METALLIC TELEGRAPH SYSTEM
FOUR-WIRE OPERATION

CONTENTS

TABLE OF ILLUSTRATIONS

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1. GENERAL

1.01 This section describes the metallic telegraph system arranged for 4-wire operation on small gauge cable circuits.

1.02 The section has been reissued to include the 20B3, 20C1 and 20C2 terminal repeaters and to take account of the present standard arrangements whereby equalizers are associated with the line rather than as previously with the repeaters.

1.03 The description and operating principles of the metallic telegraph system arranged for 2-wire operation are covered in other sections of Bell System Practices. As a number of the arrangements are the same for 2-wire and 4-wire operation, the common features have not been repeated here. The changes in the 2-wire arrangements necessary for 4-wire operation, however, are covered herein. The information given heretofore covering the arrangement of certain of the 2-wire repeaters for 4-wire operation is superseded by this section.

2. GENERAL DESCRIPTION

Fundamental Features

2.01 In 4-wire telegraph operation different paths are employed for transmission in the two directions, thus avoiding the necessity for networks or artificial lines to balance the line circuits. As indicated in Fig. 1, which is an example of a 4-wire metallic telegraph circuit between two terminal type repeaters, the sending and receiving paths are separated from each other as regards transmission over the line. The local circuit arrangements of the repeaters are the same as for 2-wire operation.

Comparison of 4-Wire with 2-Wire Operation

2.02 Telegraph transmission with 4-wire arrangements will, in general, be better than that obtained with 2-wire operation because of the improvement in stability produced by eliminating the duplex balance requirement and the effect of earth potentials. The advantage obtained by the use of wave shaping networks or equalizers at the receiving end of the line, in general, improves transmission over all lengths of section and therefore permits operation over sections of increased length including sections containing as many as two intermediate points.

2.03 The use of different paths for transmission in the two directions in 4-wire operation results in the need for twice as many cable conductors with associated compositing equipment. The susceptibility to certain types of line trouble will be increased with the use of double the number of cable conductors, however, other types of line trouble which cause interruptions to 2-wire operation by disturbing the duplex balance should not interfere in the case of 4-wire operation. More care will of course be required in patching the 4-wire circuit as it will be necessary to distinguish between the sending and receiving pairs.

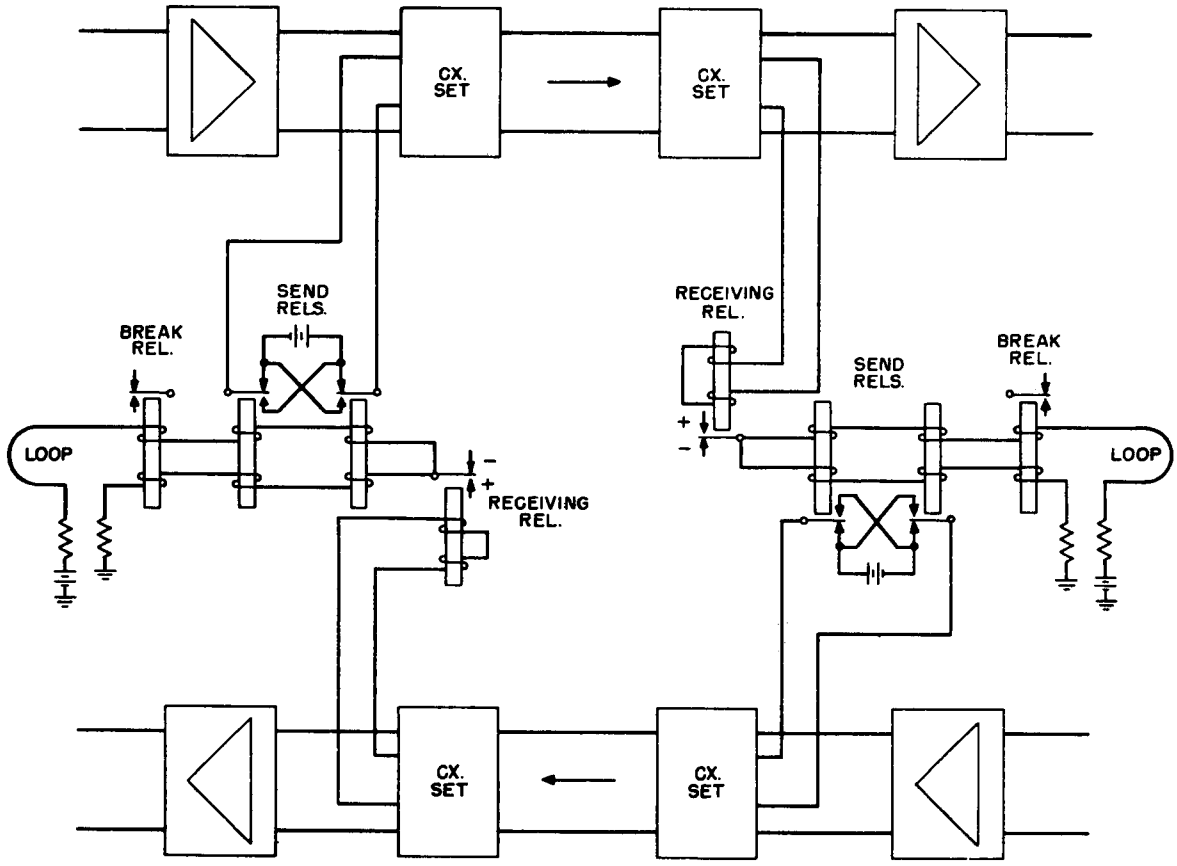


Fig. 1 - 4-wire Metallic Telegraph Circuit - Half Duplex

Reaction on Telephone Service

2.04 Four-wire metallic telegraph may be superposed on moderate length (500-1000 miles) 4-wire telephone circuits with but little unfavorable reaction on the telephone. Very long 4-wire telephone circuits are not composited throughout their entire length because of low-frequency delay distortion introduced by the composite sets.

2.05 The compositing arrangements, when the proper noise killers are used in the telegraph sets, are arranged to permit the connection of the sending sides of the telegraph repeater at either the inputs or the outputs of 4-wire telephone repeaters as indicated in Fig. 2. It is preferable, however, to connect the sending sides at the outputs. With telephone sections in excess of about 55 miles of 19-gauge cable a noticeable and perhaps slightly objectionable amount of thump may be produced when the sending side is connected at the input of the telephone repeater; therefore, where conditions permit, this arrangement should be avoided.

2.06 In Fig. 2, for example, the east metallic telegraph repeater is sending into the output phantom composite equipment (OPCE) which is the desirable connection. However, the west telegraph repeater is shown sending into the input phantom composite equipment (IPCE) which may cause thump at the west telephone terminal. To avoid this, use another 4-wire circuit (if available) and connect the west telegraph repeater to the OPCE for sending toward the east. With an odd number of repeating points (as in Fig. 2) it will always be necessary to use spare circuits to avoid sending into the IPCE. In case there are no intermediate telephone repeaters, or an even number of them, the telegraph repeaters can always be connected so as to send into the OPCE.

2.07 At intermediate telephone repeater points on 4-wire telephone circuits the telegraph circuit is interconnected between the E-W and W-E lines as indicated in Fig. 2. The purpose of this is to avoid the necessity for a direct bypass around the telephone amplifier and the consequent difficulty to avoid singing.

