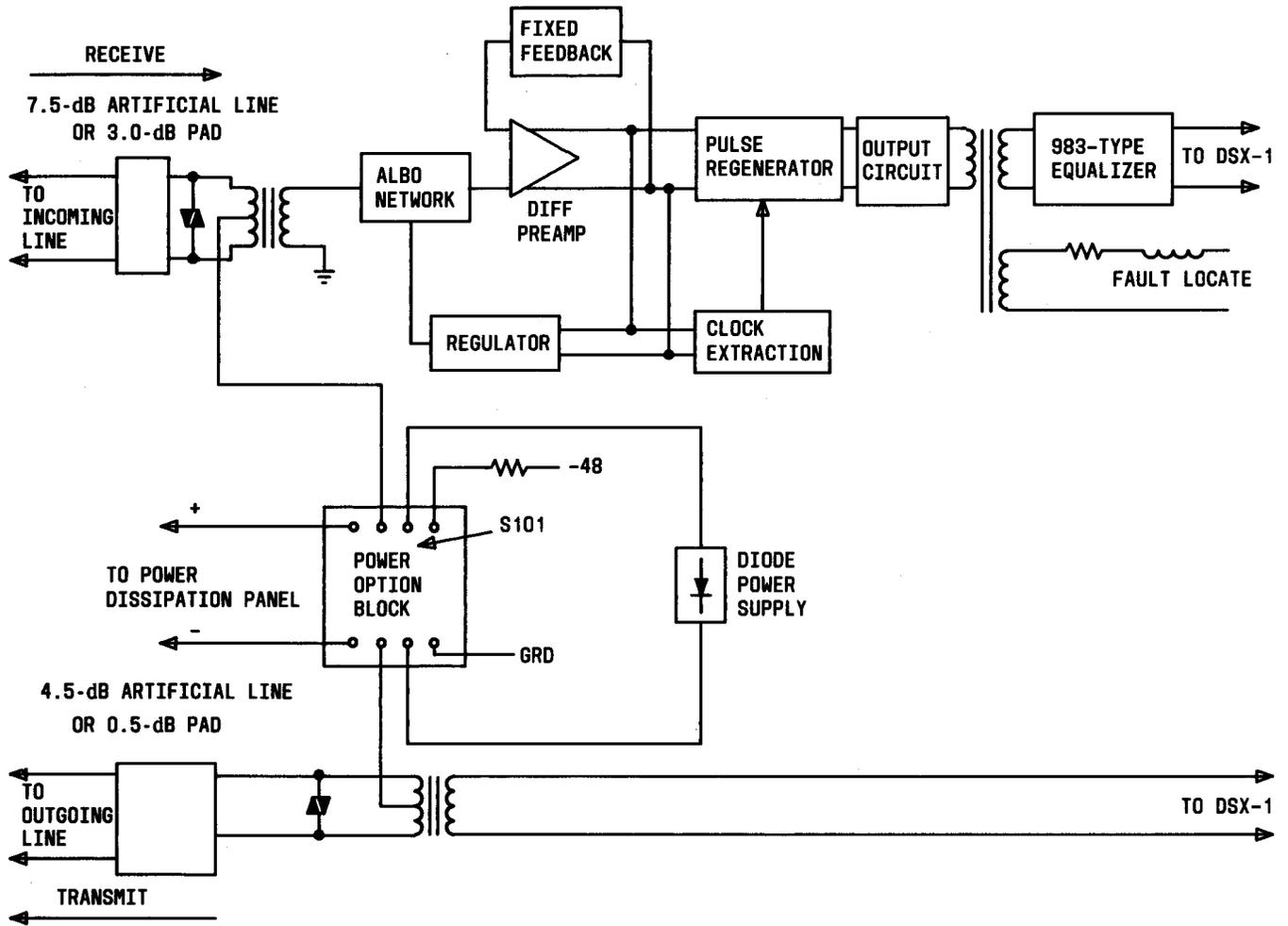


Fig. 11—Block Diagram of 206 and 236 Integrated Circuit-Type Power Looping Repeaters (EXCP)

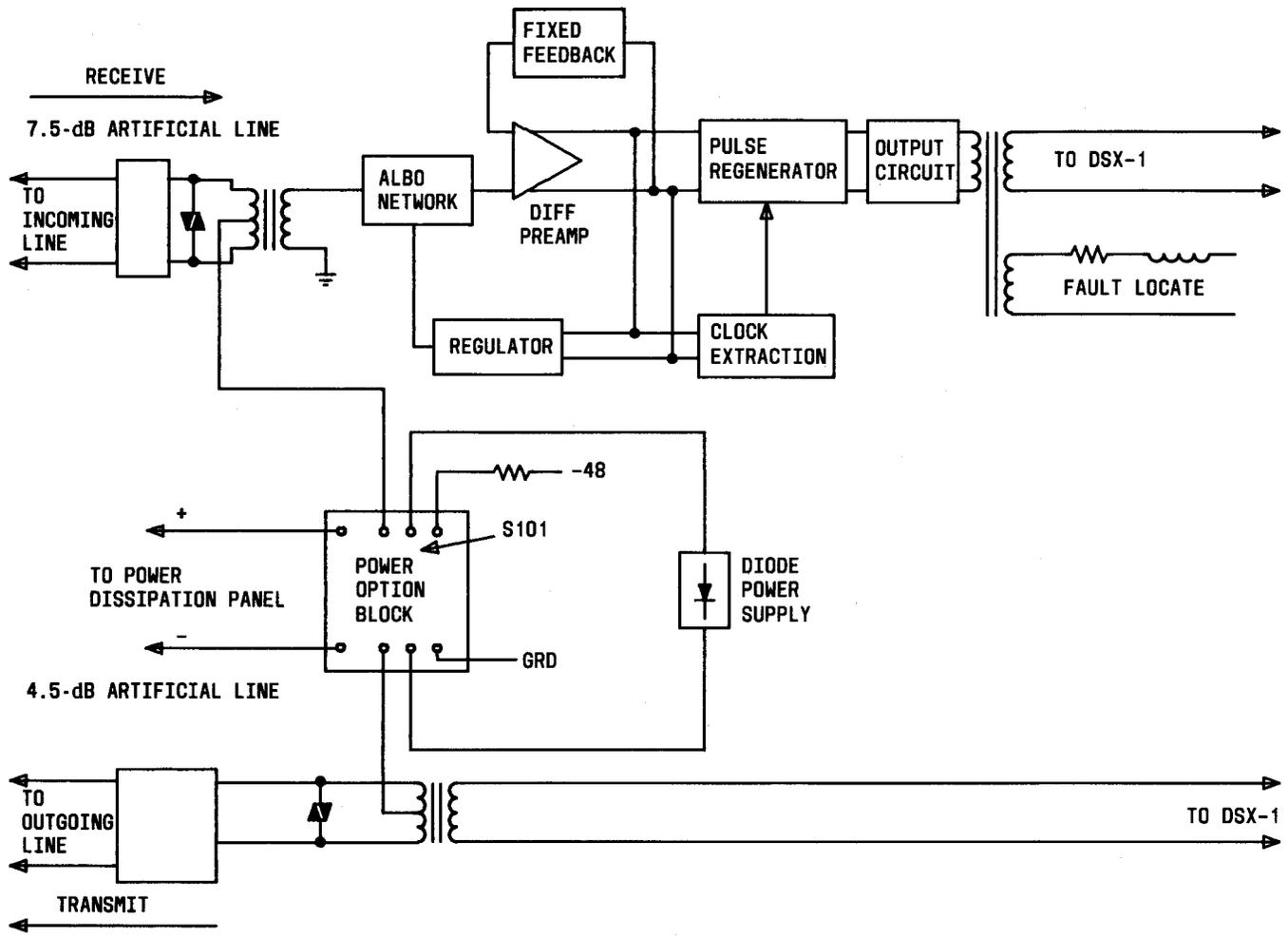


Fig. 12—Block Diagram of 221 and 231 Integrated Circuit-Type Power Looping Repeaters

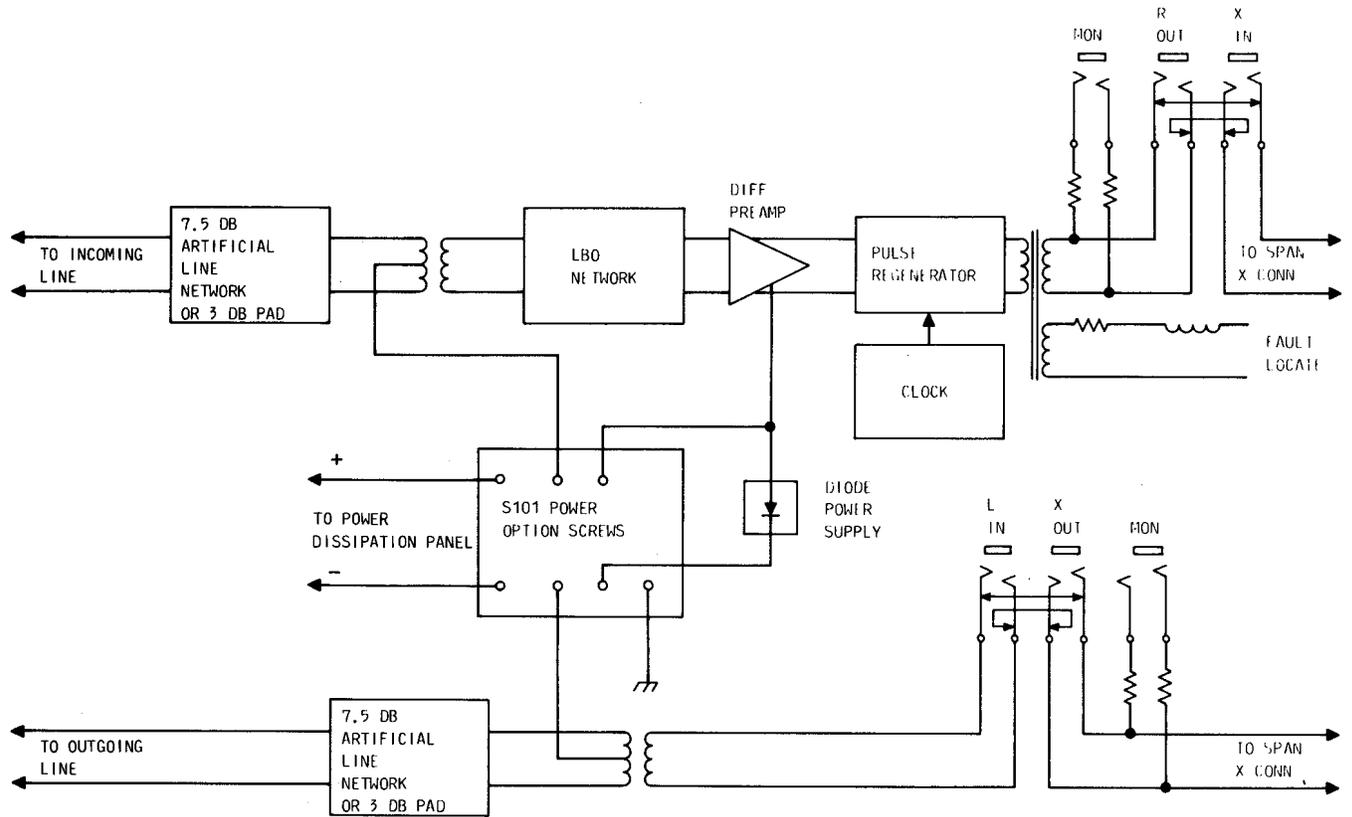
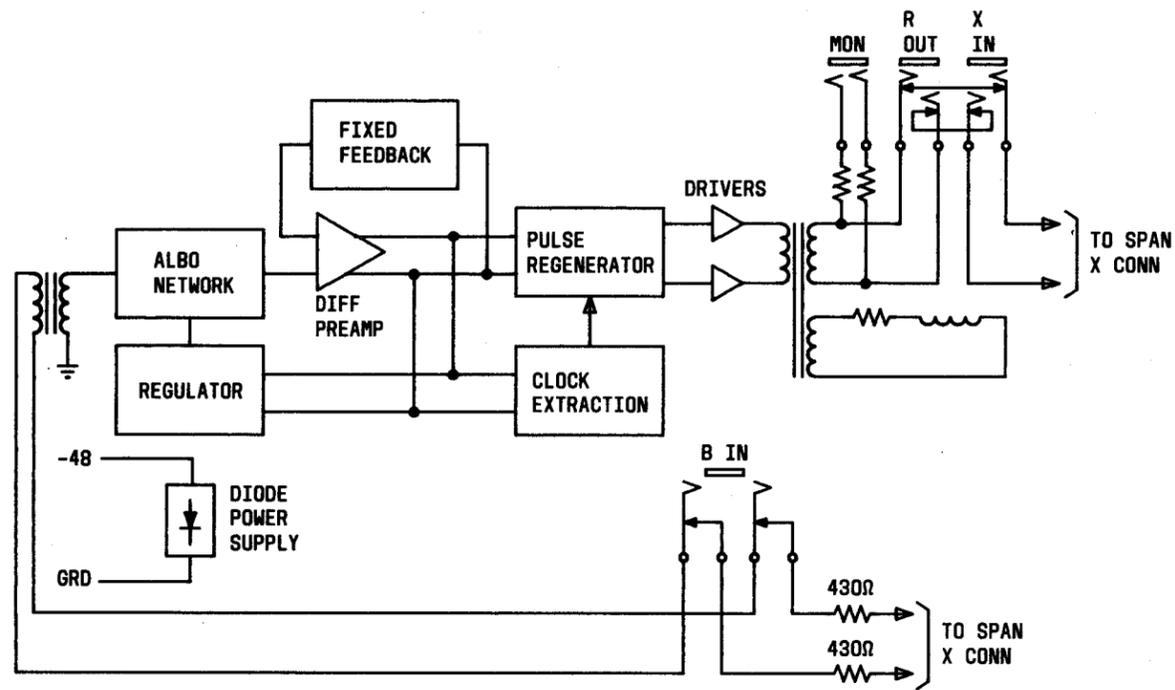
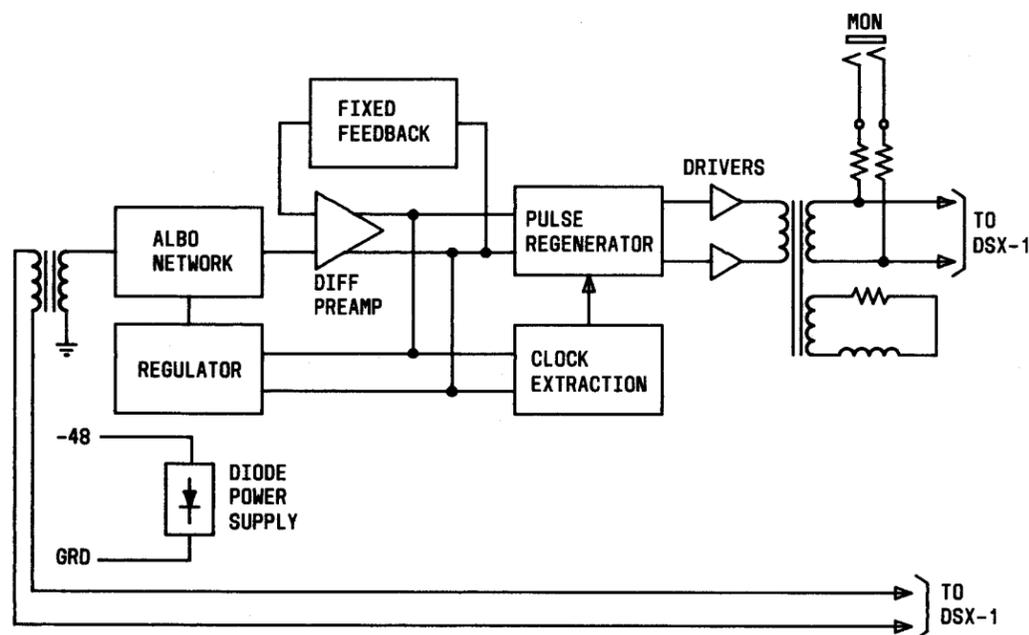


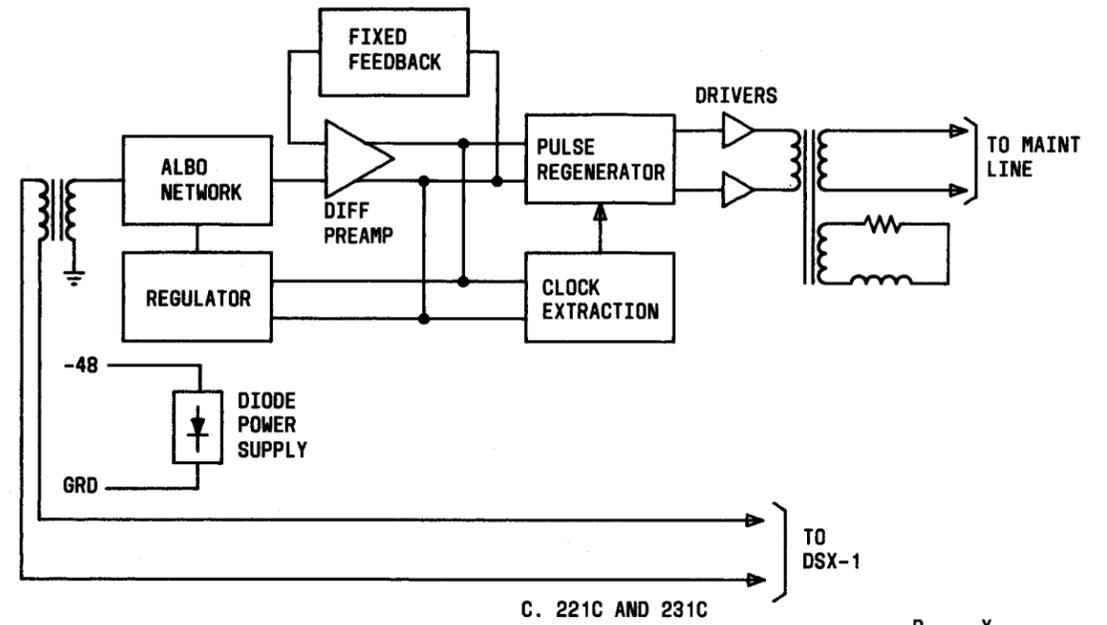
Fig. 13—Block Diagram of 206 Nonintegrated Circuit-Type Power Looping Repeater



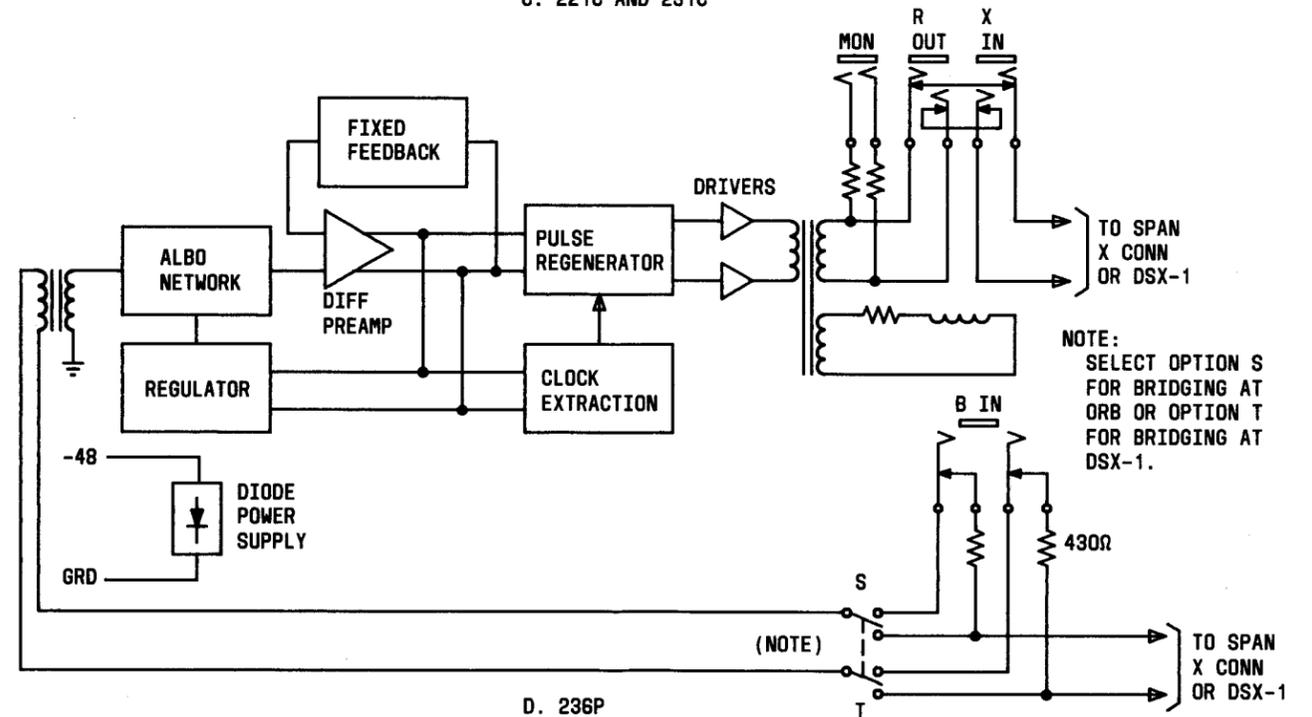
A. 206R



B. 206S



C. 221C AND 231C



D. 236P

Fig. 14—Block Diagram of Integrated Circuit Bridging Repeaters

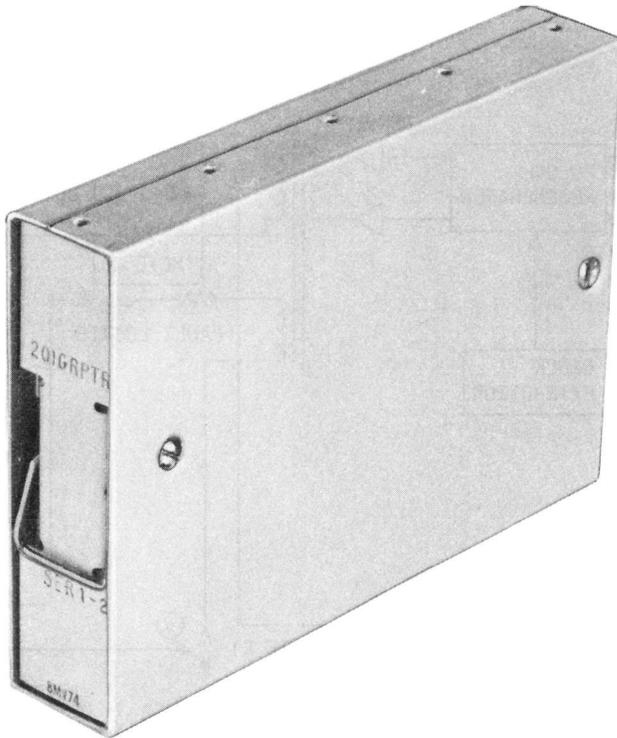


Fig. 15—201-Type Circuit Line Repeater

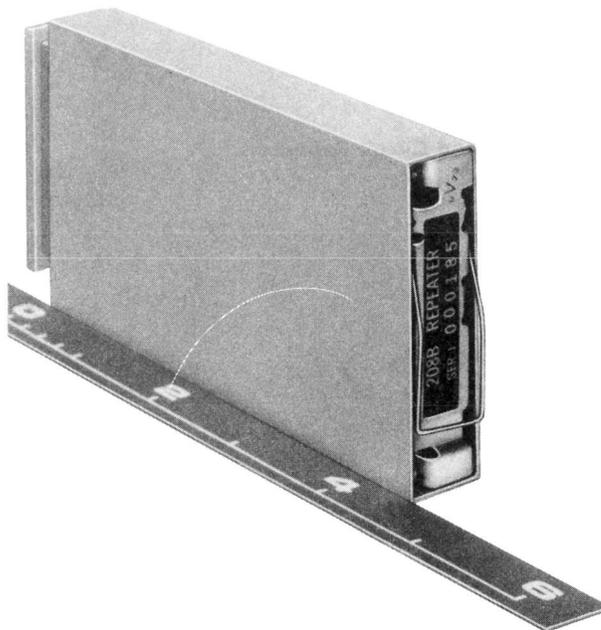


Fig. 16—208-Type Integrated Circuit Line Repeater

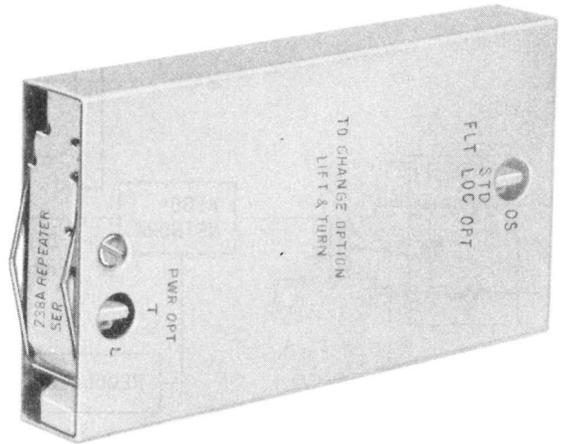


Fig. 17—238-Type Integrated Circuit Line Repeater

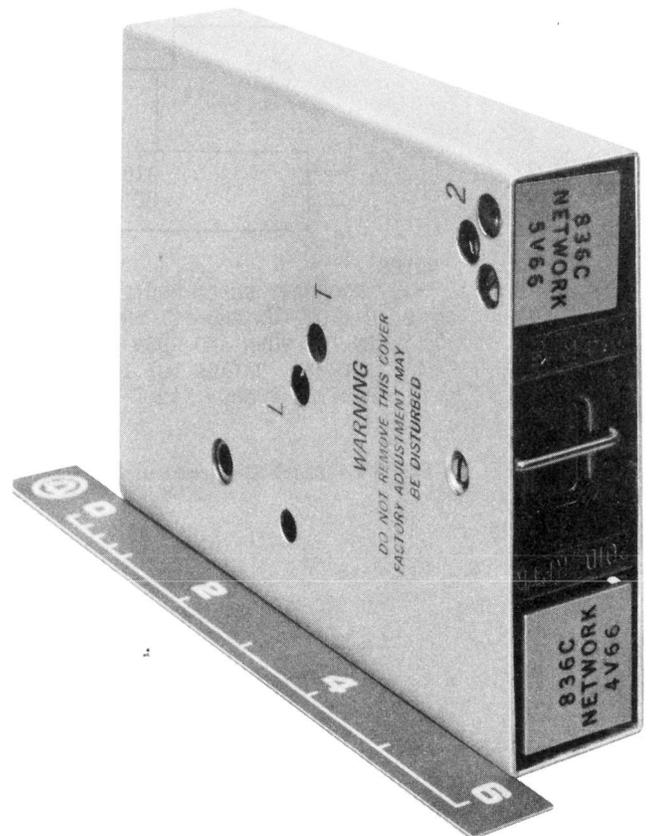
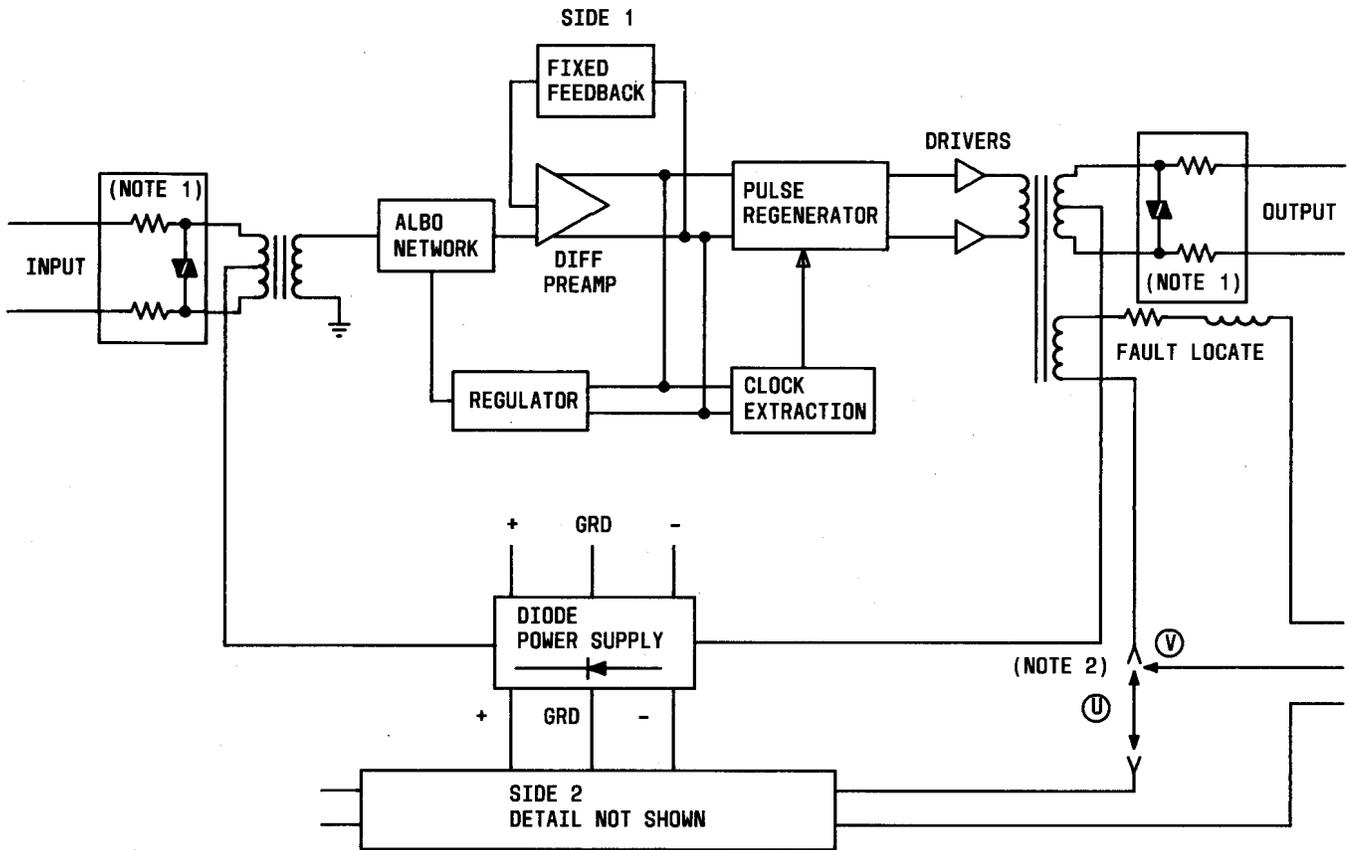


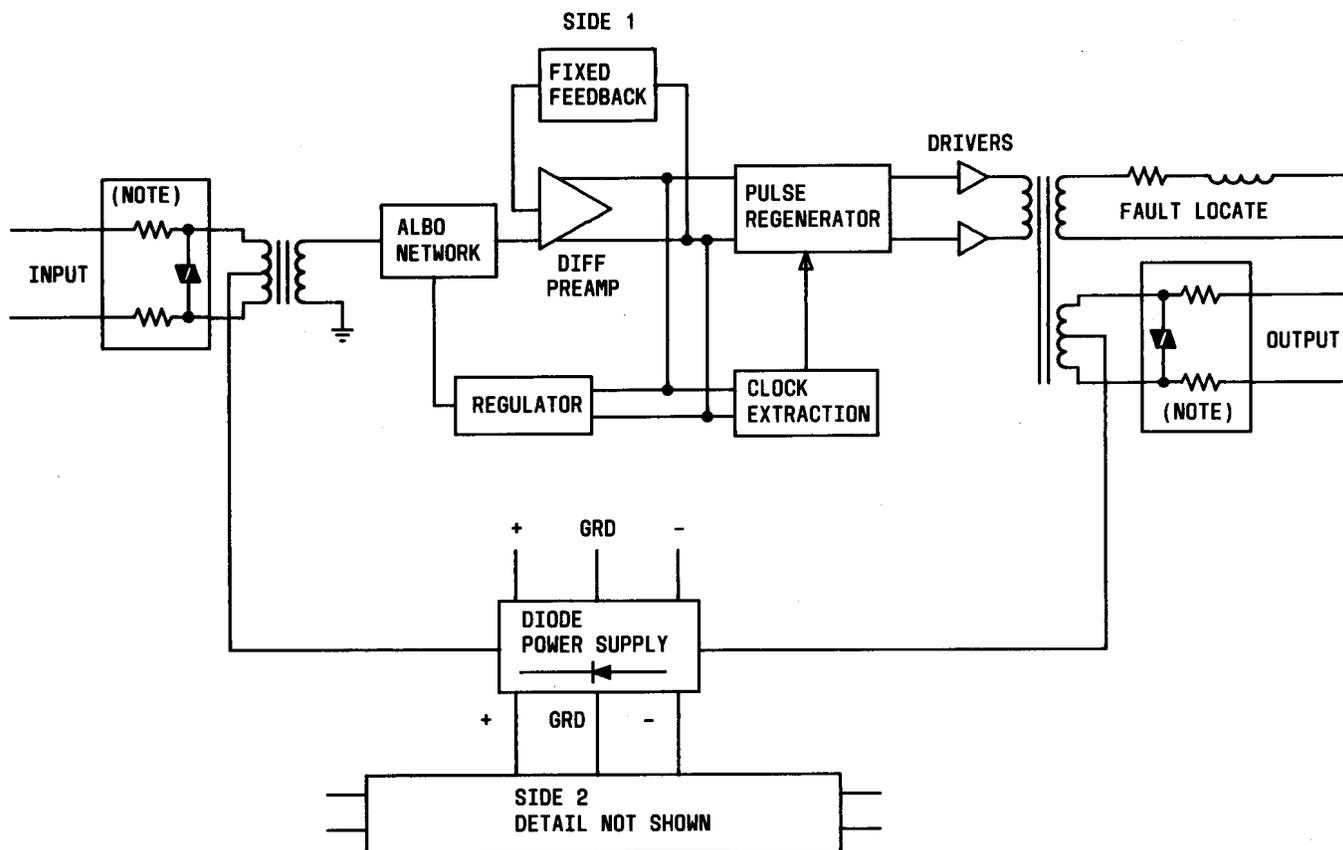
Fig. 18—201-Type Nonintegrated Circuit Line Repeater



NOTES:

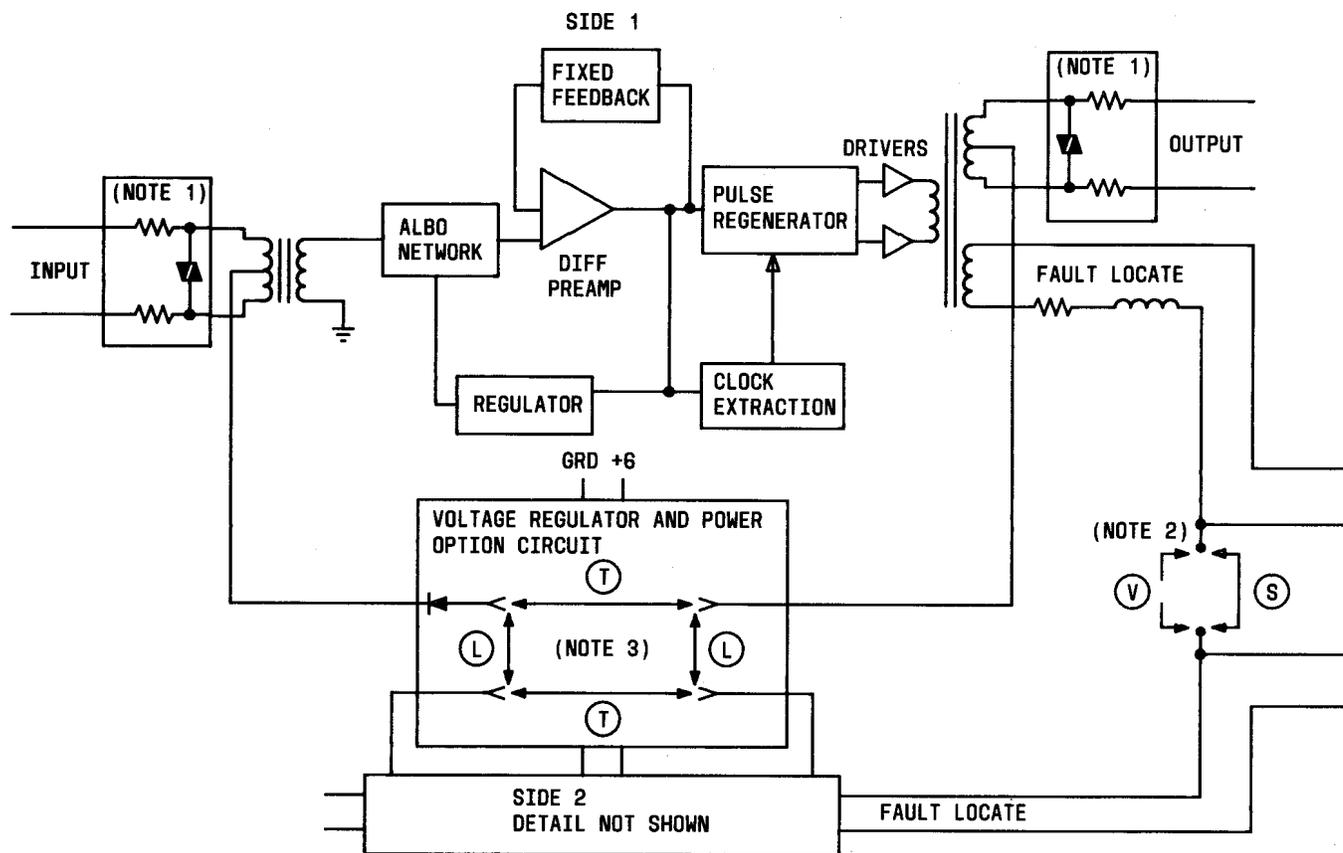
1. SECONDARY SURGE PROTECTION IS PROVIDED IN 205-TYPE REPEATERS ONLY.
2. OPTION  $\text{U}$  AND  $\text{V}$  ARE MANUFACTURING OPTIONS. OPTION  $\text{V}$  IS PROVIDED IN THE 205M AND 205N REPEATERS WHICH PROVIDES SEPARATE FAULT-LOCATE OUTPUTS. OPTION  $\text{U}$  IS PROVIDED IN THE 205G, H, J, AND K REPEATERS TO PROVIDE COMMON FAULT-LOCATE OUTPUTS.

Fig. 19—Block Diagram of 201- and 205-Type Integrated Circuit Repeaters



NOTE:  
SECONDARY SURGE PROTECTION IS PROVIDED IN 209-TYPE REPEATERS ONLY.

Fig. 20— Block Diagram of 208 and 209 Single-Letter Codes Integrated Circuit Repeaters

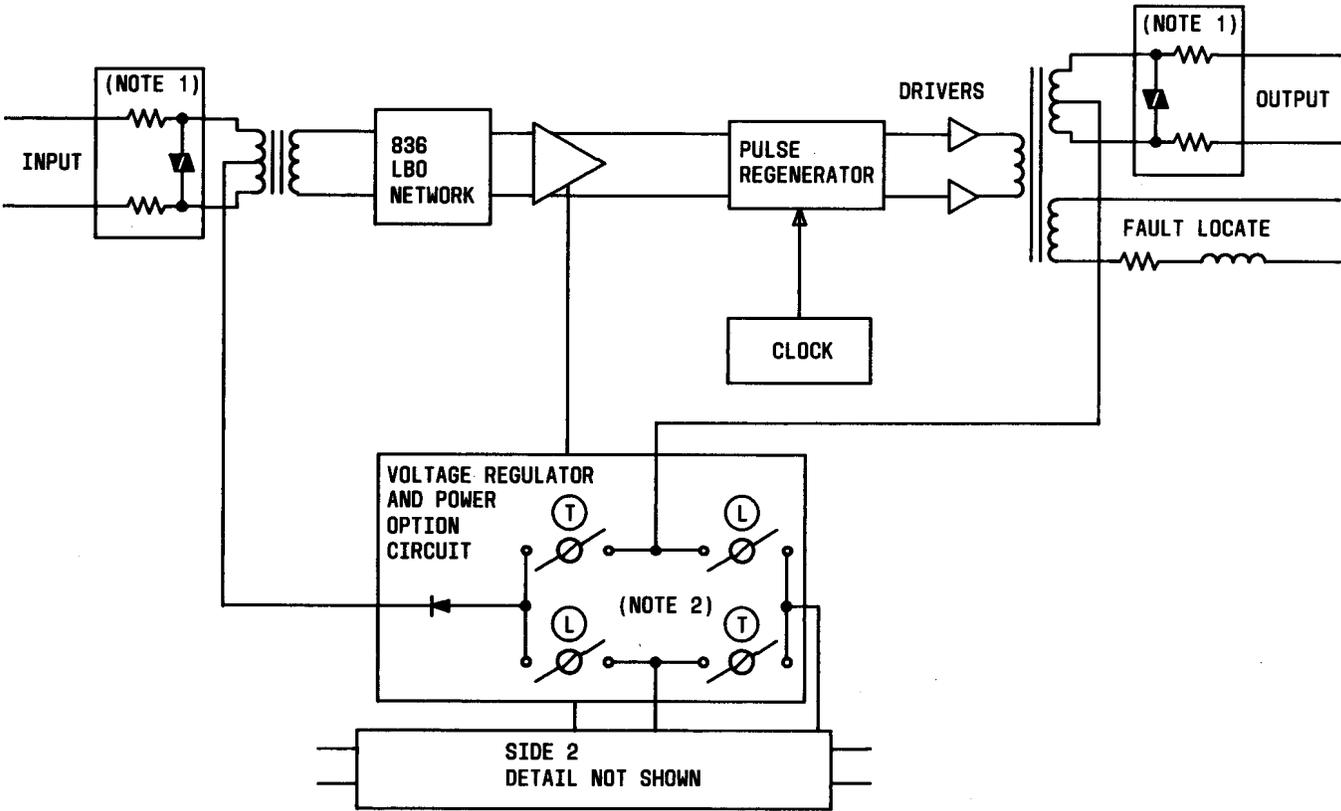


NOTES:

1. SECONDARY SURGE PROTECTION IS PROVIDED IN 209- AND 239-TYPE REPEATERS ONLY.
2. OPTION (S) AND (V) ARE PROVIDED IN 238-TYPE BIDIRECTIONAL REPEATERS ONLY. SELECT OPTION (V) FOR SEPARATE FAULT-LOCATE OUTPUTS OR OPTION (S) FOR COMMON FAULT-LOCATE OUTPUTS. OPTION (S) PROVIDED BY FACTORY IN 238-TYPE UNIDIRECTIONAL REPEATERS.
3. SELECT OPTION (T) FOR THRU LINE POWERING OR OPTION (L) FOR LOOP LINE POWERING.

Fig. 21 — Block Diagram of 238- and 239-Type and 208 and 209 Double-Letter Codes Integrated Circuit Repeaters

SIDE 1



- NOTES:
- 1. SECONDARY SURGE PROTECTION IS PROVIDED IN 205-TYPE REPEATERS ONLY.
  - 2. SELECT OPTION (T) FOR THRU LINE POWERING OR OPTION (L) FOR LOOP LINE POWERING.

Fig. 22—Block Diagram of 201- and 205-Type Nonintegrated Circuit Repeaters

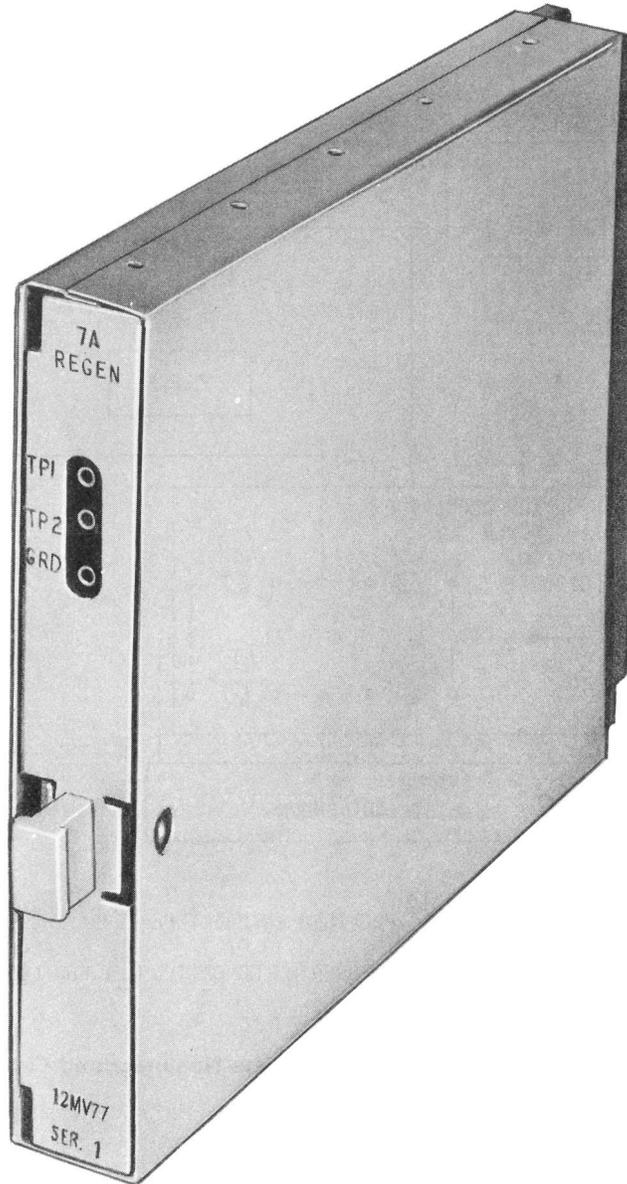


Fig. 23—7A Regenerator

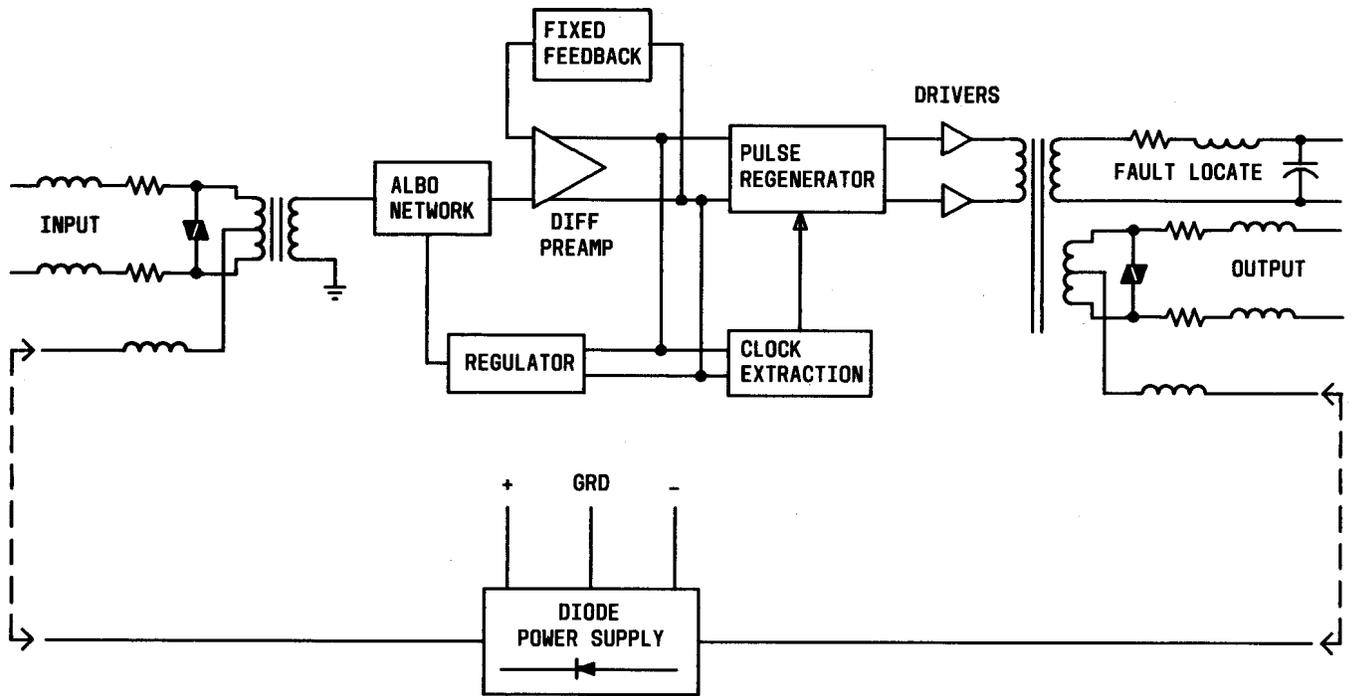
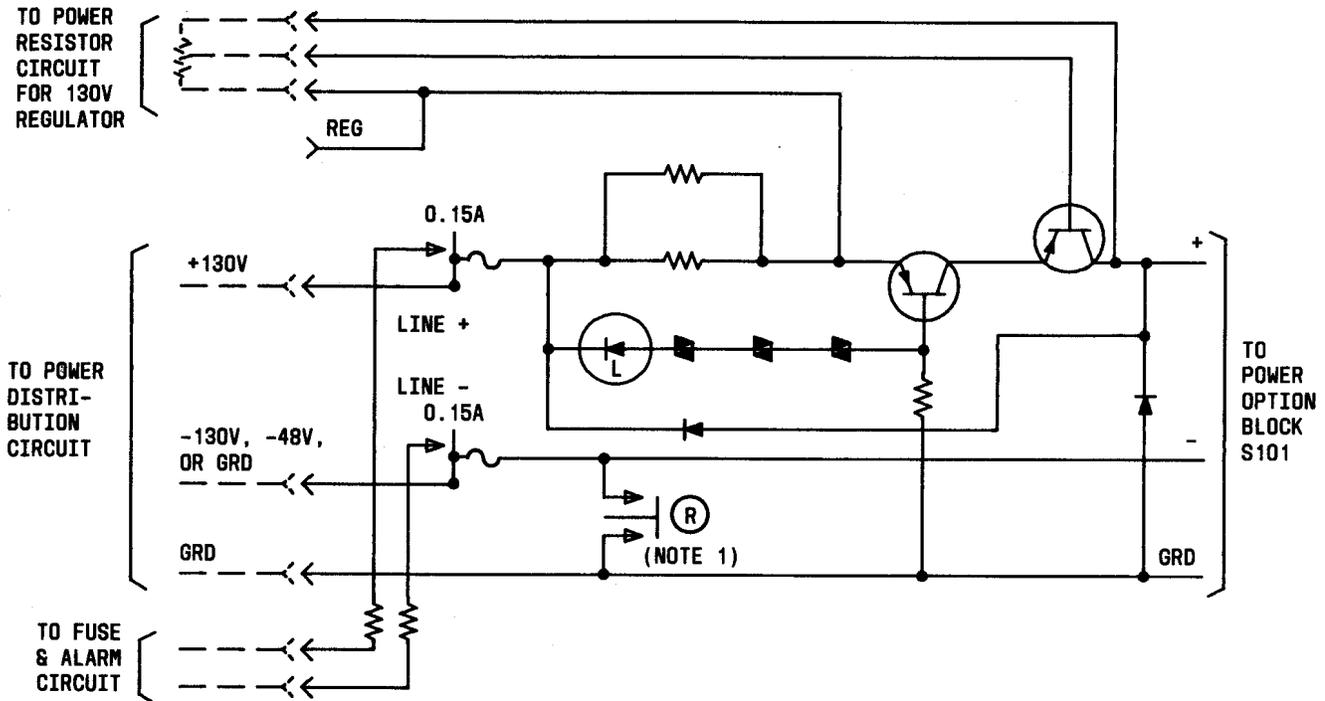
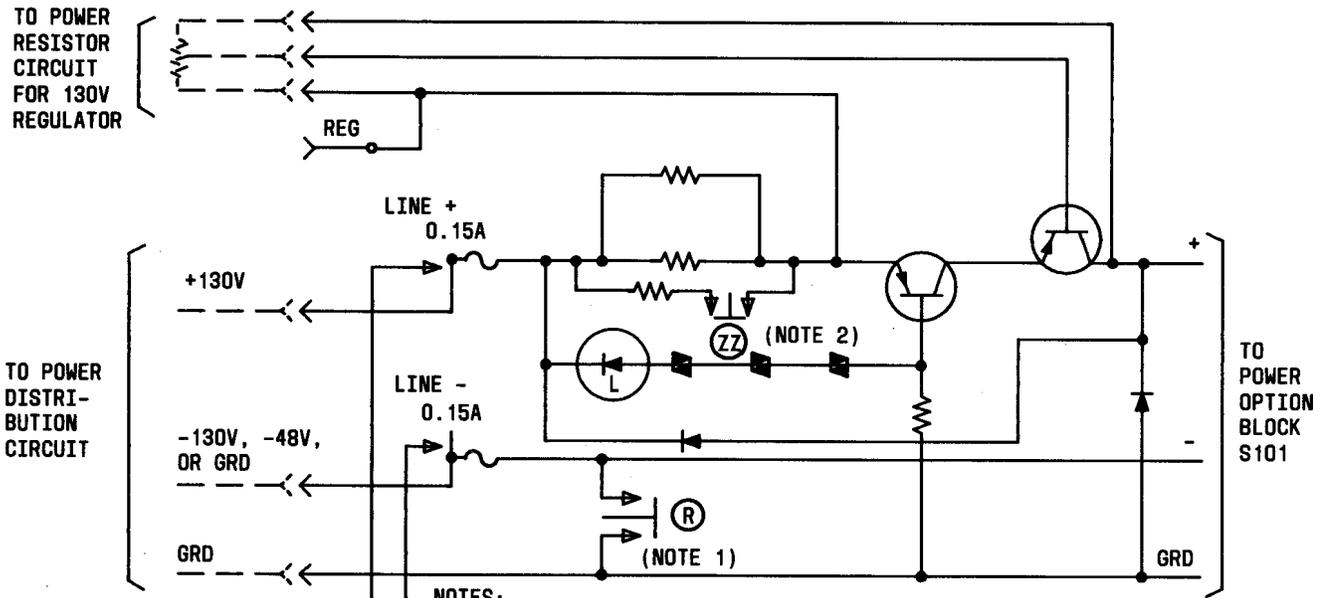