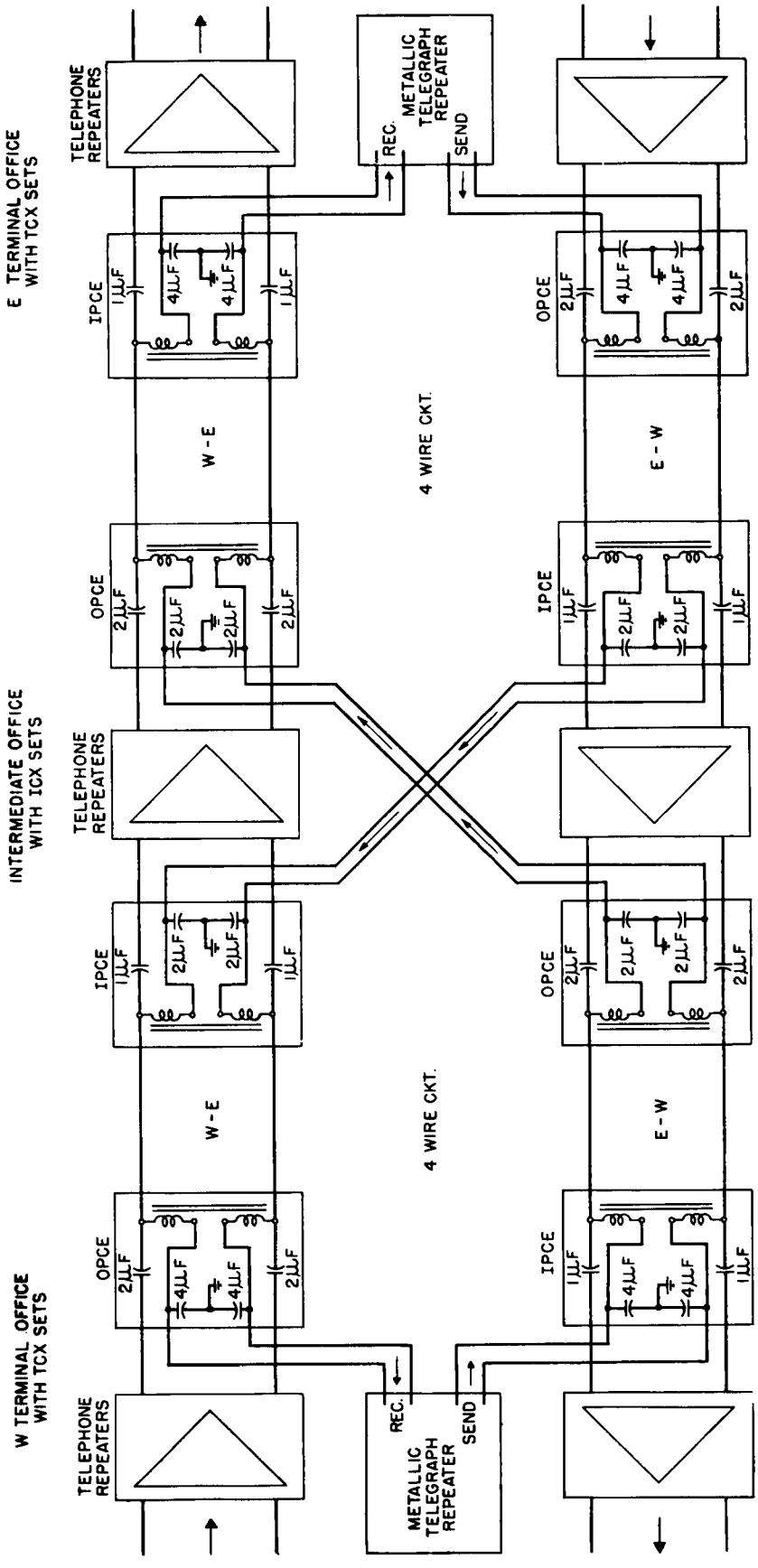


Fig. 2 - Connections for Metallic Telegraph on a 4-wire Telephone Circuit

2.08 It is expected that there will be no interference to 135-cycle signaling on 4-wire telephone circuits equipped with 44-A-1 repeaters. With Reading type 4-wire repeaters, under some conditions there may be sufficient telegraph interference to cause the armatures of the signaling relays to move slightly so as to produce noise in the telephone circuit. It is desirable therefore to avoid whenever possible the use of facilities equipped with Reading type repeaters employing 135-cycle signaling. For cases where this type of facility must be used, repeating coils are available, the use of which will minimize this interference.

2.09 The use of 4-wire telegraph on 2-wire telephone circuits will, in general, permit the same 135-cycle signaling ranges as are obtained when 2-wire telegraph is employed. However, there may be some reduction in the 135-cycle signaling range on B-88 and H-88 2-wire side circuits, employing 93-type repeating coils. As discussed in other sections of Bell System Practices this reduction in signaling range may be compensated for by increasing the lower signaling current limit.

2.10 No regulating resistance is provided to limit the line current and, therefore, the line current depends upon the length of section. However, potentiometers are provided in the newer types of repeaters and may be installed in the older types which may be employed to reduce the voltage applied to the line when short telegraph sections (under 55 miles of 19-gauge cable) are used. A potentiometer is not ordinarily used when a line is equalized.

3. FOUR-WIRE CIRCUIT ARRANGEMENTS

General

3.01 All of the several types of terminal and through metallic telegraph repeaters are arranged or may be modified for 4-wire operation. The terminal repeaters are coded 20A1, 20B1, 20B2, 20B3, 20C1 and 20C2 and the through repeaters are coded 20AX1, 20BX1, 20BX2, and 20BX3. The principles employed in the 4-wire arrangement of these repeaters are the same for all types of repeaters.

3.02 In modifying the 2-wire repeaters for 4-wire operation there are a number of changes which are common to all types. These are given in the first group listed below. In addition other modifications are required in certain of the repeaters and are listed in the second group. The details regarding these changes are covered in Part 4, 4-Wire Modifications for Specific Types of Repeaters.

3.03 Required modifications common to all types of repeaters are as follows:

(1) If the repeater is to be used to send at the inputs of telephone repeaters the B-2 wiring of the sending end noise killer is used, otherwise the B-1 wiring is used. (See Fig. 3.)

(2) A receiving end noise killer is added.

(3) The 135-cycle resonant shunt is rearranged.

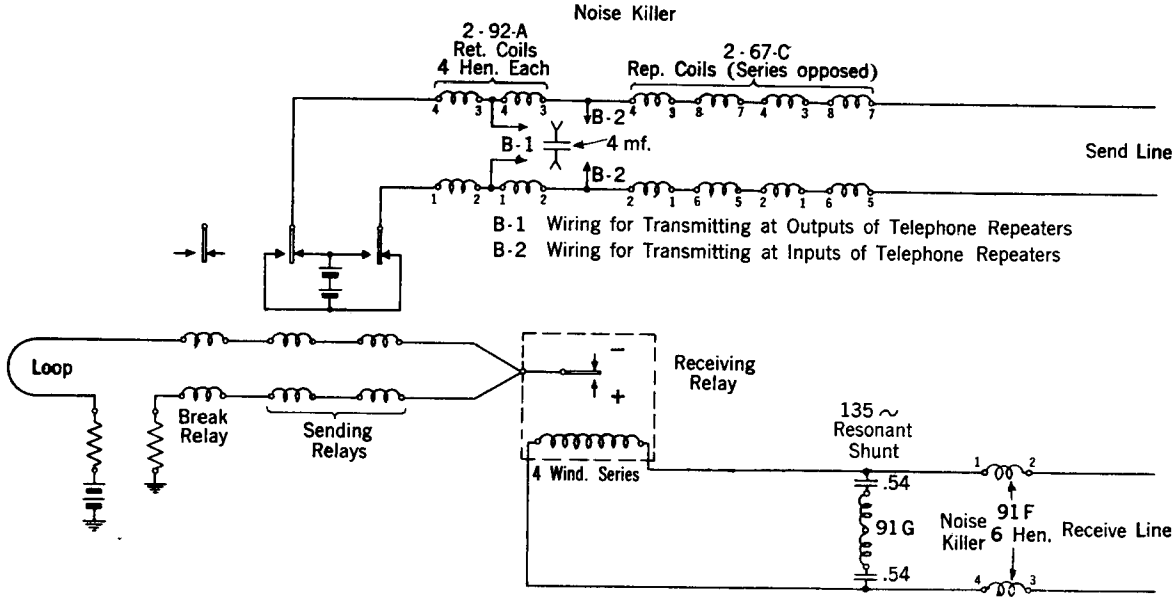


Fig. 3 - Arrangement of Noise Killers and Resonant Shunt (20B1 and 20B2 Repeaters)

(4) The transmitter branch connection to the receiving relay is removed and a second line pair is connected to the transmitter branch. This will be the transmitting pair.

(5) The artificial line is disconnected and all the line windings of the receiving relay are connected series aiding.

(6) The repeaters are arranged so that the receiving and sending line currents may be read. When measuring the sending current the meter is connected directly in the sending line and therefore follows the outgoing signals. As it is connected in only one side of the line, longitudinal currents may cause small variations in the reading. These should cause no difficulty however: the average value of current should be taken as the correct reading.

3.04 Modifications which, in addition to the above, are applied to certain types of repeaters are as follows:

(1) The vibrating circuits of all but the latest types of repeaters are modified for 4-wire operation.

(2) It may be desirable, in order to reduce the metallic line battery voltage when short sections are involved, to install in the older types of repeaters a potentiometer which has been designed for this purpose, if the short section is not equalized.

(3) In some cases the monitoring arrangements are modified for 4-wire operation.

Noise Killers

3.05 The arrangement of the noise killers of the repeaters for 4-wire operation is indicated on Fig. 3 using the circuit of the 20B1 and 20B2 repeaters as an example.