Fig. 24—Block Diagram of 7A Regenerator

SECTION 365-200-101



A. 206B, 206F, 206J, AND 206M

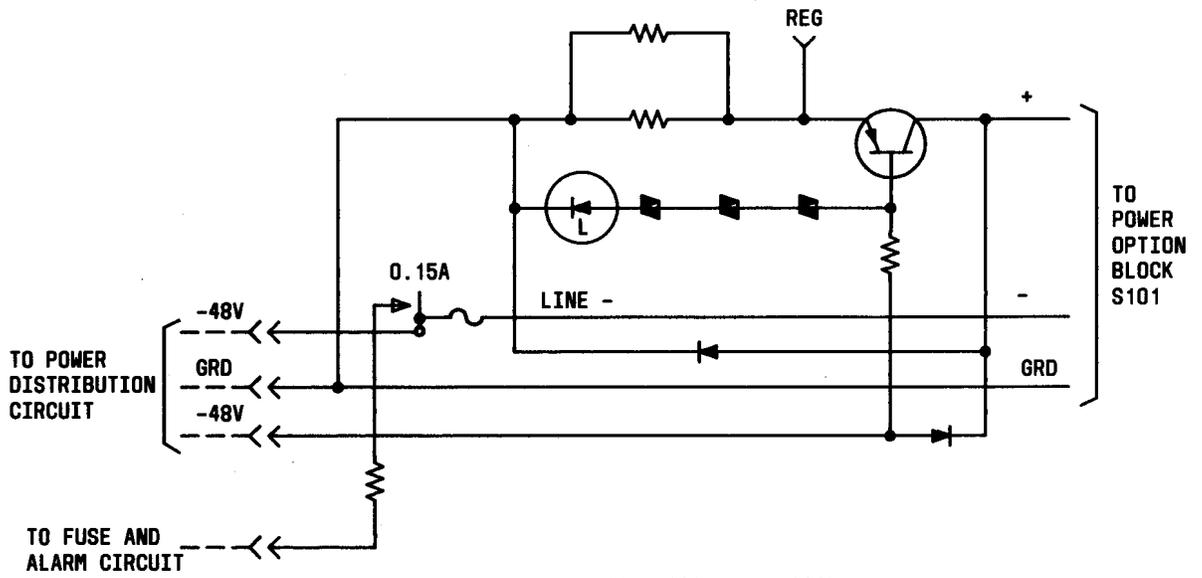


B. 206U AND 206AA

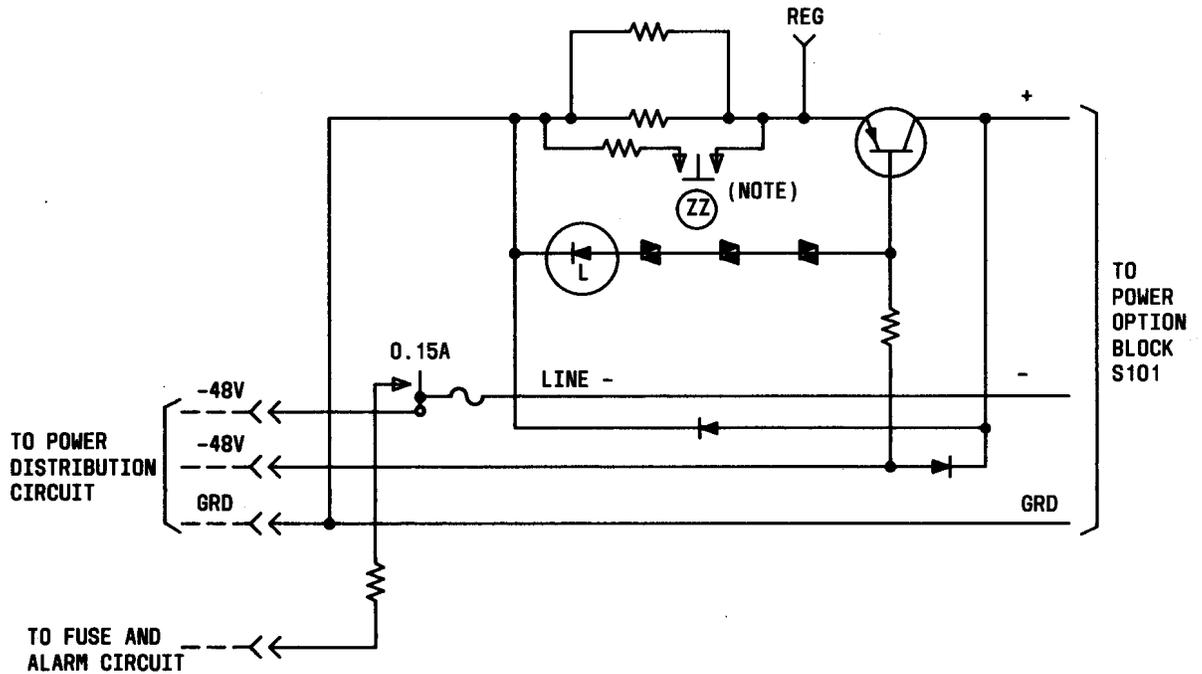
NOTES:

1. WHEN POWERING THE LINE WITH +130 VOLTS AND GROUND, THE LINE-FUSE MUST BE REPLACED WITH A DUMMY FUSE AND THE (R) OPTION SCREW TURNED MAXIMUM CLOCKWISE TO OBTAIN GROUND.
2. TO PROVIDE 140-MA LINE CURRENT, THE (ZZ) OPTION SCREW MUST BE TURNED MAXIMUM CLOCKWISE (CLOSED). FOR 60-MA LINE CURRENT, THE (ZZ) OPTION MUST BE OPEN (2 COMPLETE TURNS COUNTERCLOCKWISE).

Fig. 25—130-Volt Line Current Regulator Used in 206-Type Repeaters



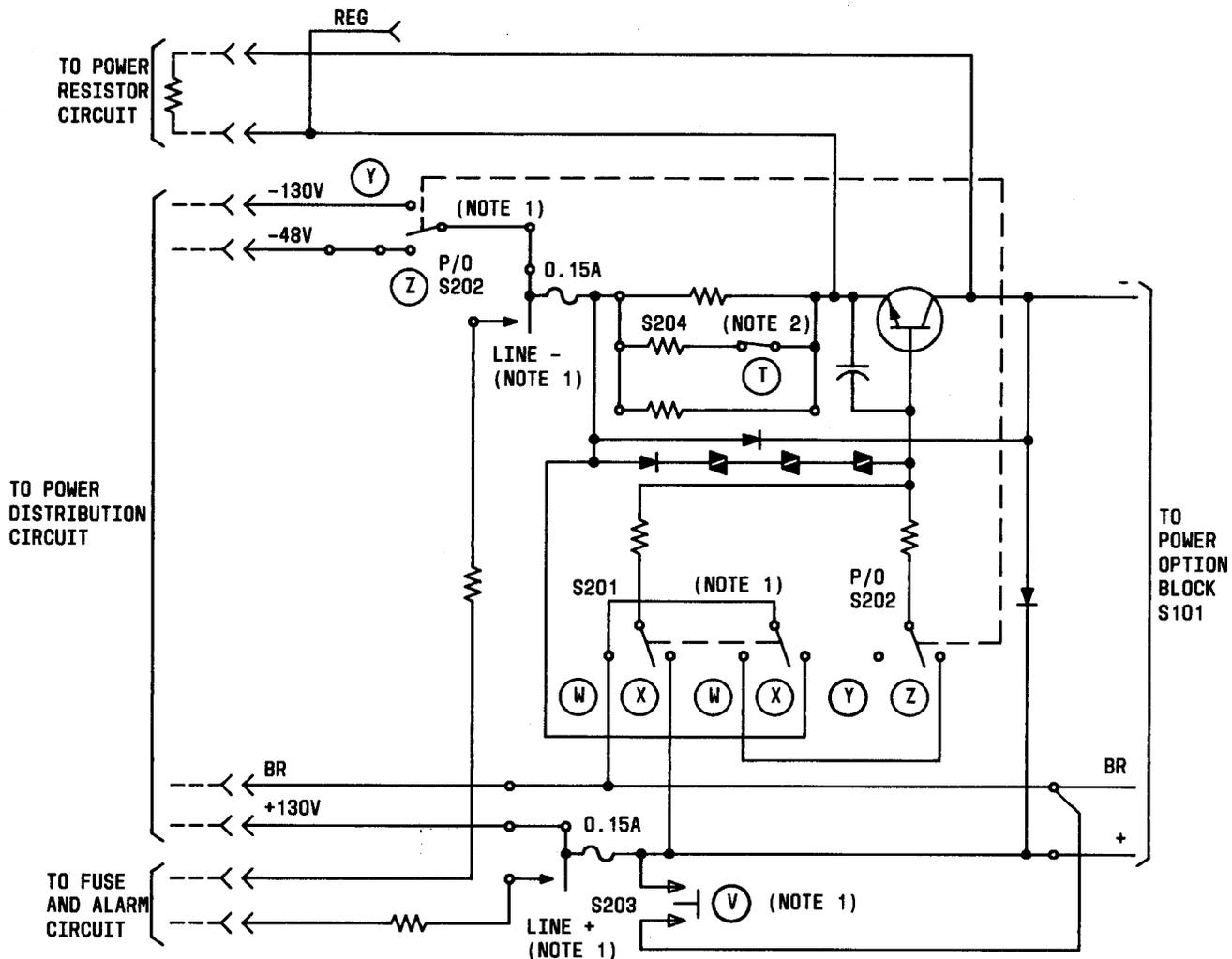
A. 206A, 206E, 206H, AND 206L



B. 206T AND 206Y

NOTE:  
 TO PROVIDE 140-MA LINE CURRENT, THE (ZZ) OPTION SCREW MUST BE TURNED MAXIMUM CLOCKWISE (CLOSED). FOR 60-MA LINE CURRENT, THE (ZZ) OPTION MUST BE OPEN (2 COMPLETE TURNS COUNTERCLOCKWISE).

Fig. 26—48-Volt Line Current Regulator Used in 206-Type Repeaters



NOTES:

1. OFFICE POWERING OPTIONS ARE PROVIDED BY SWITCHES S201 AND S202 AND SELECTOR BLOCK S203 AS FOLLOWS:

OFFICE BATTERY	OPTIONS REQUIRED		
	SWITCH		SELECTOR BLOCK
	S201	S202	S203
-48 VOLTS & BATTERY RETURN †	W	Z	V CLOSED
+130 VOLTS & BATTERY RETURN *	X	‡	V OPEN
+130 & -130 VOLTS	W	Y	V OPEN
+130 & -48 VOLTS	W	Z	V OPEN

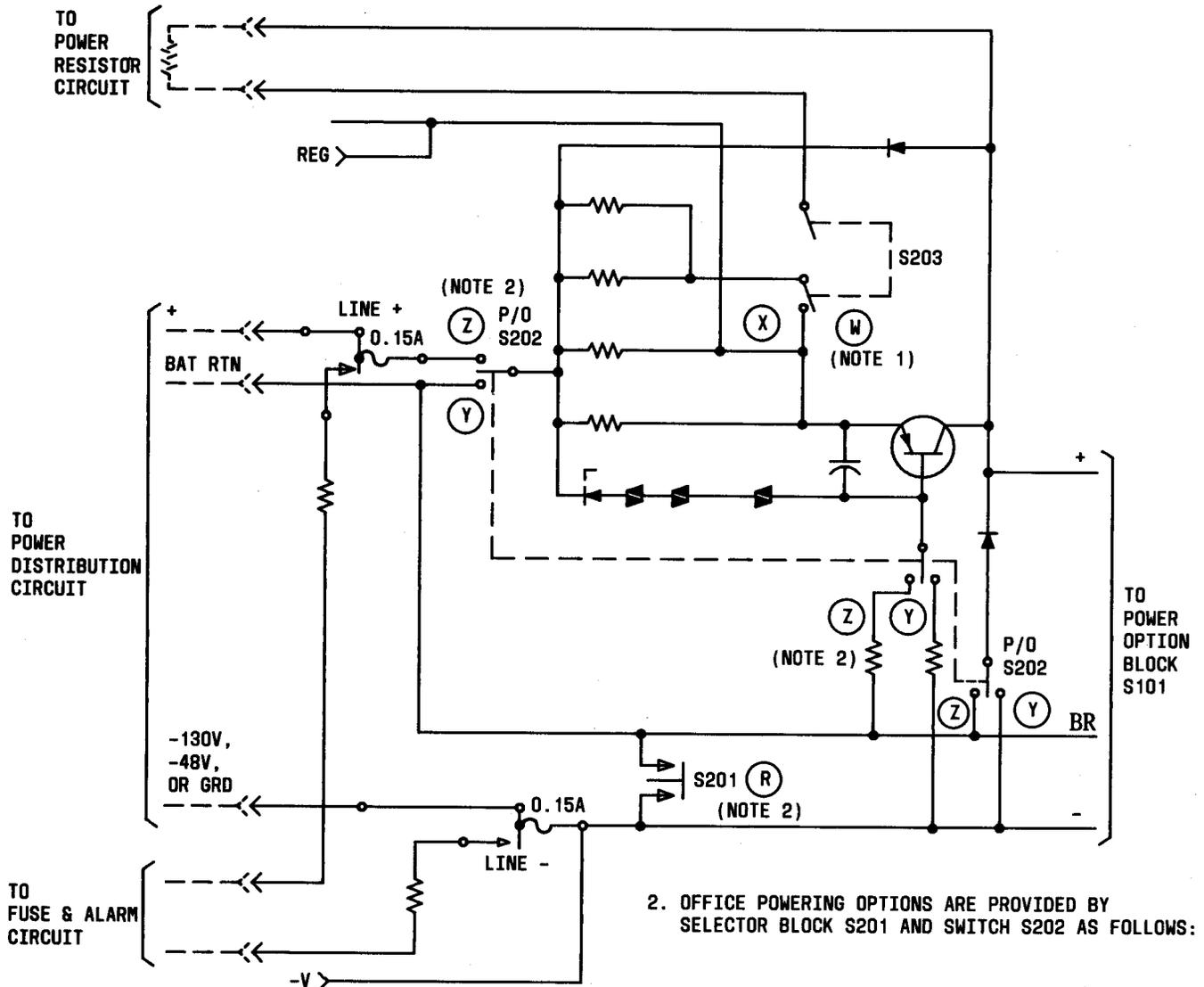
\* WHEN +130 VOLT BATTERY AND BATTERY RETURN IS USED, REPLACE FUSE LINE - WITH A DUMMY FUSE.

† WHEN -48 VOLT BATTERY AND BATTERY RETURN IS USED, REPLACE FUSE LINE + WITH A DUMMY FUSE.

‡ EITHER OPTION (Y) OR (Z) MAY BE SELECTED WHEN POWERING WITH +130 VOLTS AND BATTERY RETURN.

2. FOR 140-MA LINE CURRENT OPERATION, SELECT OPTION (T); FOR 60-MA LINE CURRENT OPERATION DO NOT SELECT OPTION (T). THE 231D DOES NOT HAVE 60/140-MA OPTION.

Fig. 27—48- and 130-Volt Line Current Regulator Used in 221A, 231A, and 231D Repeaters



2. OFFICE POWERING OPTIONS ARE PROVIDED BY SELECTOR BLOCK S201 AND SWITCH S202 AS FOLLOWS:

236A, 236C, 236E, 236G, 236J, 236L, 236N, 236AA, AND 236AC

NOTES:

1. THE NOMINAL LINE CURRENT IS SELECTED BY PROPER OPERATION OF SWITCH S203 AS FOLLOWS:

NOMINAL LINE CURRENT	OPTION SWITCH S203
140 mA	X*
60 mA	W*

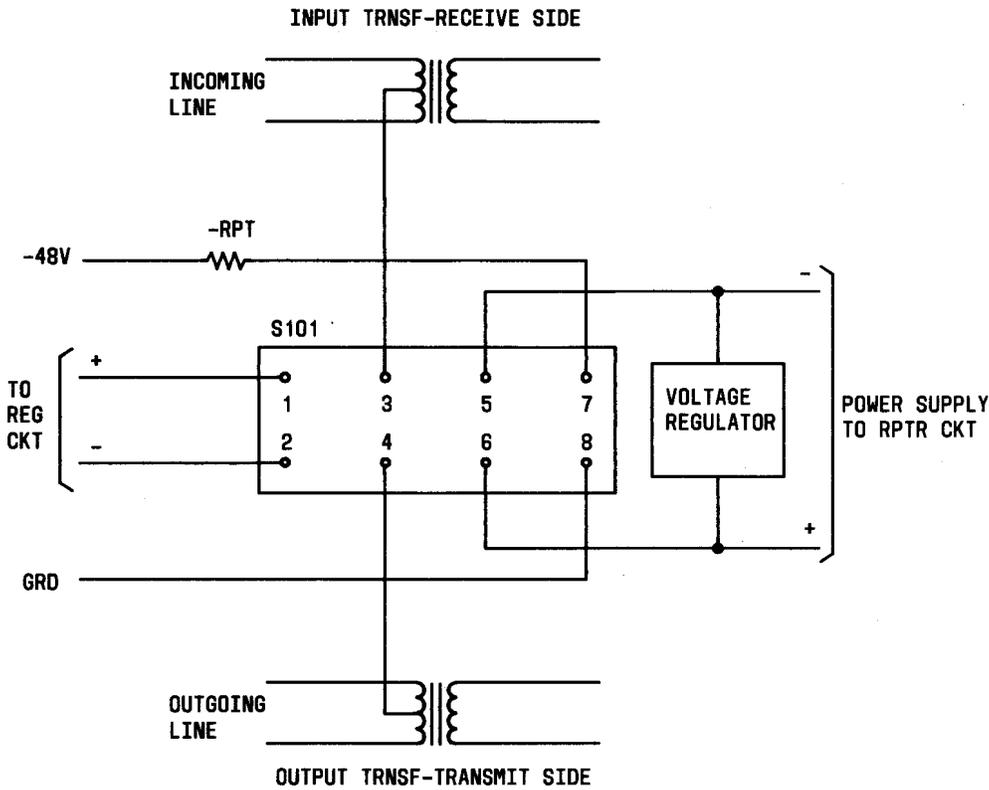
\*236A, C, J, AND L DO NOT HAVE 60/140-mA OPTION

OFFICE BATTERY	OPTIONS REQUIRED	
	SELECTOR BLOCK S201	SWITCH S202
* -48V AND BATTERY RET	R OPEN	Y
† +130V AND BATTERY RET	R CLOSED	Z
+130V AND -48V	R OPEN	Z
+130V AND -130V	R OPEN	Z

\* WHEN -48 VOLTS AND BATTERY RETURN IS USED, REPLACE FUSE LINE + WITH A DUMMY FUSE.

† WHEN +130 VOLTS AND BATTERY RETURN IS USED, REPLACE FUSE LINE - WITH A DUMMY FUSE.

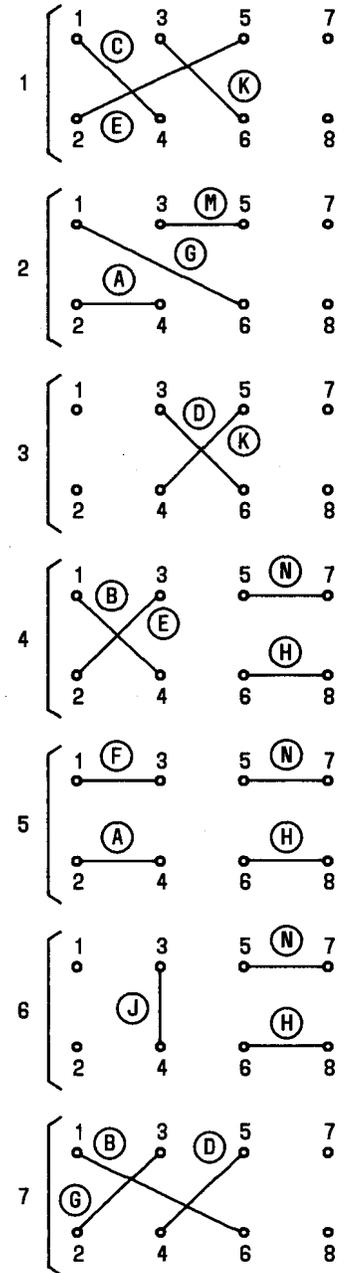
◆ Fig. 28— 48- and 130-Volt Line Current Regulator Used in 231- and 236-Type Repeaters ◆



POWERING CONDITIONS ARE PROVIDED BY TURNING DOWN OPTION SCREWS ON SWITCH S101, AS SPECIFIED, TO MAXIMUM CLOCKWISE POSITION. OPTION SCREWS NOT SPECIFIED SHOULD REMAIN IN THE UP POSITION (2 COMPLETE TURNS COUNTERCLOCKWISE).

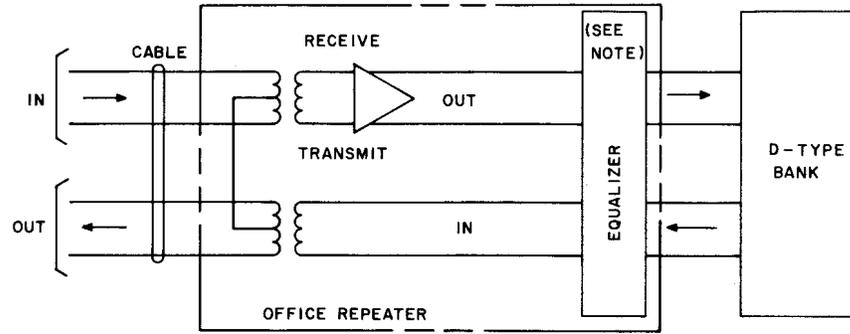
	POWERING CONDITION LINE REPEATER OPERATION	OPTION SCREWS
OFFICE REPEATER POWERED IN SERIES WITH LINE	1 BIDIRECTIONAL	C, E, K
	7 *UNIDIRECTIONAL-1ST SHELF OR POWER LOOP	B, D, G
	2 *UNIDIRECTIONAL-2ND SHELF OF POWER LOOP	A, G, M
	3 BIDIRECTIONAL, LINE POWERED FROM OTHER END	D, K
OFFICE REPEATER POWERED SEPARATELY	4 BIDIRECTIONAL	B, E, H, N
	4 *UNIDIRECTIONAL-1ST SHELF OF POWER LOOP	
	5 *UNIDIRECTIONAL-2ND SHELF OF POWER LOOP	A, F, H, N
	6 BIDIRECTIONAL, LINE POWERED FROM OTHER END	H, J, N

\*FOR UNIDIRECTIONAL LINE REPEATER OPERATION TWO OFFICE REPEATERS ARE REQUIRED TO COMPLETE THE POWER LOOP.



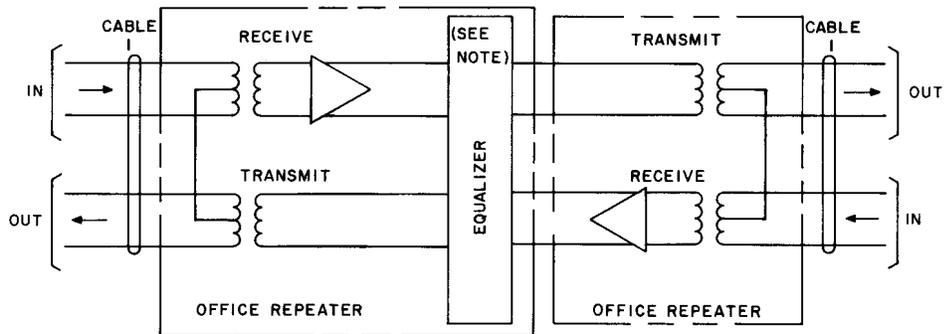
SCHEMATIC REPRESENTATION OF OPTIONS FOR SWITCH S101

Fig. 29—Powering Conditions and Options Provided by S101



NOTE:  
EQUALIZER USED WITH EXCP REPEATERS ONLY.

**Fig. 30—1-Cable Power Looping Operation at Terminal Office**



NOTE:  
EQUALIZER USED WITH EXCP REPEATERS ONLY.

**Fig. 31—1-Cable Power Looping Operation at Through Office**

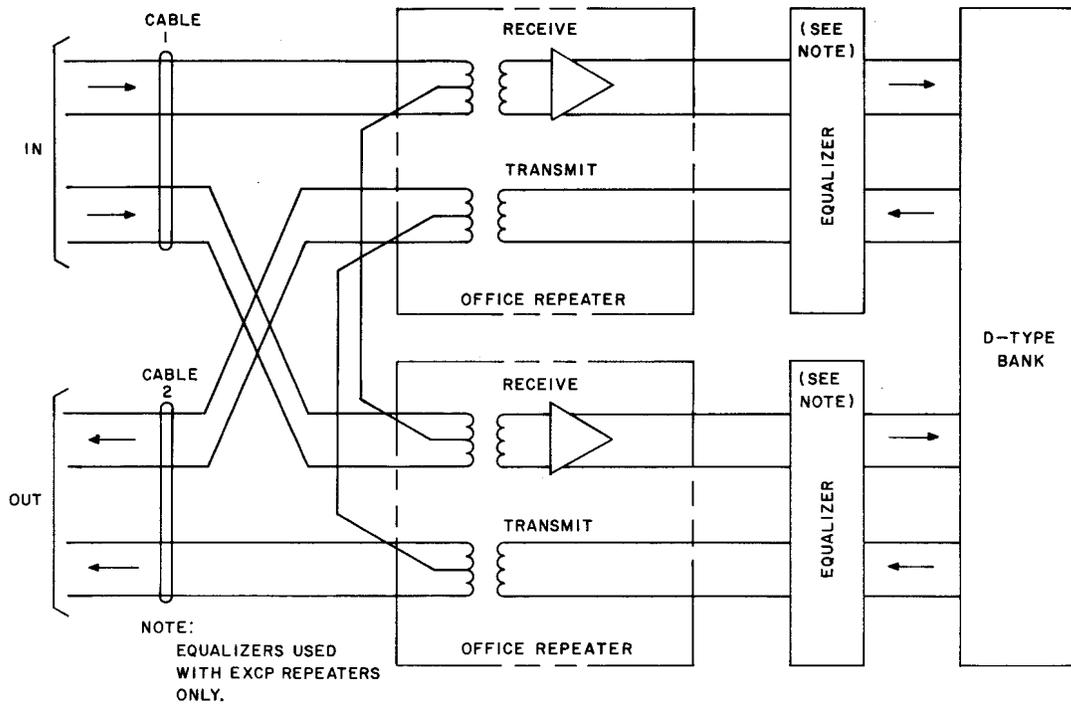


Fig. 32—2-Cable Power Looping Operation at Terminal Office

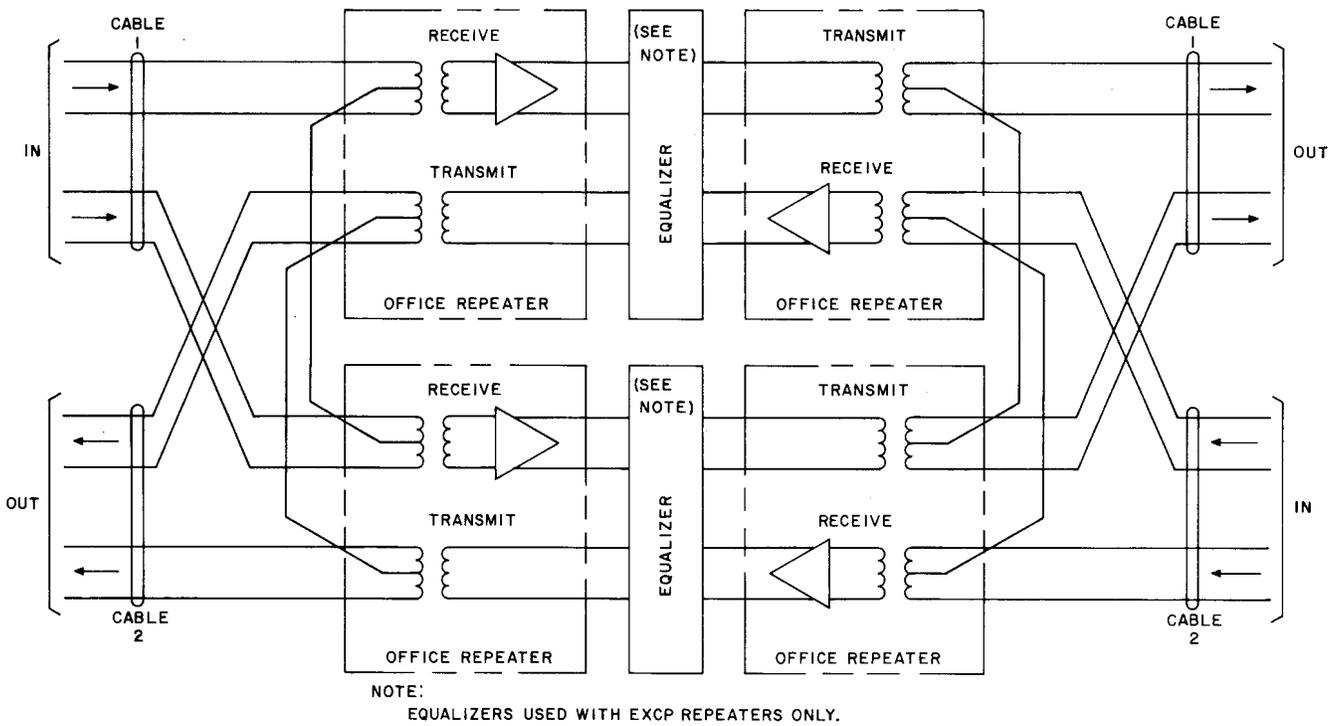


Fig. 33—2-Cable Power Looping Operation at Through Office

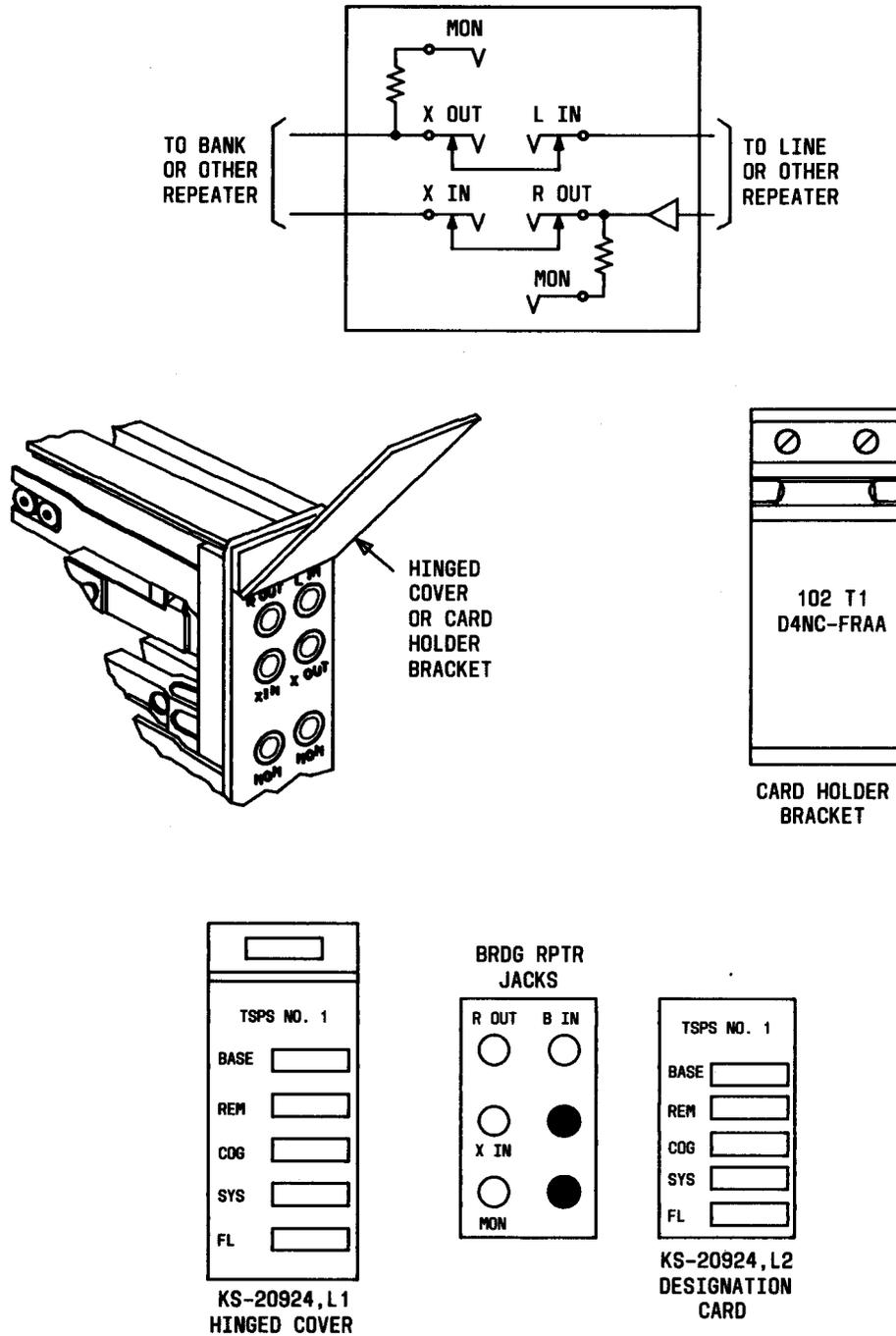
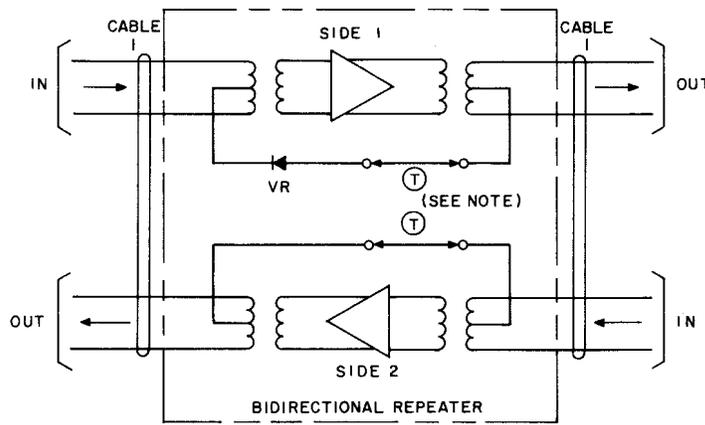