3.06 With 4-wire operation the absence of the shunting effect of the artificial line circuit results in a greater amount of sending-end thump as compared with 2-wire operation. This would be objectionable when sending at the inputs of telephone repeaters if the sending noise killer were not modified. As shown in Fig. 3, the shunt condensers of the noise killer are connected between the 92A retardation coils when sending at the outputs of telephone repeaters and on the line side of the 92A retardation coils when sending at the inputs of telephone repeaters. In the latter case the attenuation of the higher telegraph frequencies is increased thus reducing the amount of sending-end thump. This also tends to decrease the amplitude of the telegraph signals and make them more susceptible to interference and bias.

3.07 Two 67C repeating coils are connected between the 92A coils and the sending line for both 2-wire and 4-wire operation. It will be noted that these have their windings connected in opposition so that they have little effect on the metallic telegraph currents. They do, however, offer an impedance to longitudinal currents thus reducing the thump experienced on the phantom circuit.

3.08 To prevent excessive receiving-end thump, an inductance of 6 henries, obtained by the use of a 91F retardation coil, is connected in series with the receiving line. This inductance reduces the amount of the noise heard in the telephone circuit due to the action of the vibrating circuit and movement of the armature of the receiving relay. In general, its effect on telegraph transmission is small.

Resonant Shunts

3.09 A resonant shunt tuned to 135 cycles is connected across the windings of the receiving relay to prevent the 135-cycle current used for signaling on the telephone circuit from flowing through the receiving relay. The connection of this 135-cycle resonant shunt to the receiving relay is indicated in Fig. 3. The two condensers and the two halves of the retardation coil which make up this resonant shunt are all connected in series across the receiving relay windings. The shunt is optional equipment for the 20C1 and 20C2 repeaters and is used only when they are operated with lines employing 135-cycle signaling.

Equalizers

3.10 Equalizers may be provided at the receiving end of metallic telegraph circuits to improve the wave shape of the incoming signals. Formerly these equalizers were a part of the telegraph repeaters but for reasons of flexibility they are now associated with the telegraph lines. They are described in Section E45.261.

Vibrating Circuits

3.11 To provide for the best transmission results the vibrating circuit employed in 4-wire operation must, in general, be different from that employed in 2-wire operation. Figs. 4, 5 and 6 show the vibrating circuits used in 4-wire operation with the exception of that used with the 20C1 repeater. The vibrating circuit for this repeater is shown in Fig. 7. The vibrating

circuit for the 20C2 repeater is the same as shown in Fig. 7 when connected for inverse neutral operation and the same as shown in Fig.4 when connected for balanced loop operation. Fig. 4 shows the design of the vibrating circuit for the 20A1, 20B1, 20B2 and 20B3 terminal type repeaters. In Fig. 5 and Fig. 6 the vibrating circuit arrangements for the through type repeaters are shown, the arrangement for the 20AX1 through repeater being indicated in Fig. 5 and the arrangement for the 20BX1, 20BX2, and 20BX3 through repeaters being shown in Fig. 6.

3.12 The vibrating circuit designs are such that no change in the constants is necessary to accommodate the permissible range of length of section.

Monitoring Arrangements

3.13 The monitoring features provided for 4-wire operation are, in general, the same as those provided for 2-wire operation. However, changes in the connection of the monitoring sets are necessary as will be described later in the detailed description of the several types of repeaters.

Connections to Service Board

3.14 Fig. 8 indicates the connections of a metallic telegraph terminal repeater to the service board. The following steps must be taken when the repeater is to be so connected.

(1) Operate the DUPLEX key to FULL.

(2) Operate GND BAT key to REV so that positive battery will be connected to the marking contact of the receiving relay.

(3) See that 250 ohms is added in series with the receiving leg and that no other resistance or rheostat is left connected in.

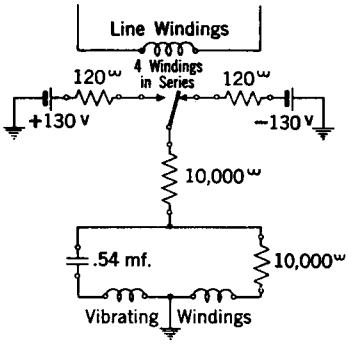


Fig. 4 - Vibrating Circuit for 20A1, 20B1, and 20B2, Terminal Type Repeaters

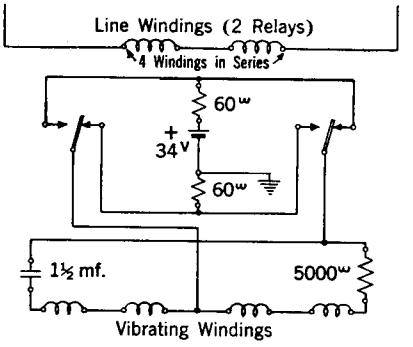


Fig. 5 - Vibrating Circuit for 20AX1 Through Type Repeater

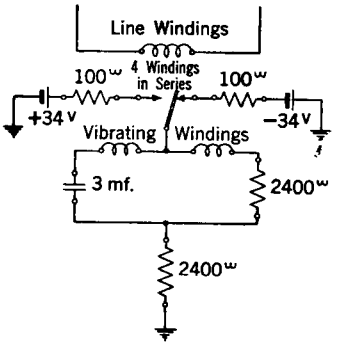


Fig. 6 - Vibrating Circuit for 20BX1, 20BX2 and 20BX3 Through Type Repeaters

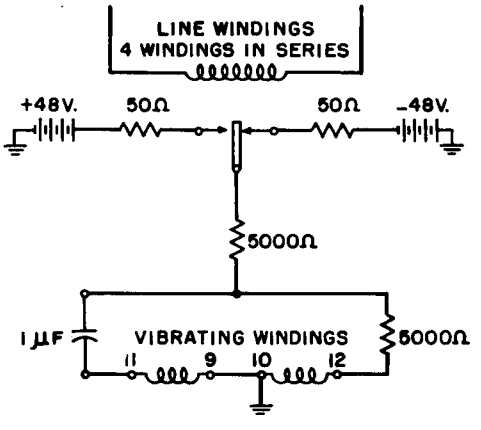


Fig. 7 - Vibrating Winding of 20C1 Repeater Connected for Inverse Neutral Operation

(4) Remove the wire normally connecting the apex of the loop circuit to battery.

(5) Remove the loop balancing resistance and connect to circuit directly to ground.

(6) Remove the break relay windings which are normally in series with the send relay.

4. FOUR-WIRE MODIFICATIONS FOR SPECIFIC TYPES OF REPEATERS

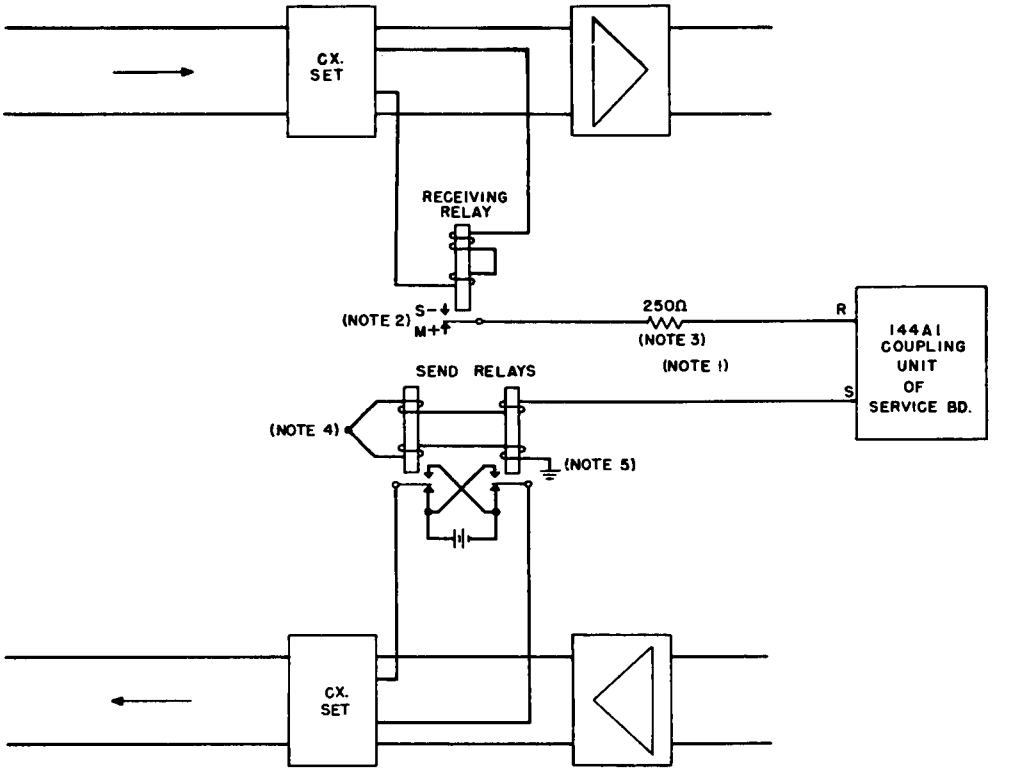
General

4.01 The extent of the changes required in order to convert a repeater for 4-wire operation depends on whether or not it was originally arranged for either 2- or 4-wire operation. The 20A1, 20AX1 and 20BX1 repeaters, which were not originally intended for 4-wire operation, require the greatest amount of modification. The repeaters built initially for either 2-wire or 4-wire operation require certain changes which will provide more satisfactory 4-wire operation than can be obtained with the initial arrangements. After modification for 4-wire operation, the actual operating features are about the same for all types of repeaters.