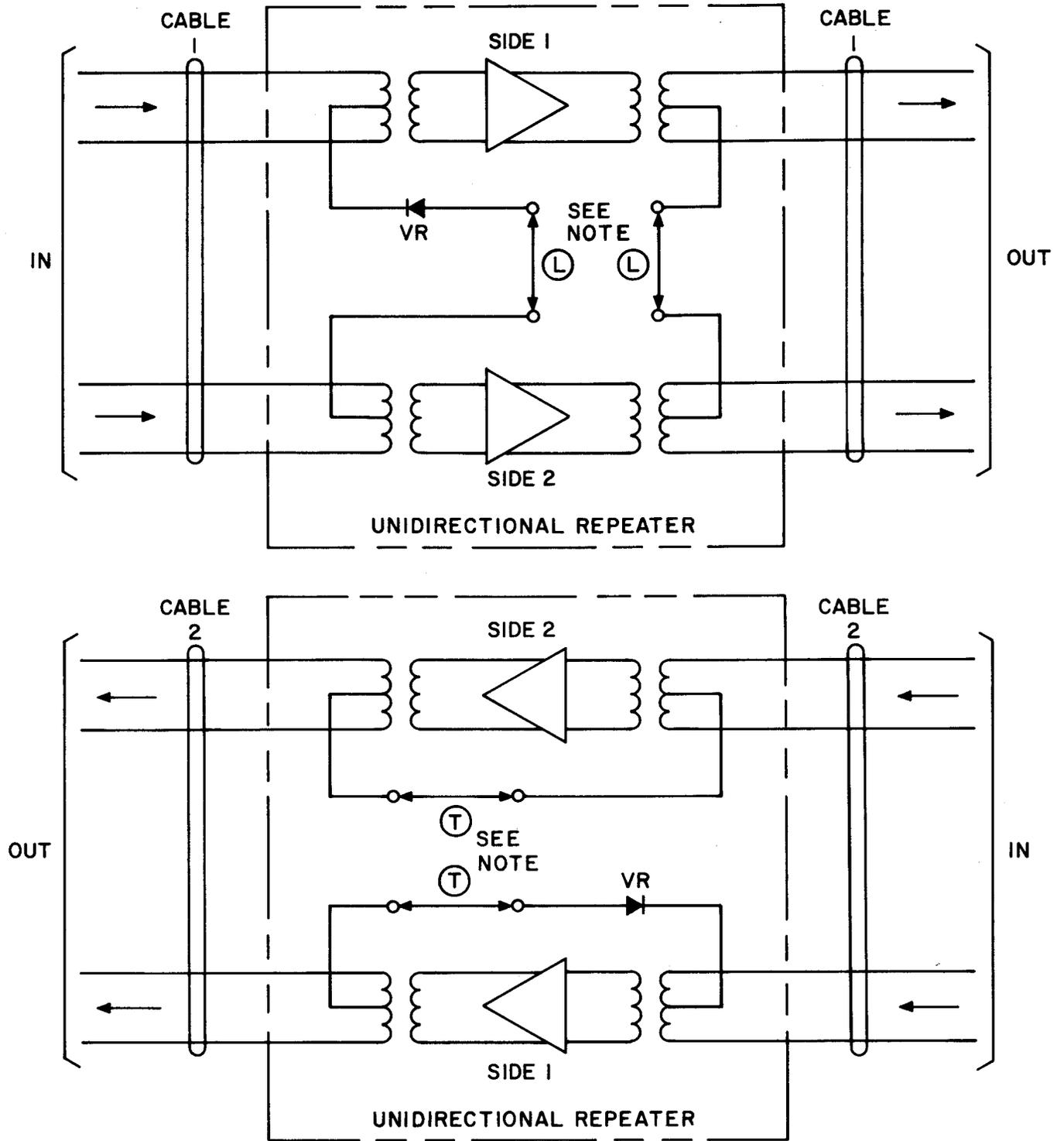
Fig. 34—Jacks and Identification for 206- and 236-Type Repeaters



NOTE:

LINE POWERING ARRANGEMENTS AND FAULT-LOCATE OUTPUTS ARE PROVIDED BY SELECTING THE CORRECT REPEATER CODE OR SETTING OPTION SWITCHES, OR OPTION SCREWS.

Fig. 35—Bidirectional Repeater Operation



**NOTE:**

LINE POWERING ARRANGEMENTS ARE PROVIDED BY SELECTING THE CORRECT REPEATER CODE, OR SETTING OPTION SWITCHES, OR OPTION SCREWS.

**Fig. 36—Unidirectional Repeater Operation**

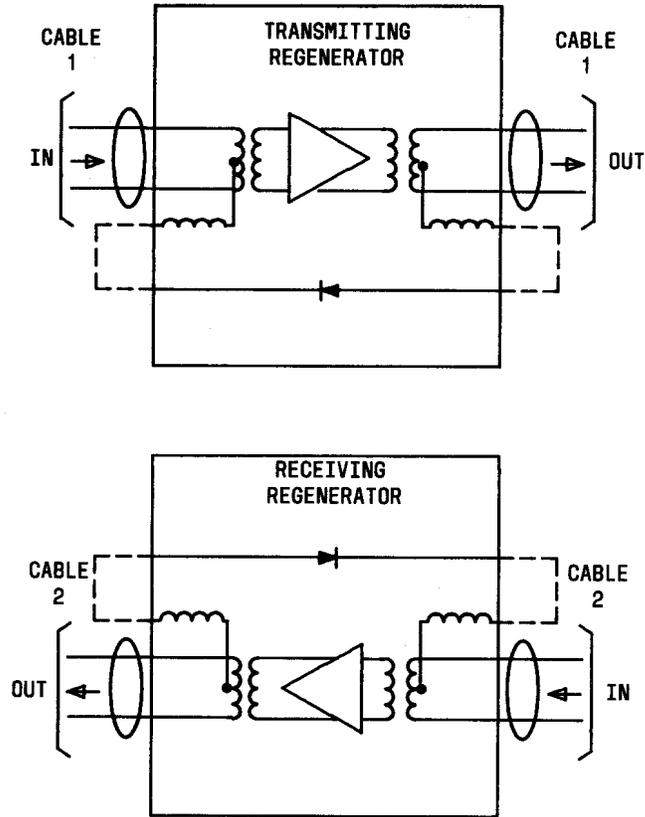


Fig. 37—7A Regenerator Operation

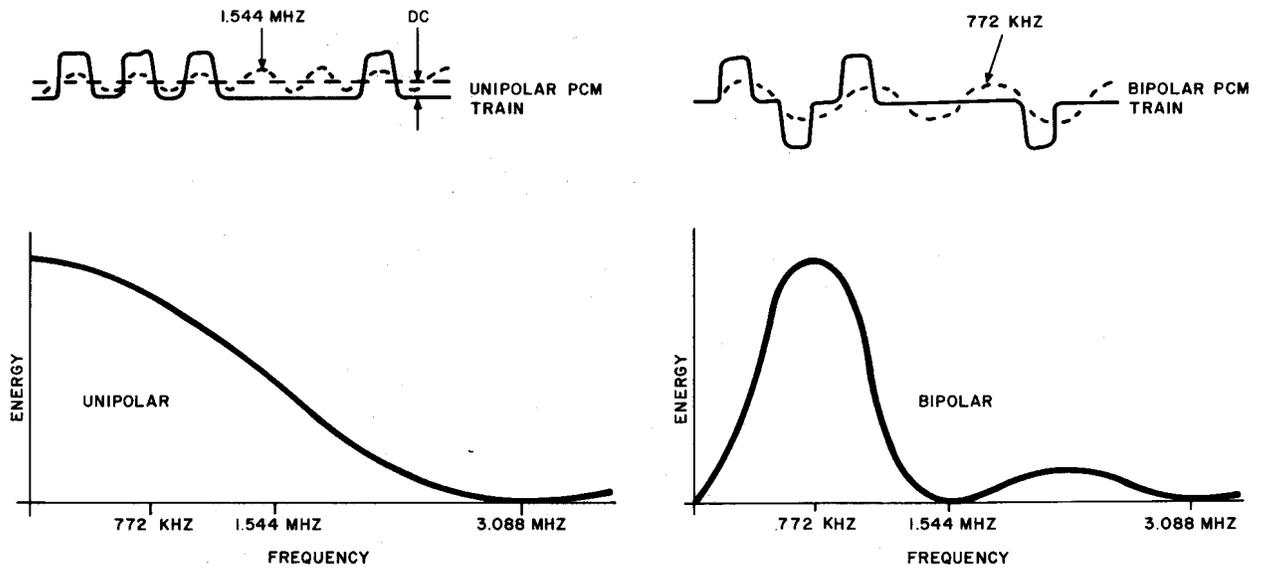


Fig. 38—Energy Spectra of Unipolar and Bipolar Pulse Trains

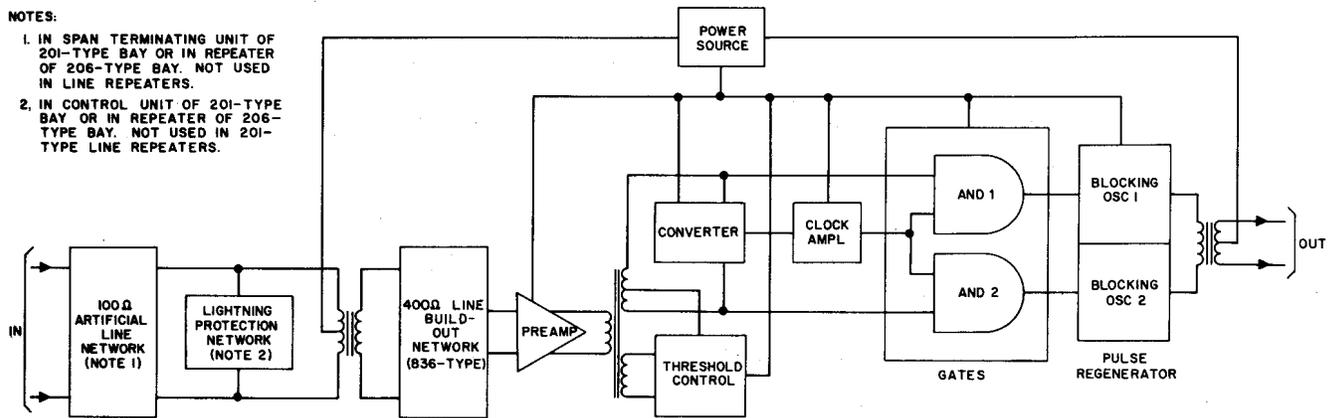


Fig. 39—Basic Nonintegrated Circuit Repeater Diagram, One Side

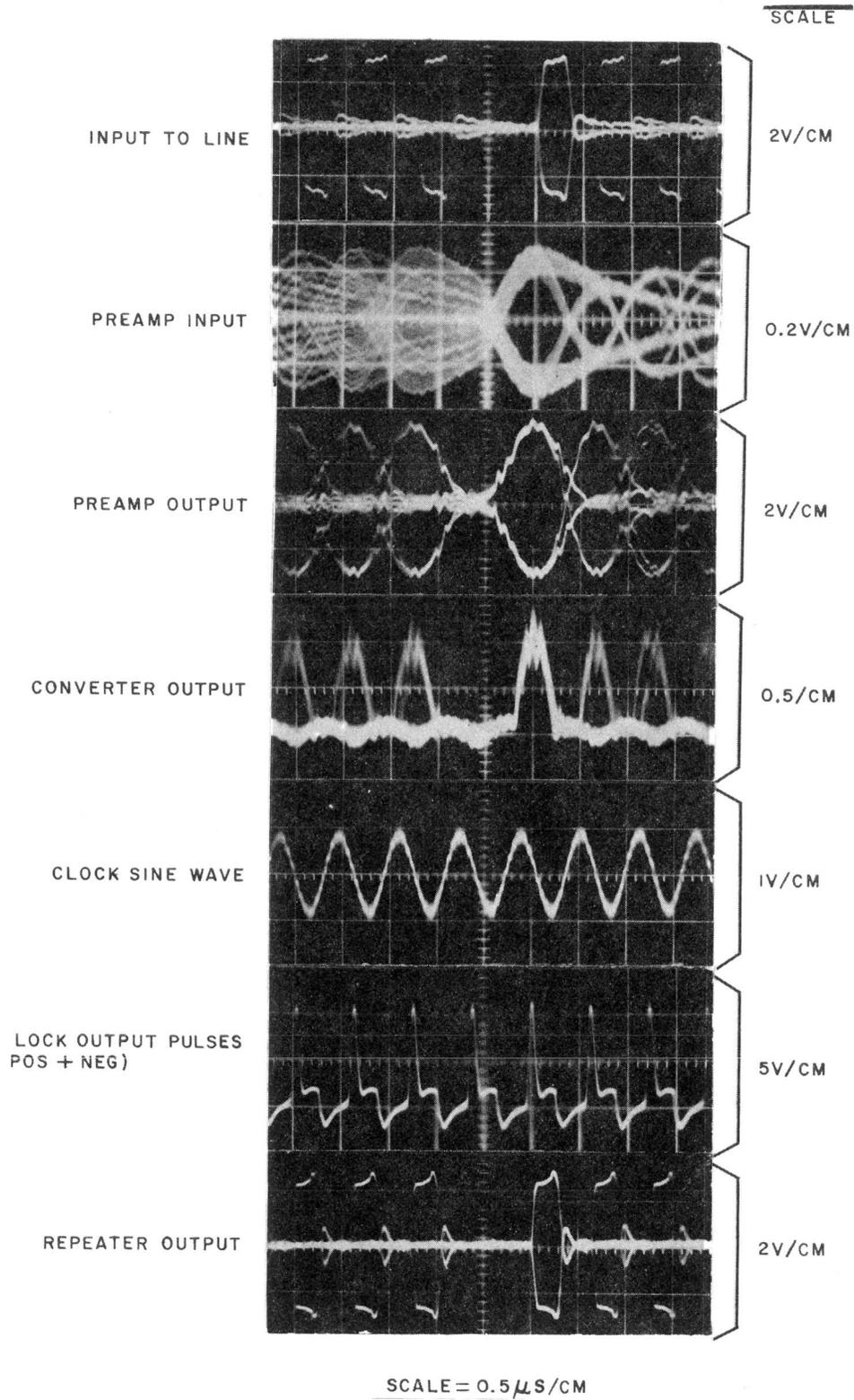
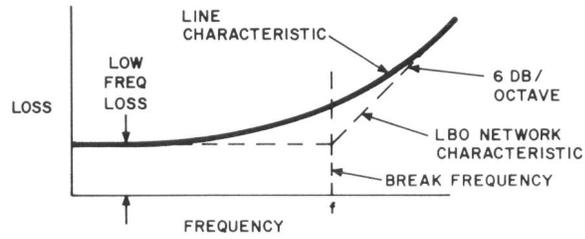
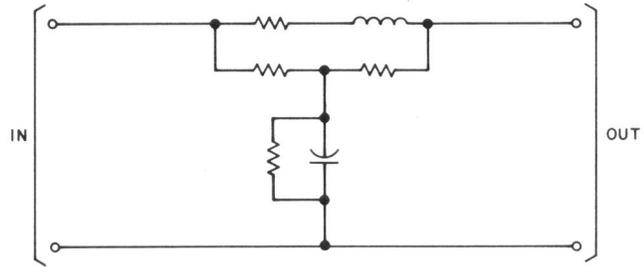