20A1 (102B) Terminal Type and 20AX1 (101B) Through Type Floor-Mounted Repeaters

4.02 In addition to the common changes, listed under 3.03, the changes specific to these types of repeaters are as follows:

(1) The double winding line meter is reconnected so that one winding is in the sending line and the other is in the receiving line, a short-circuiting key is mounted in place of one of the C keys of the artificial line unit which permits the use of either winding. Two meters and two short-circuiting keys are employed on the 20AX1 repeater.



NOTES:
1. ARRANGE REPEATER FOR FULL DUPLEX.
2. RECEIVING RELAY MARK CONTACT TO POSITIVE BATTERY.
3. ADD 250Ω TO R LEG CKT.
4. REMOVE APEX BATTERY.
5. SUBSTITUTE GROUND FOR BALANCING RESISTANCE.

Fig. 8 - Connections of Metallic Telegraph Terminal Repeater to Service Board

(2) As a part of the vibrating circuit changes the line sounders are removed from the vibrating circuit, thereby improving the operation of the vibrating circuit and also of the sounder. In the case of the 20A1 repeaters of the earliest models, the Ward Leonard resistance units of the vibrating circuit are replaced by more suitable units. This is done in order to make possible the use of common circuit drawings, to overcome difficulty in determining the amount of resistance and to avoid the possible use of an incorrect value of resistance.

(3) In the case of the 20A1 repeater, a bias corrector is available consisting of a 2000-ohm resistance and a 4 mf. condenser in parallel which may be connected in series with the loop circuit. This may be of use for certain short loops containing a considerable amount of inductance, but will not be required for long loops since these are corrected by the use of standard wave-shaping equipment as specified in other instructions.

(4) It may be desirable to add a potentiometer for reducing the metallic line battery voltage when short sections are involved, if the short section is not equalized.

4.03 All of the general features such as cutting, sending in one direction at a time, receiving signals on the meters and sounders, and the general operation of the local circuits are identical to those of the repeaters when arranged for 2-wire operation. When the retardation coil of the equalizer is used the line meter on the receiving line will read somewhat less than the full line current because some of the current will be shunted through the coil. The reading will depend on the value of the resistance connected in series with the coil.

4.04 For both the terminal and through type repeaters, direct repetition is retained. The through type repeater will continue to operate on a double commutation basis.

4.05 The use of such features as the bias corrector and the potentiometer are optional depending upon circuit layout conditions.

4.06 The circuit features of the 20A1 terminal repeater are shown in Fig. 26. Fig. 23 covers the 20AX1 through repeater.

4.07 The simplified circuits for the 20A1 repeater under various operating conditions are shown in Figs. 9, 10 and 11.

4.08 Simplified circuits of the 20AX1 repeaters are shown on Fig. 12.

20BX1 (103A, 104A, 105A Panels) Through Telegraph Repeaters

4.09 These repeaters when arranged for 4-wire operation are essentially the same as the 20AX1 repeaters except they employ single commutation. Also they are arranged for common monitoring and when sending from the monitoring set the two sides of the repeaters are separated, thus blocking through transmission.

4.10 In addition to the general changes common to all types of repeaters, listed in 3.03 the wiring of the line circuits to the monitoring jacks has been rearranged, these two jacks being connected one in each line. The monitoring panel has been modified to correspond to the changes of the repeater. All of the windings of the 92A retardation coils of the transmitting branch in the monitoring set are connected in series with the battery side of the line, and the condenser is bridged to ground between the two retardation coils. This will then leave a slight unbalance in the impedance of the transmitting branch with respect to ground but this is not of consequence.

4.11 The connection of the monitoring set to the repeater is somewhat different in the case of 4-wire operation than it is in the case of 2-wire operation. For sending on a repeater from a monitoring set, the B jacks of the east and west sides of the repeaters should be connected to the monitoring set by means of two 3-conductor cords leaving the A jacks unused. This will permit sending from the repeater, reading line current in the sending line at approximately one-half scale and receiving the line signals on the sounders. To read receiving line current, the cords to the B jacks should be removed and connected between the A jack of both the monitoring set and the repeater. This will then permit transmission of signals through the repeater but signals cannot be sent nor can signals be observed on the sounders.

Caution: Connect the cords first to the monitoring set and then to the repeater and remove in the reverse order so that the line circuit will not be opened during this operation. Also, no patches should be made with the CUT key of the monitoring set operated.

4.12 The sending line potentiometers are provided on an optional basis depending upon circuit layout conditions. Equipment modifications are such as to give a complete working repeater but no attempt is made to provide as flexible monitoring arrangements as are available for the other types of repeaters.

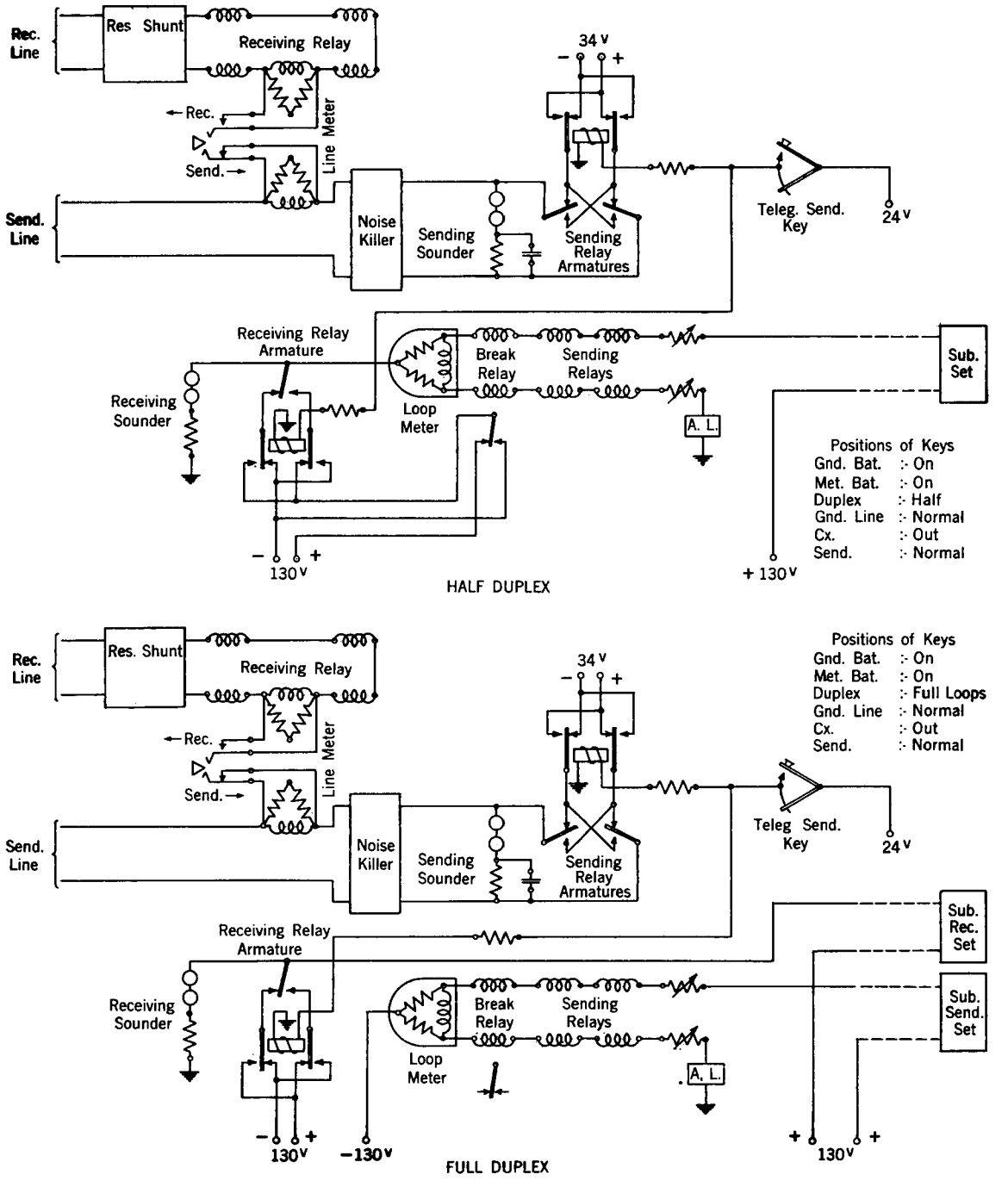


Fig. 9 - 20A1 (102B) Terminal Repeater - Circuit for Sending to Both Line and Loop from Repeater - Measuring Receiving Line Current - Reading Signals

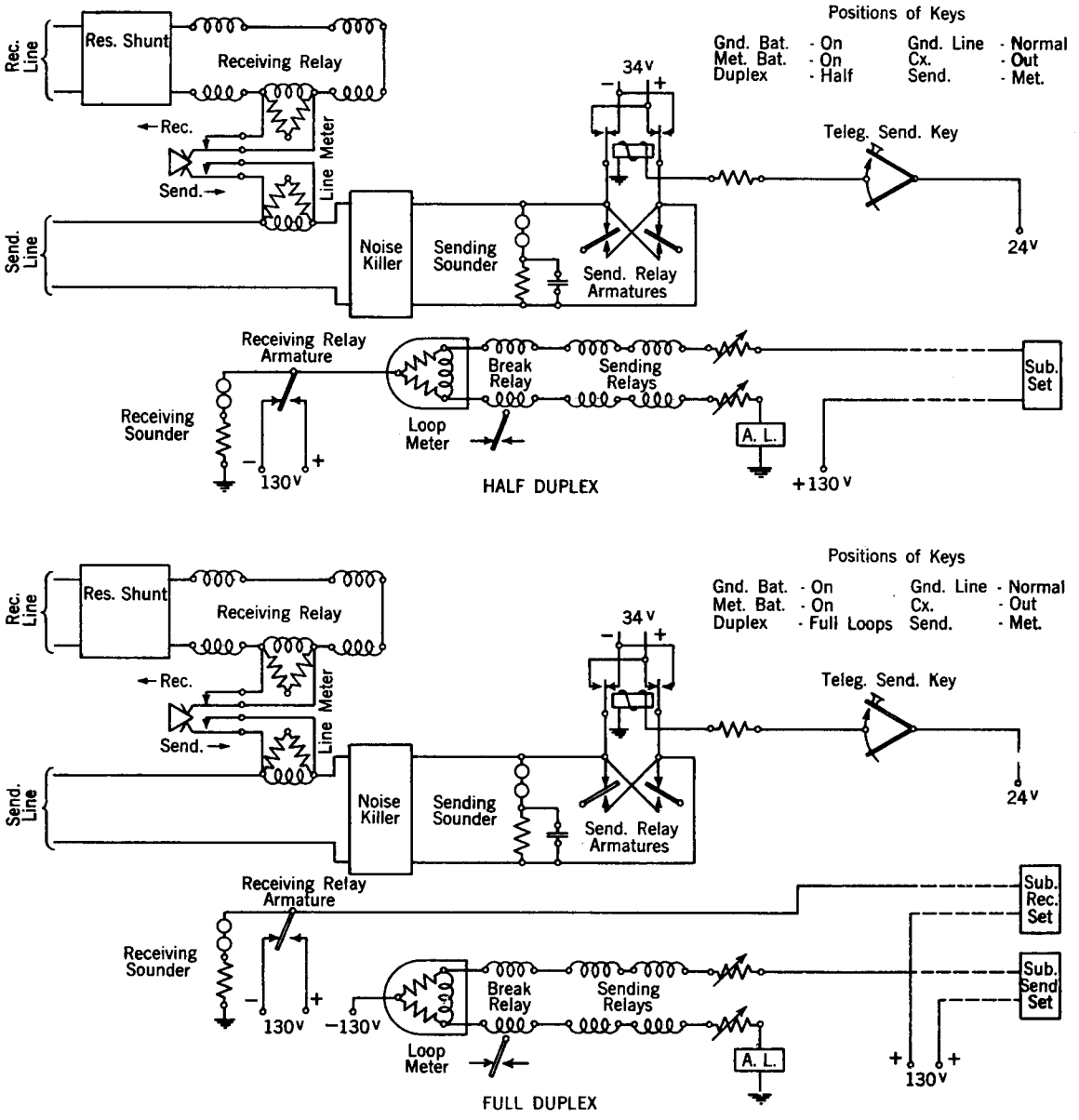
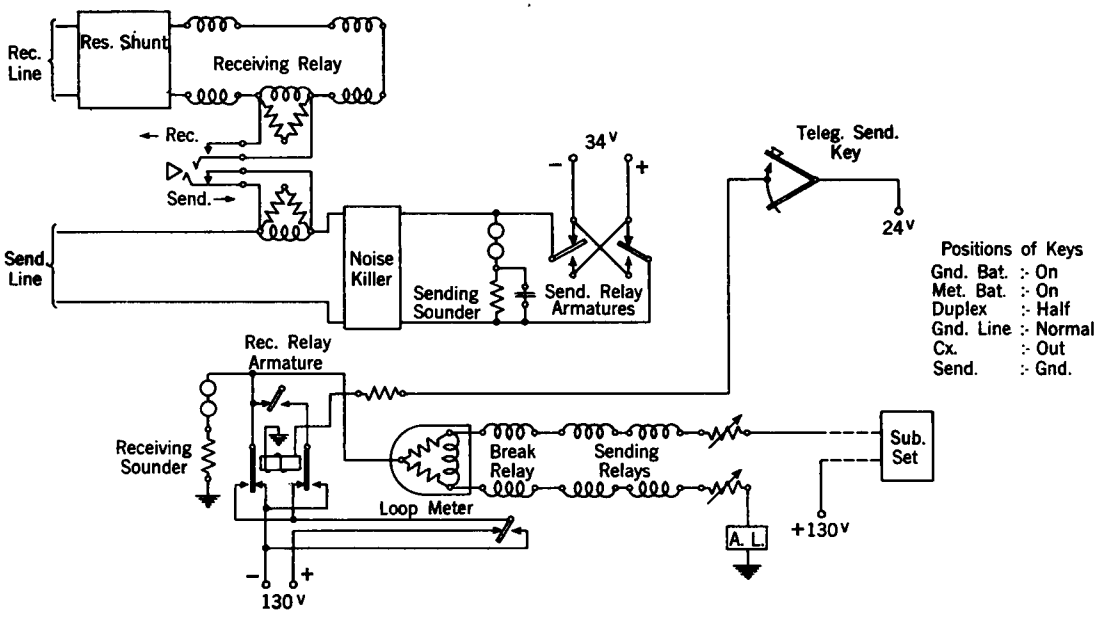


Fig. 10 - 20A1 (102B) Terminal Repeater - Circuit for Sending to Line Only from Repeater - Measuring Sending Line Current



HALF DUPLEX

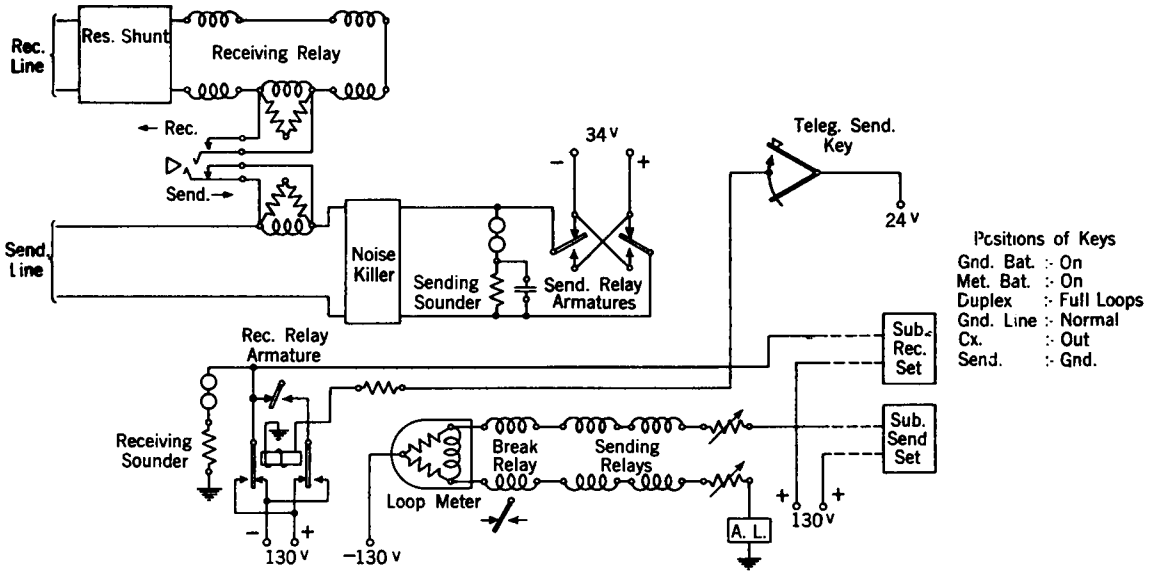


Fig. 11 - 20A1 (102B) Terminal Repeater - Circuit for Sending to Loops Only from Repeater