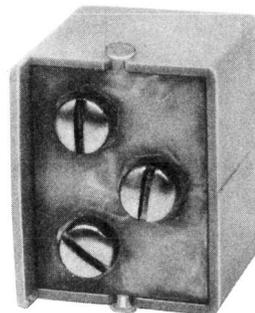
Fig. 40—Repeater Waveforms



**Fig. 41—Basic 836-Type LBO Network, Circuit and Loss Characteristics**



TOP VIEW



BOTTOM VIEW

**Fig. 42—836-Type LBO Network**

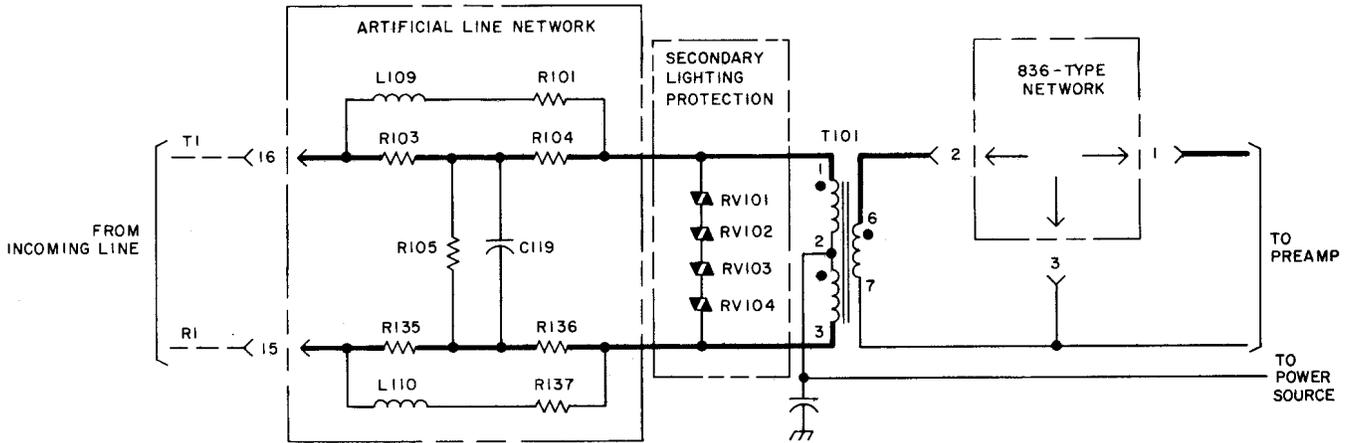


Fig. 43—100-Ohm Artificial Line Network for the Nonintegrated Circuit 206-Type Repeater

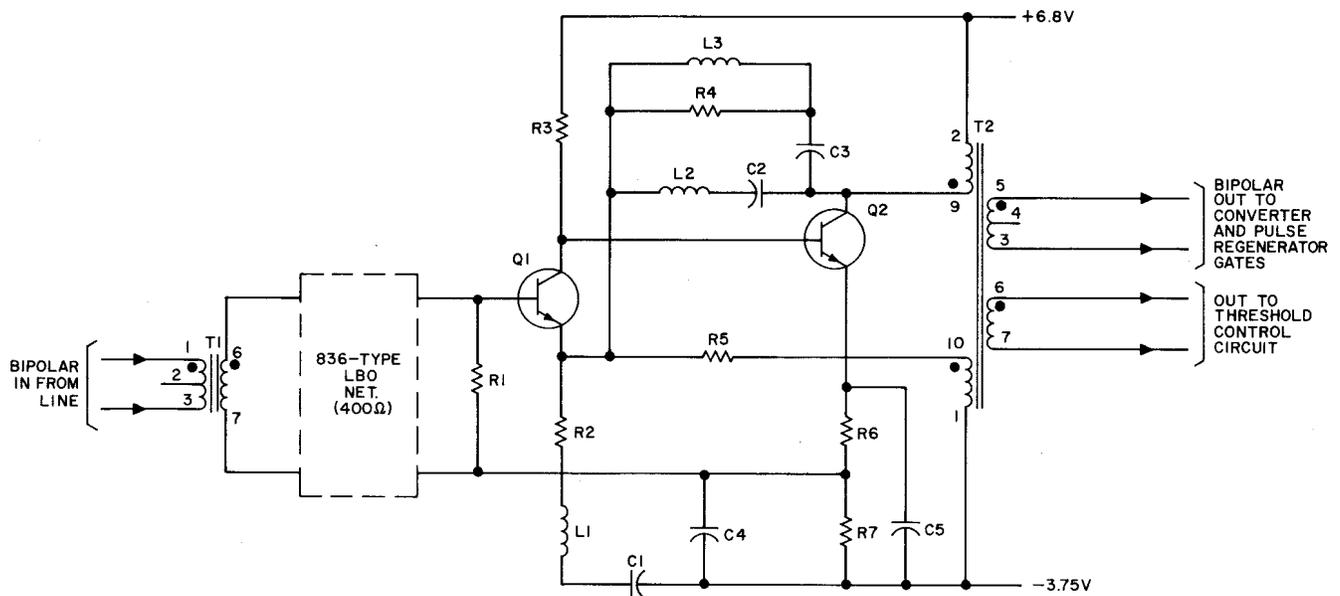


Fig. 44—Preamplifier Circuit Used in Nonintegrated Circuit Repeaters

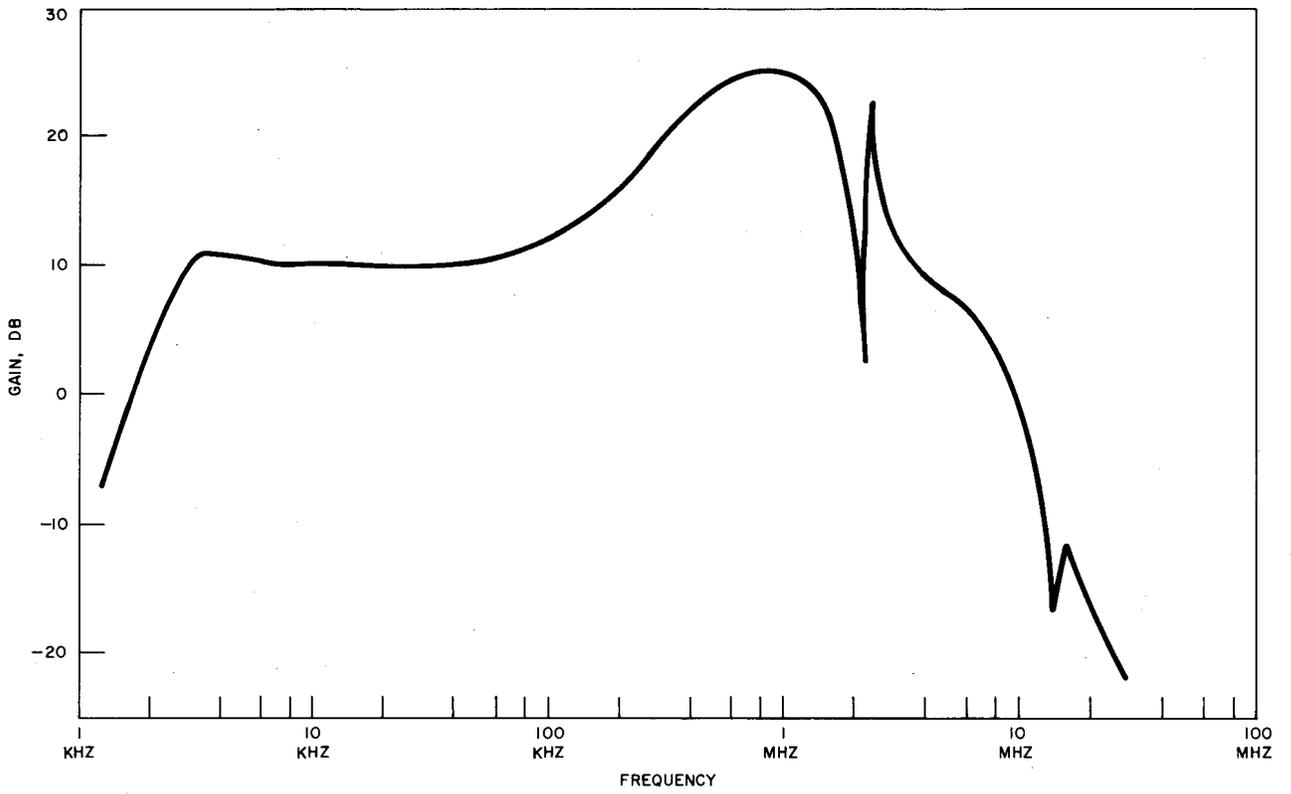
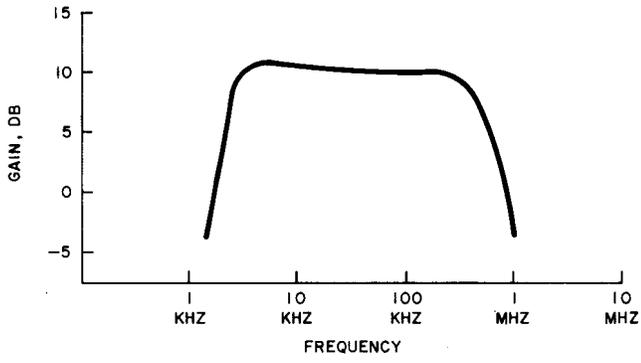
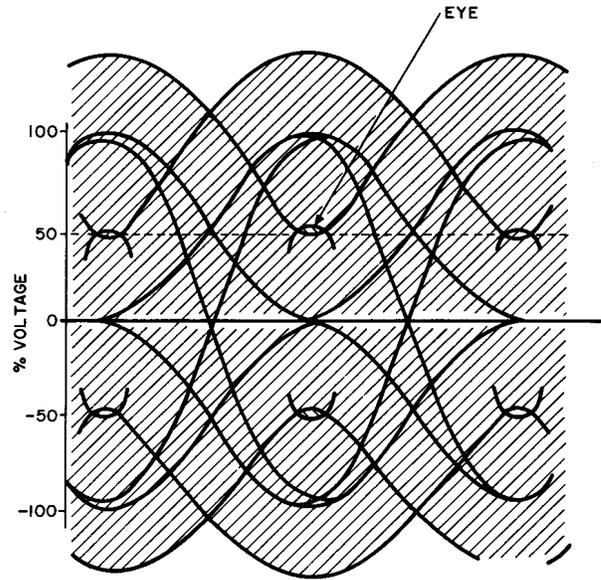


Fig. 45—Typical Preamplifier Response

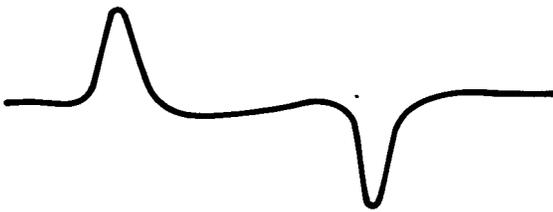
**SECTION 365-200-101**



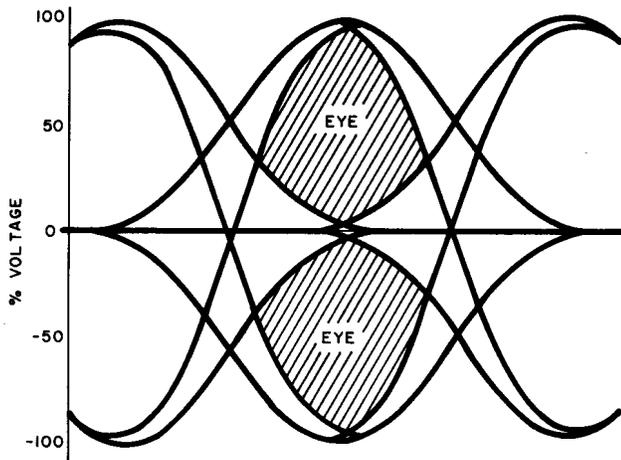
**Fig. 46—Typical Response of Preamplifier Plus 6000-Foot Cable Section**



**Fig. 49—Eye Diagram Obtained When Interference Is Severe**



**Fig. 47—Preamplifier Output Signal for a Repetitive Input of a One Followed by Seven Zeros**



**Fig. 48—Eye Diagram**

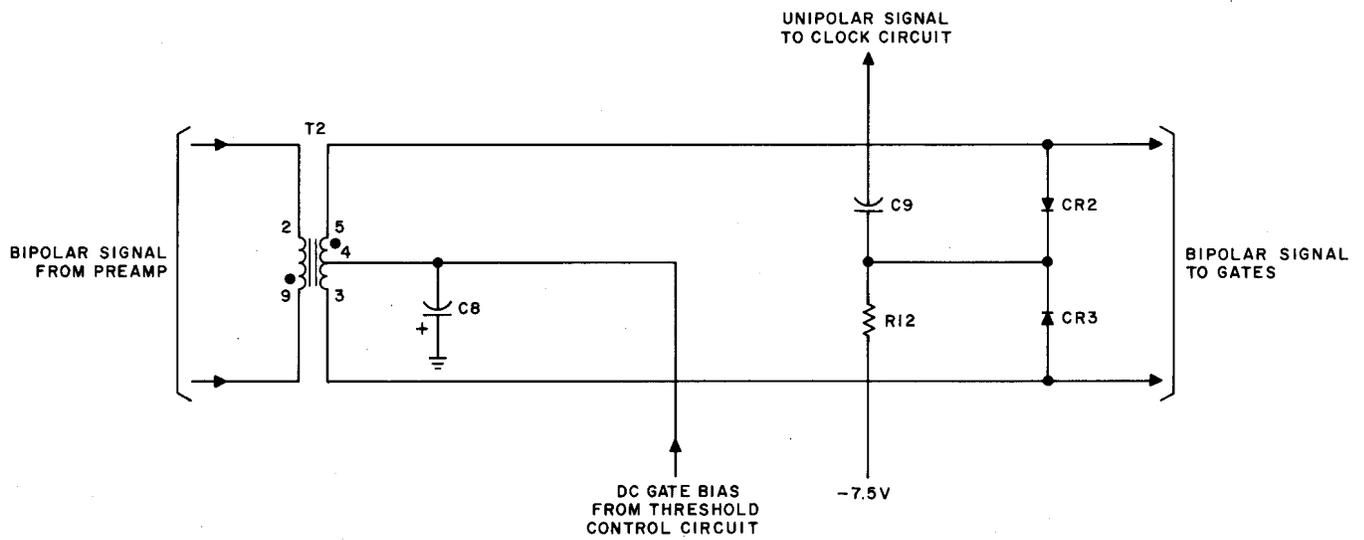


Fig. 50—Converter Circuit Used in Nonintegrated Circuit Repeaters

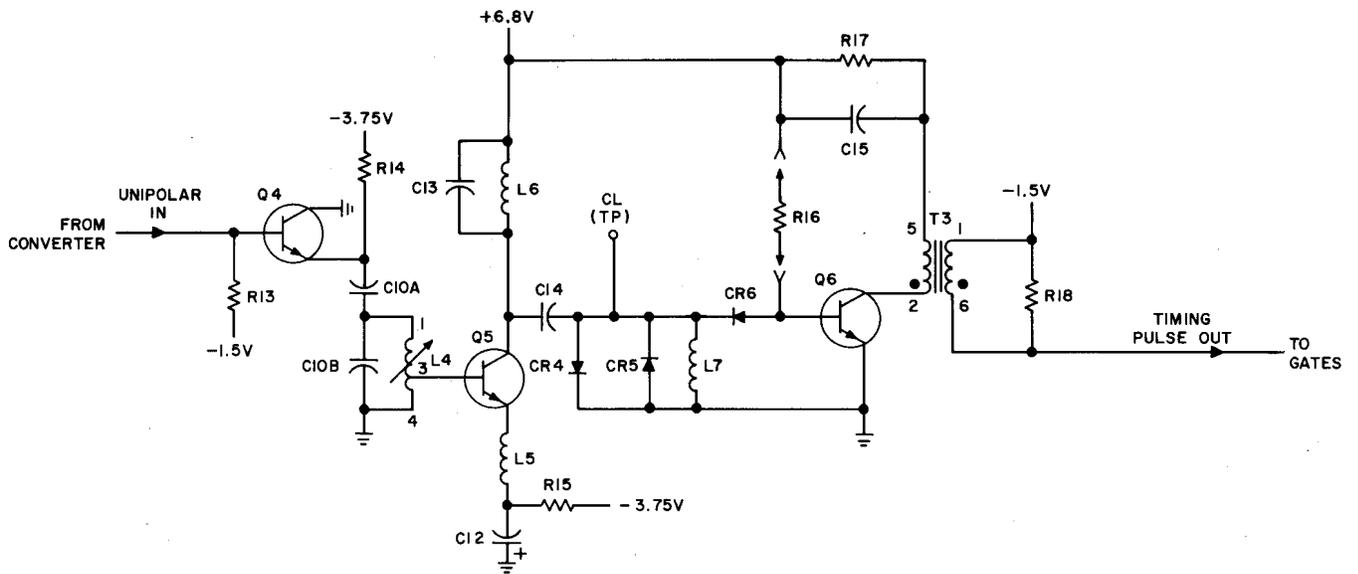


Fig. 51—Clock Circuit Used in Nonintegrated Circuit Repeaters

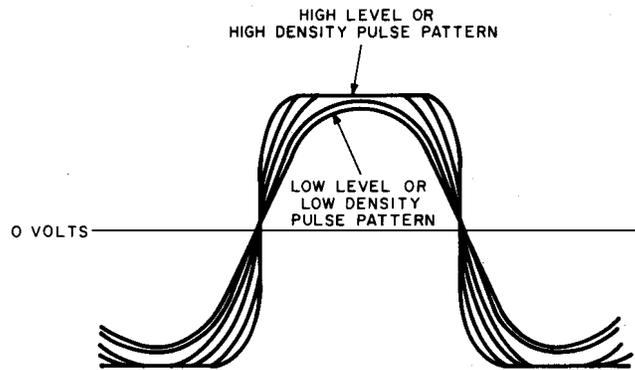


Fig. 52—Clock Signal at Test Point CL

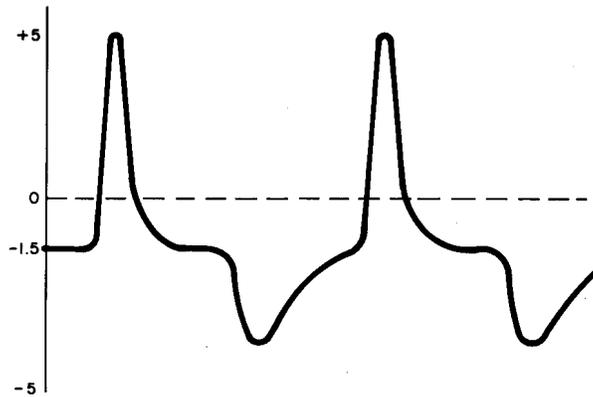


Fig. 53—Clock Output Pulses (Timing Pulses)