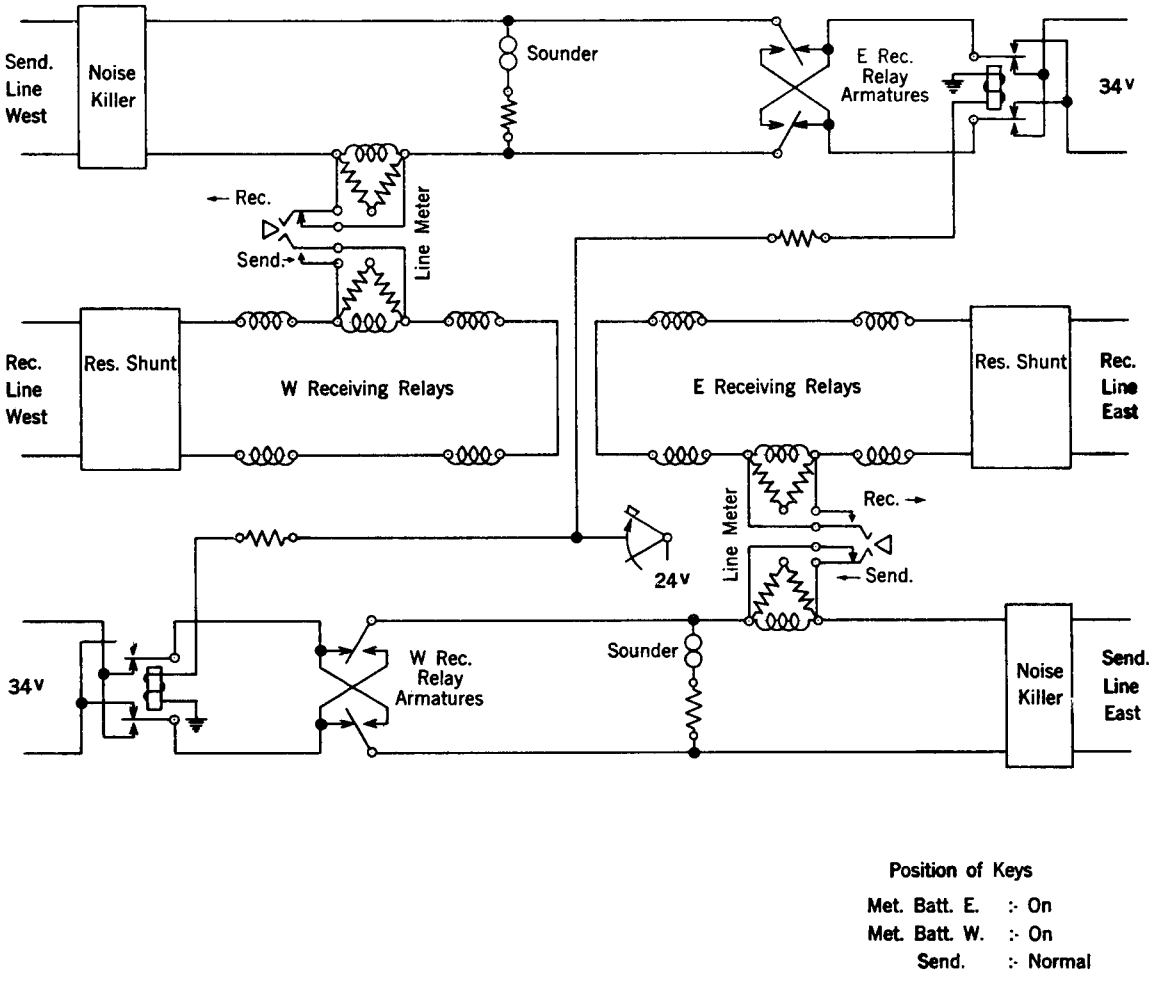


Fig. 12 - Circuit of 20AX1 Through Repeater - Arranged for Sending in Both Directions

4.13 The circuit features of the 20BX1 repeater are shown in Fig. 24. The monitoring set is similar to that used with the 20BX3 repeater as shown in Fig. 30

20B1, 20B2 Terminal Type Rack-Mounted Repeaters and 20BX2 and 20BX3 Through Type Rack-Mounted Repeaters

4.14 These repeaters were designed initially for either 2-wire or 4-wire operation and consequently lend themselves readily to 4-wire operation. However, certain improvements in the 4-wire features have been made and the repeaters can easily be modified.

4.15 The circuit features of the 20B1 repeater and monitoring set are shown in Figs. 27 and 31. Fig. 28 shows the circuit of the 20B2 repeater and the monitoring set is similar to that of the 20BX3.

4.16 Simplified circuits of the 20B1 and 20B2 repeaters under various operating conditions are shown in Fig. 13 to Fig. 18 inclusive.

4.17 The circuit features of the 20BX2 and 20BX3 repeater and monitoring set are shown in Figs. 25 and 30. The 4-wire features of the 20BX3 repeater are the same as those of the 20BX2 type.

4.18 Simplified circuits of the 20BX2 and also of the 20BX3 repeaters under various operating conditions are shown in Fig. 19 to Fig. 22 inclusive.

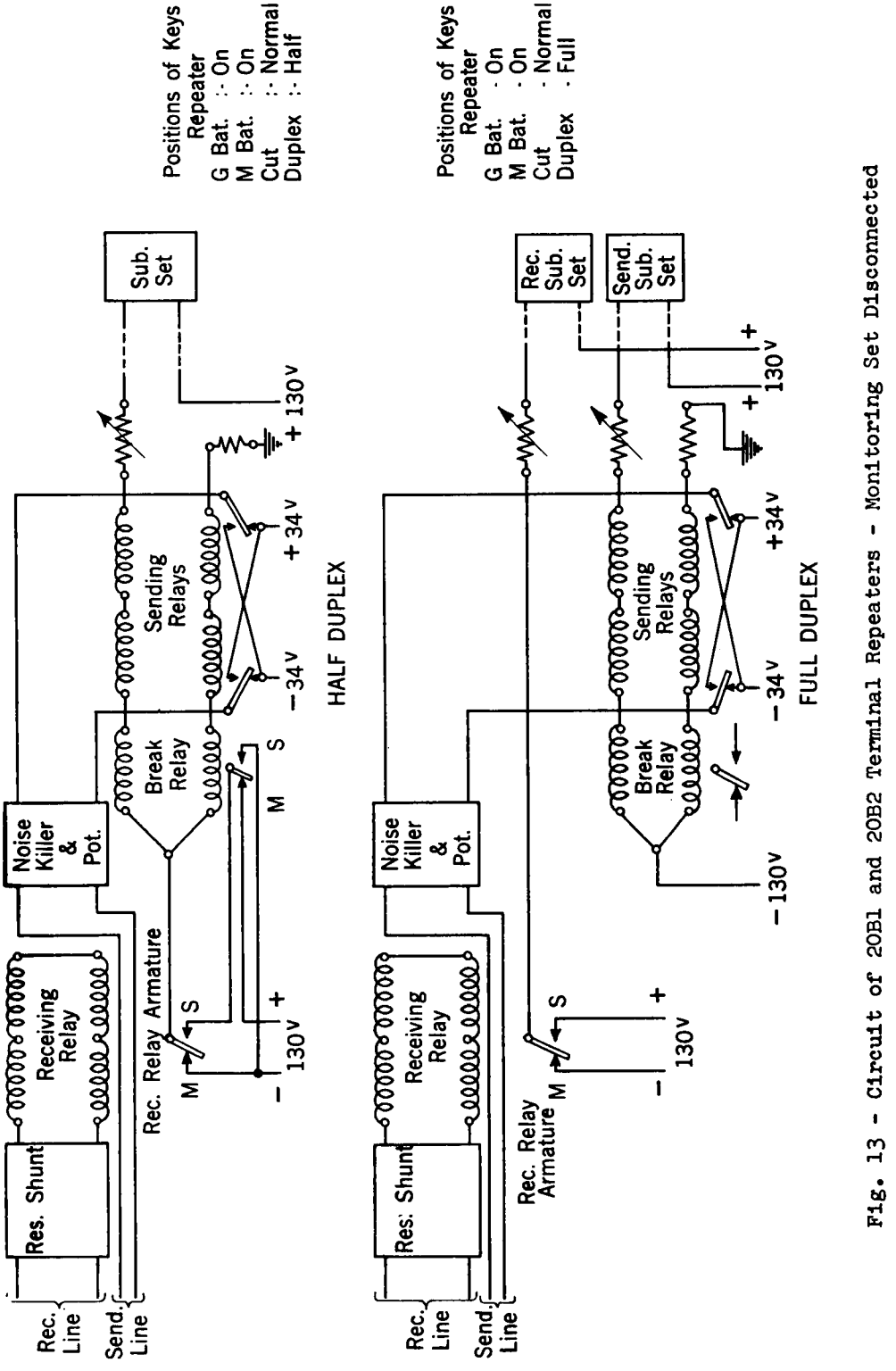


Fig. 13 - Circuit of 20B1 and 20B2 Terminal Repeaters - Monitoring Set Disconnected

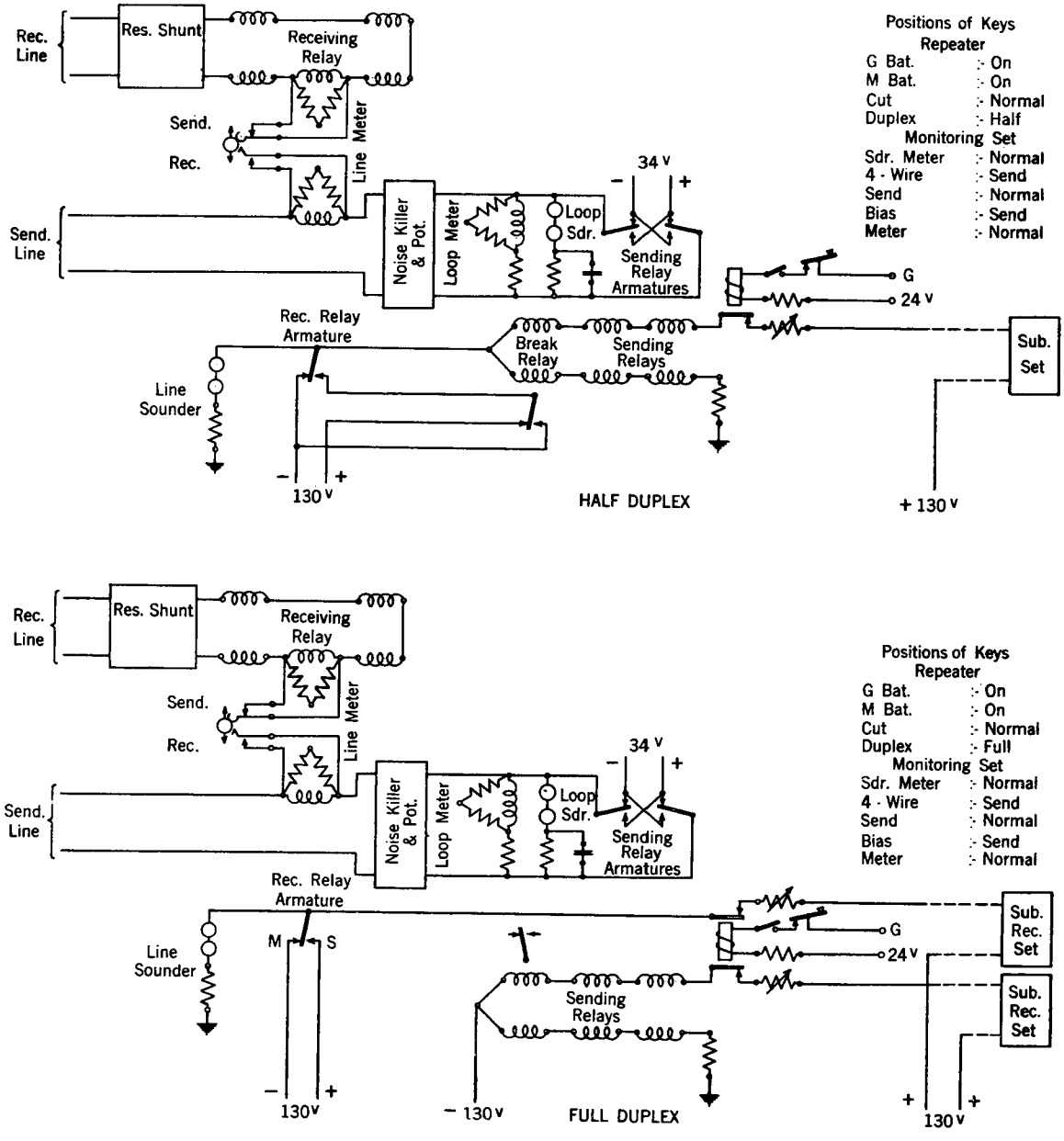


Fig. 14 - 20B1 and 20B2 Terminal Repeaters - Circuit for Sending Both Ways from Repeater - Measuring Sending Line Current - Reading Signals Measuring Sending Bias

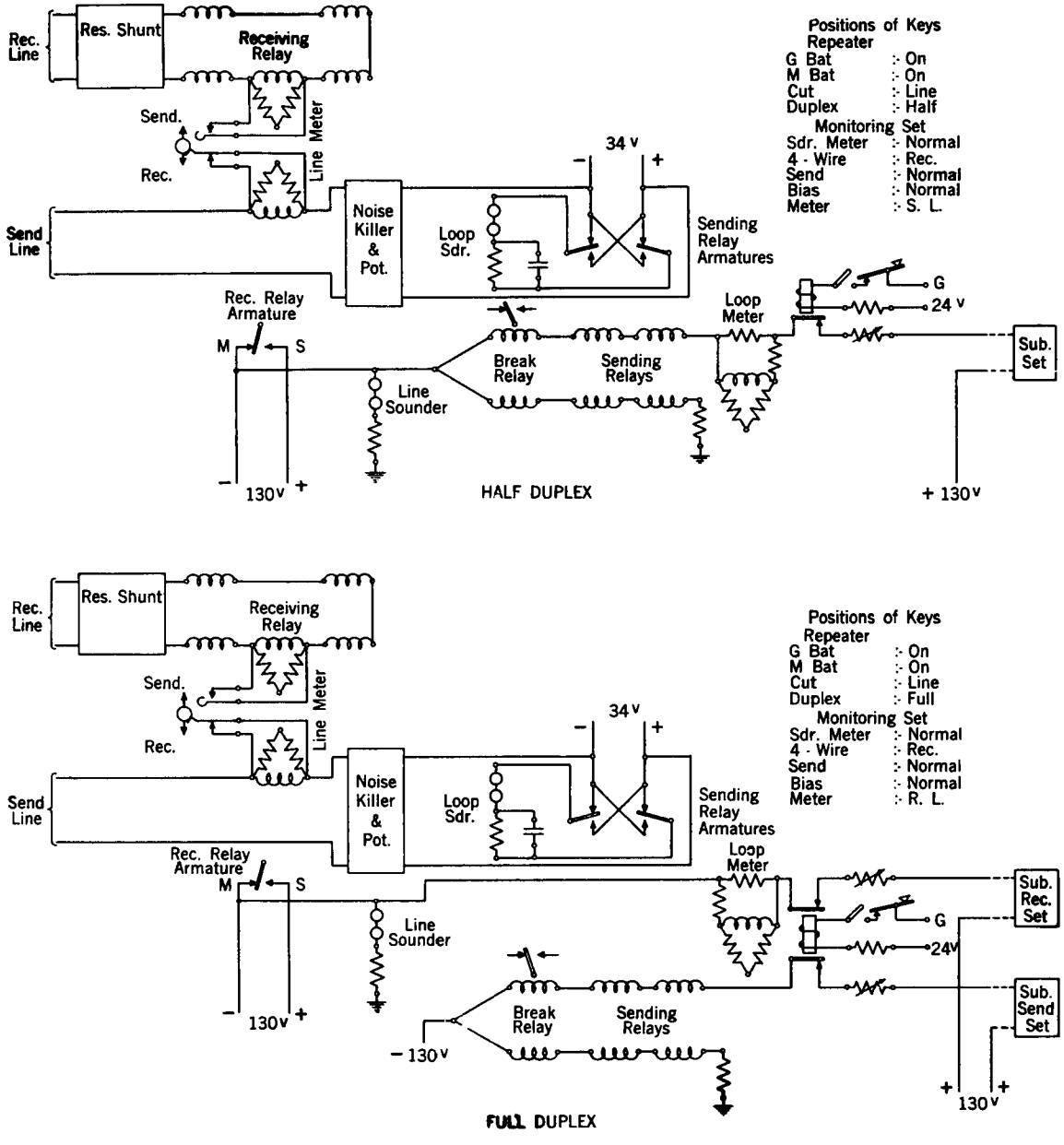


Fig. 15 - 20B1 and 20B2 Terminal Repeaters - Circuit for Sending to Loops (Cut Line) - Measuring Loop Current