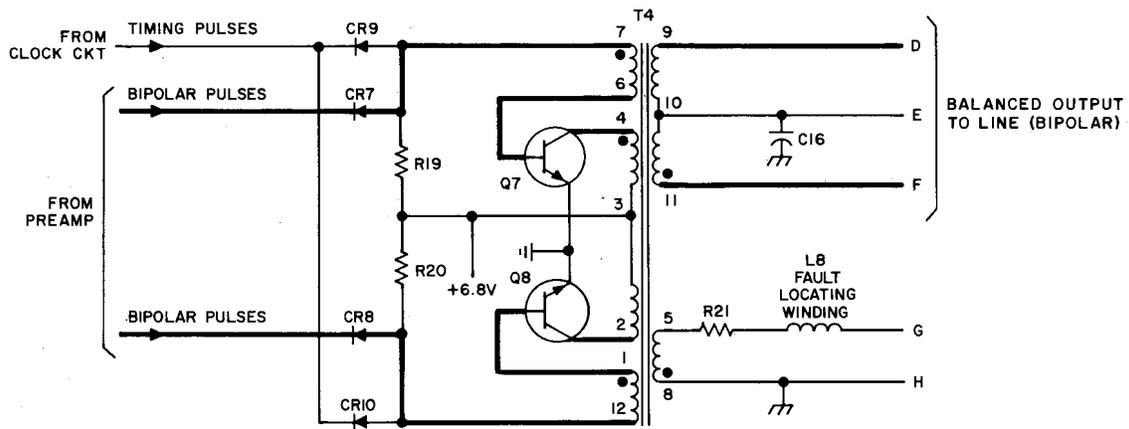


Fig. 54—Pulse Regenerator Used in Nonintegrated Circuit Repeaters

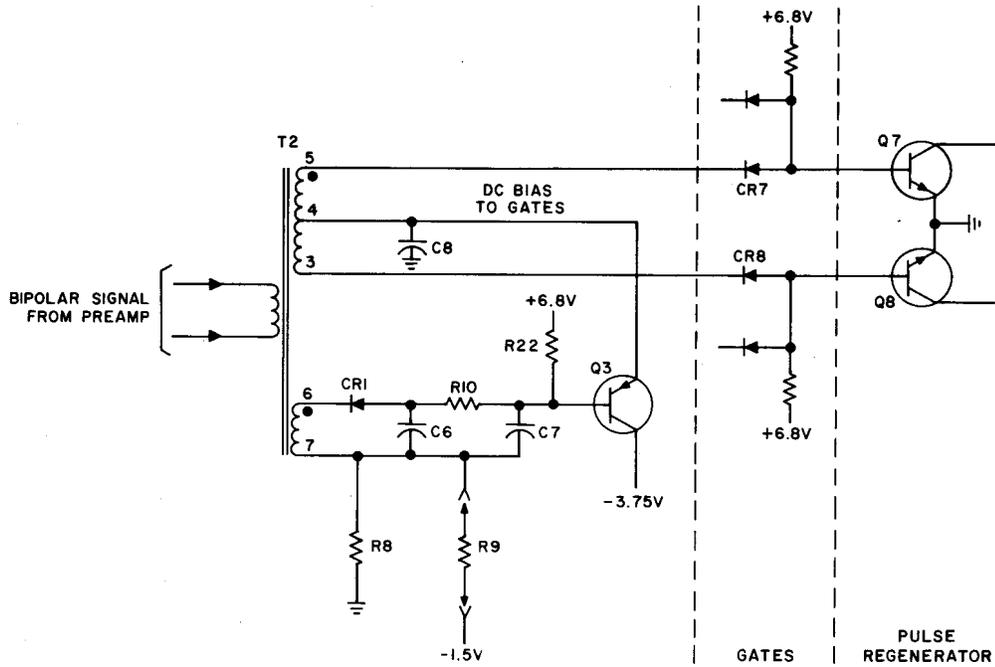


Fig. 55— Automatic Threshold Control Circuit Used in Nonintegrated Circuit Repeaters

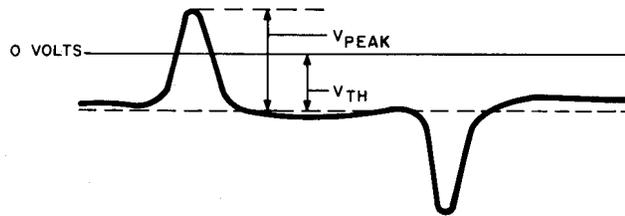


Fig. 56—Preamplifier Output Signal Showing Gate Bias Conditions Developed by Threshold Control Circuit

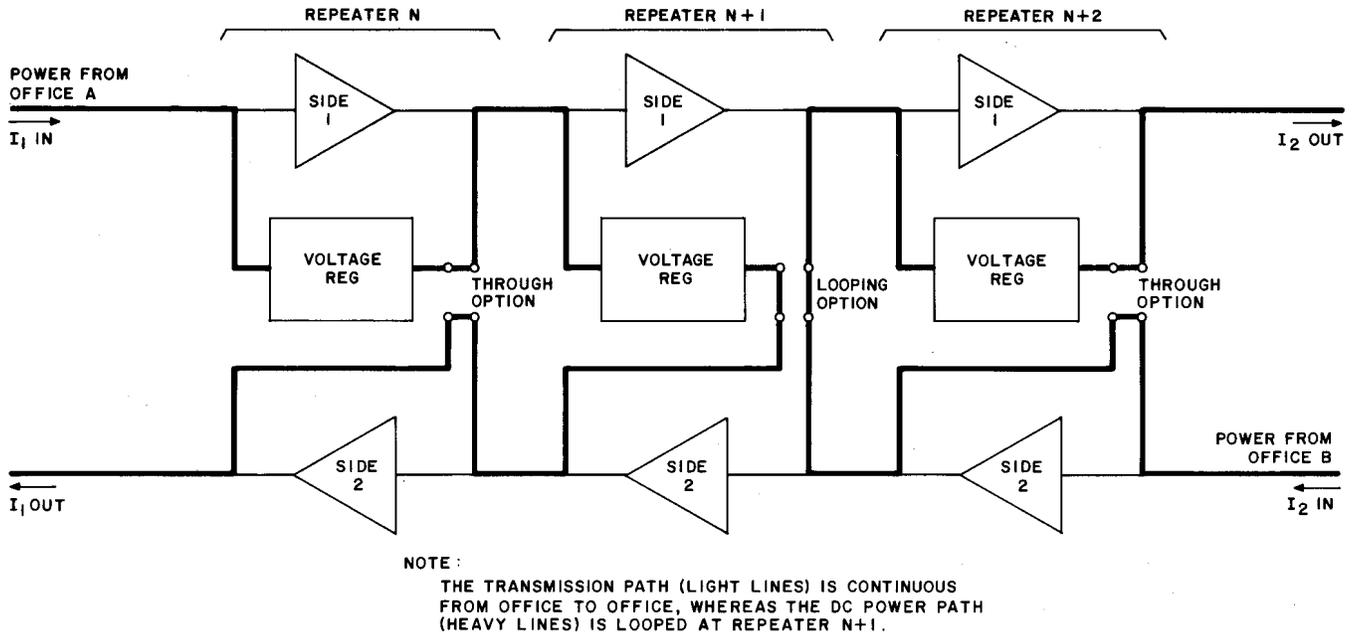


Fig. 57—Typical Section of Powered Digital Line

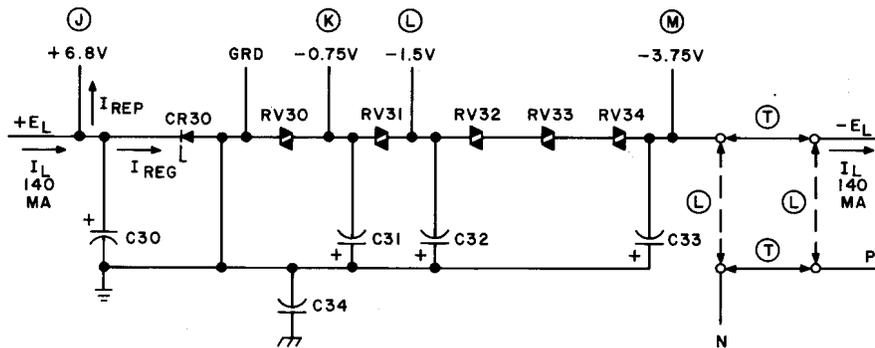


Fig. 58—Voltage Regulator Circuit Used in Nonintegrated 201- and 205-Type Repeaters

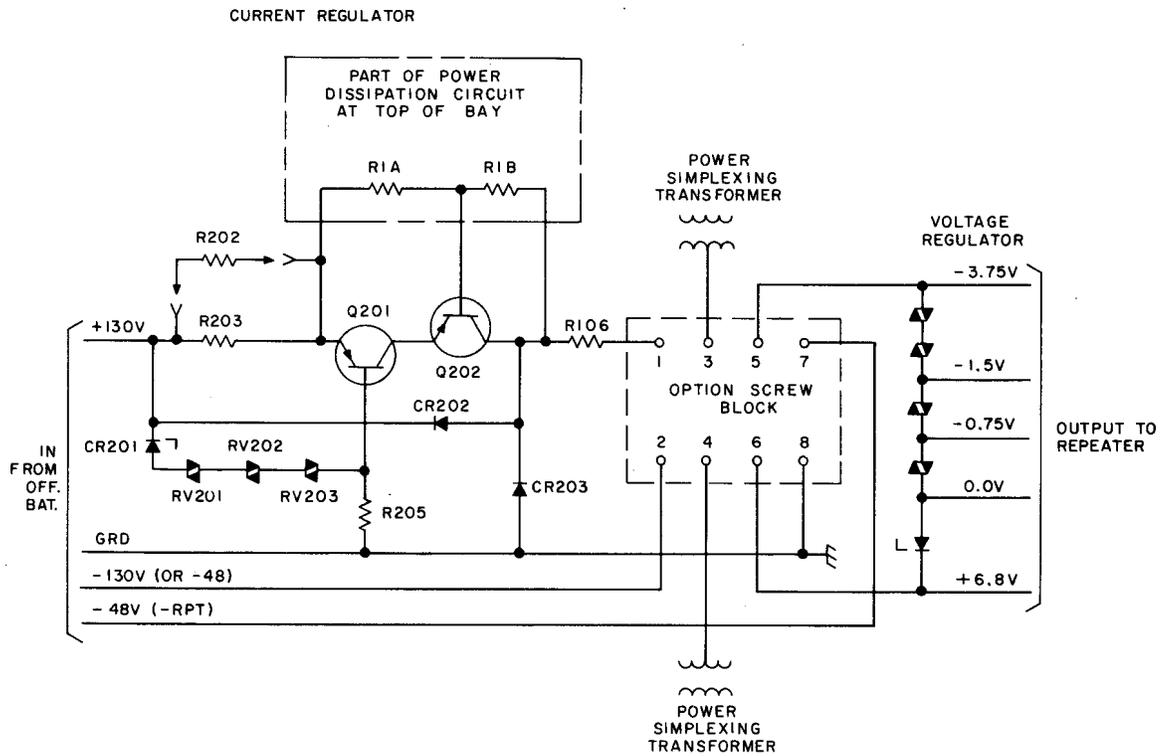
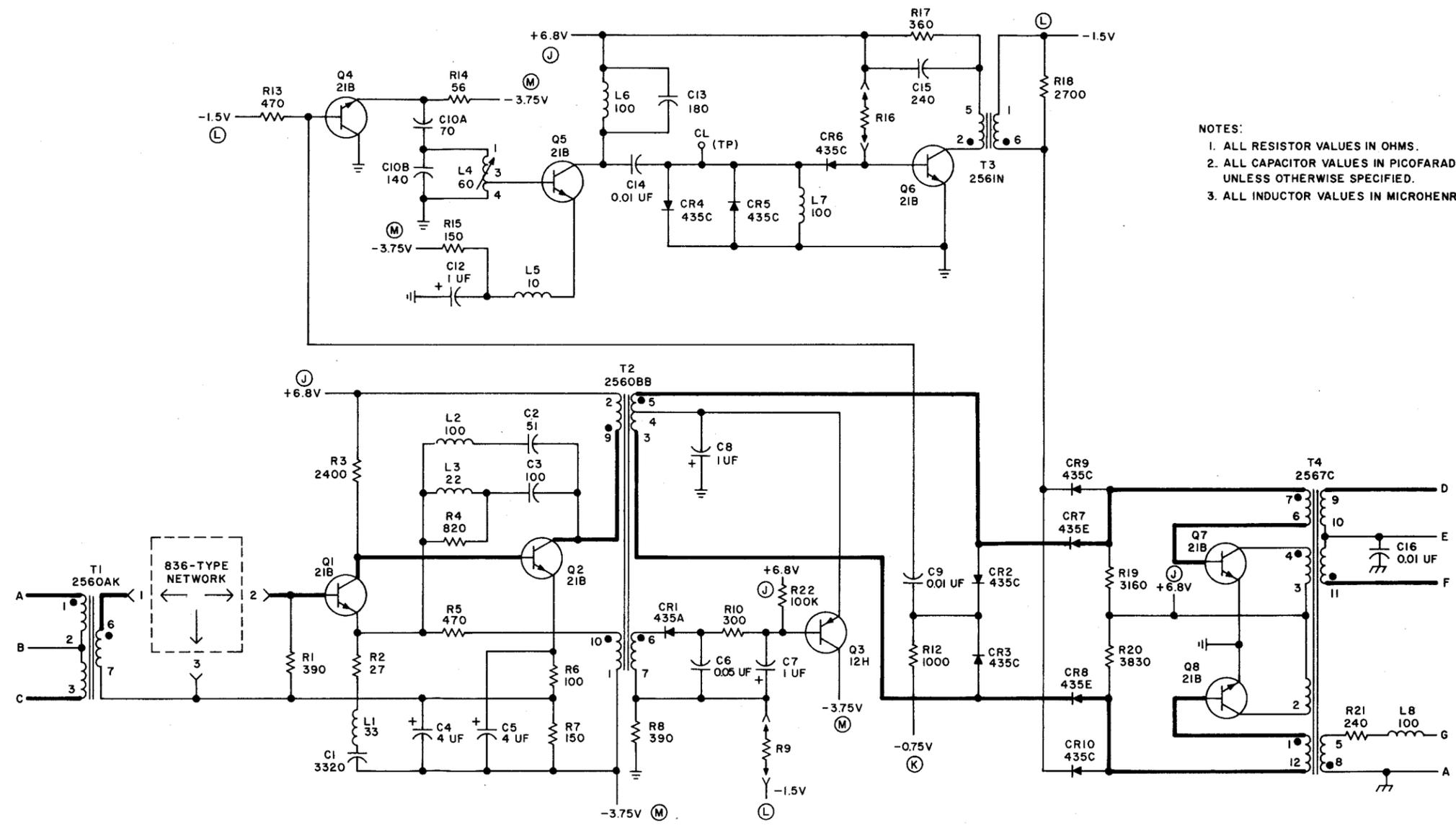


Fig. 59—Automatic Line Current Regulator, +130 Volt Type for Nonintegrated Circuit 206-Type Repeater



- NOTES:
1. ALL RESISTOR VALUES IN OHMS.
  2. ALL CAPACITOR VALUES IN PICOFARADS UNLESS OTHERWISE SPECIFIED.
  3. ALL INDUCTOR VALUES IN MICROHENRIES.

Fig. 60—Nonintegrated Circuit 201-Type Repeater, One Side

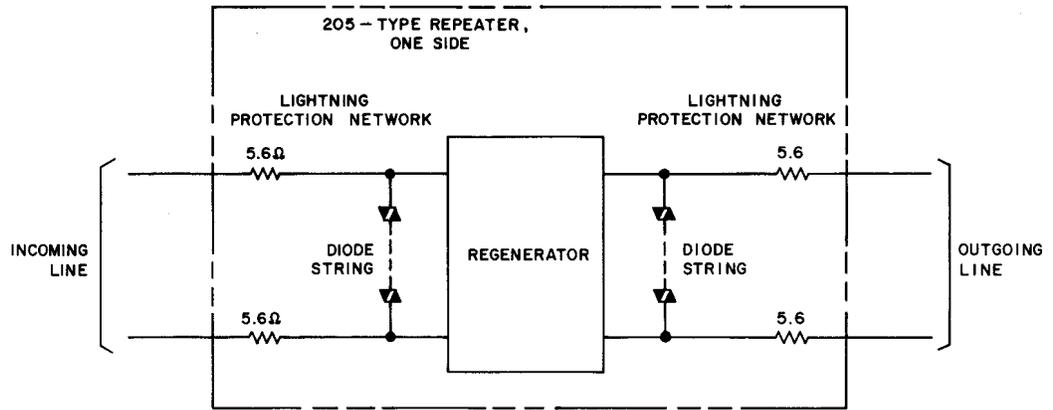


Fig. 61—Lightning Protection Network Used in 205-Type Repeater