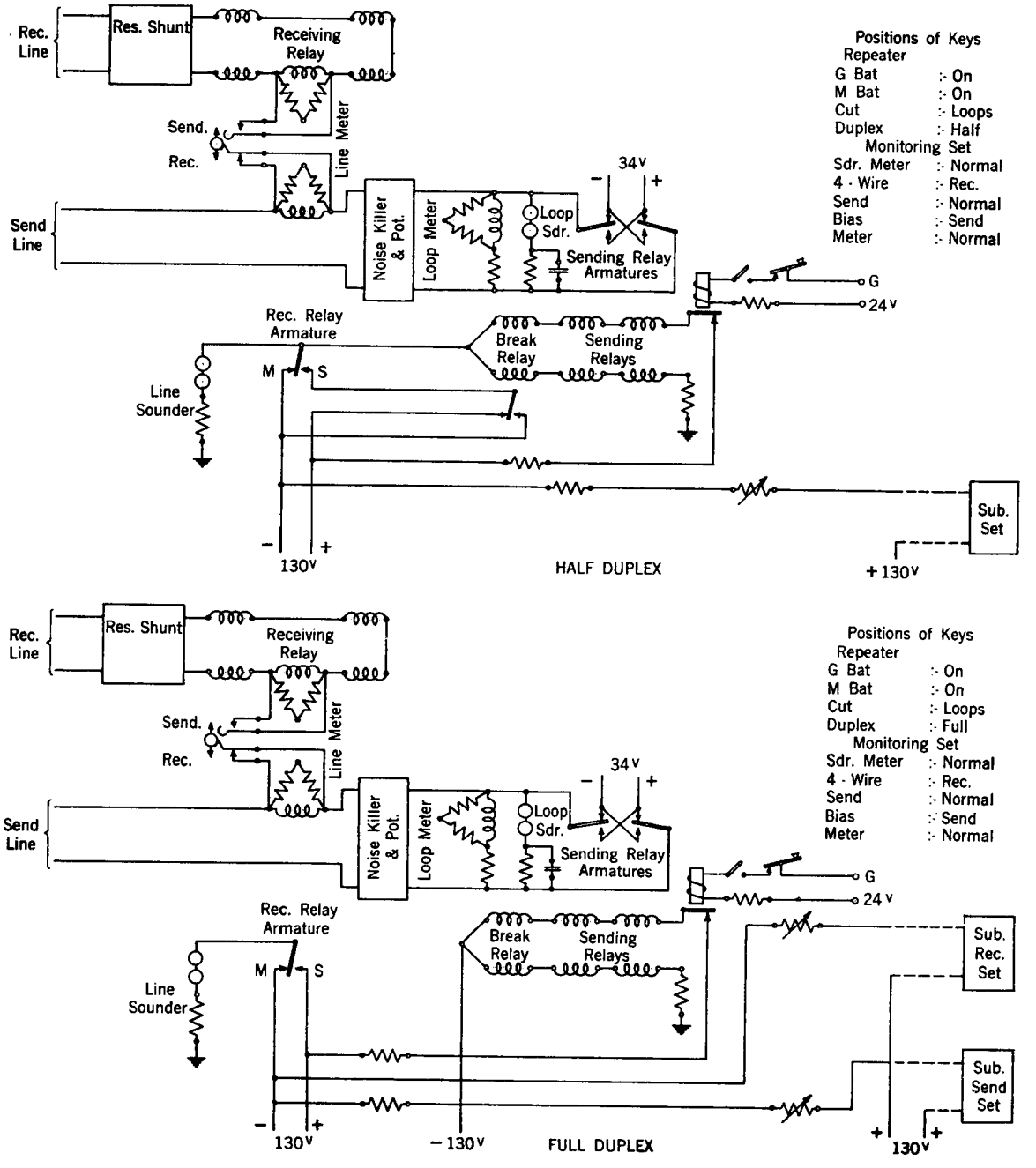


Fig. 16 - 20B1 and 20B2 Terminal Repeaters - Circuit for Sending to Line (Cut Loops)

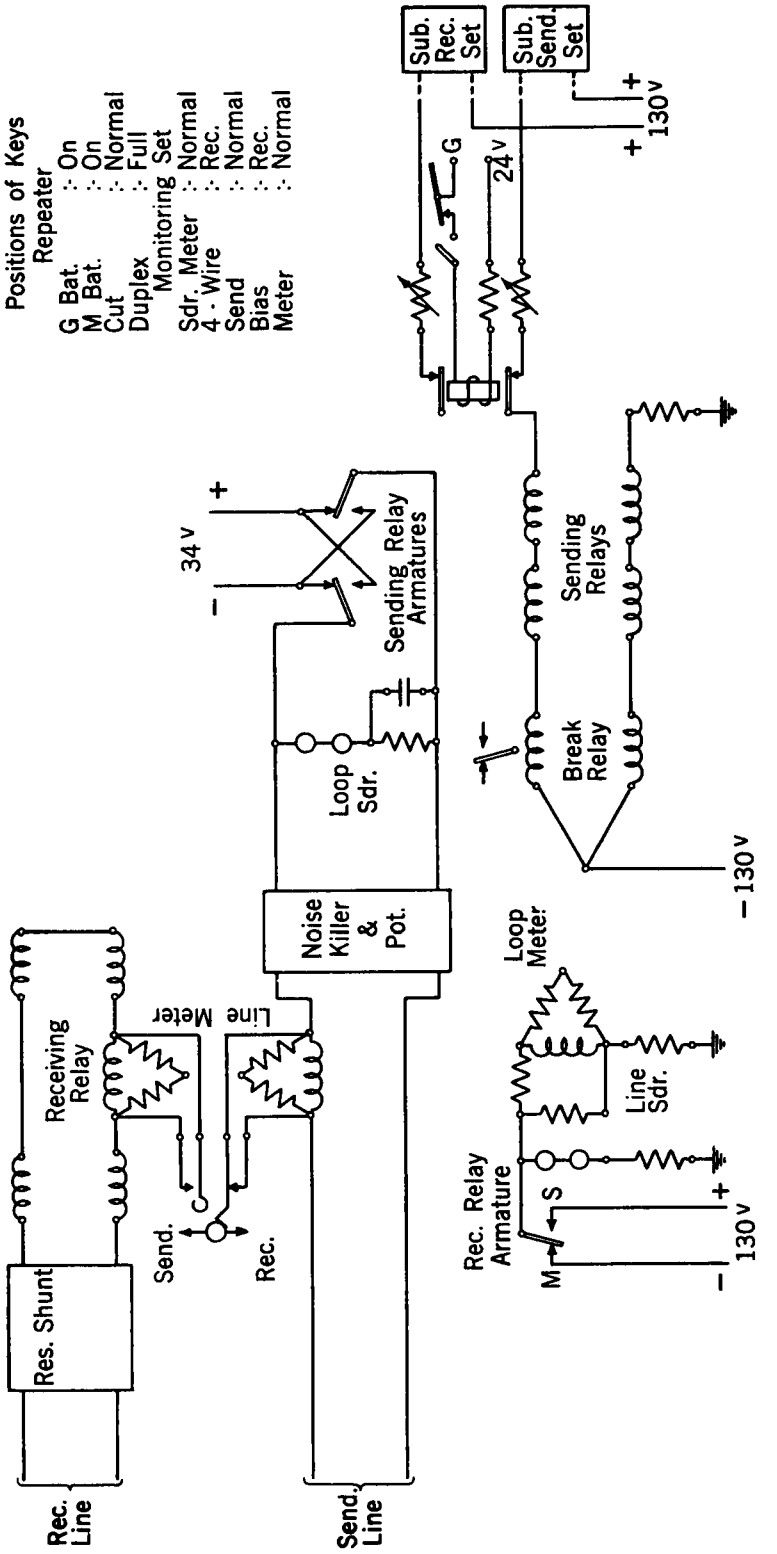
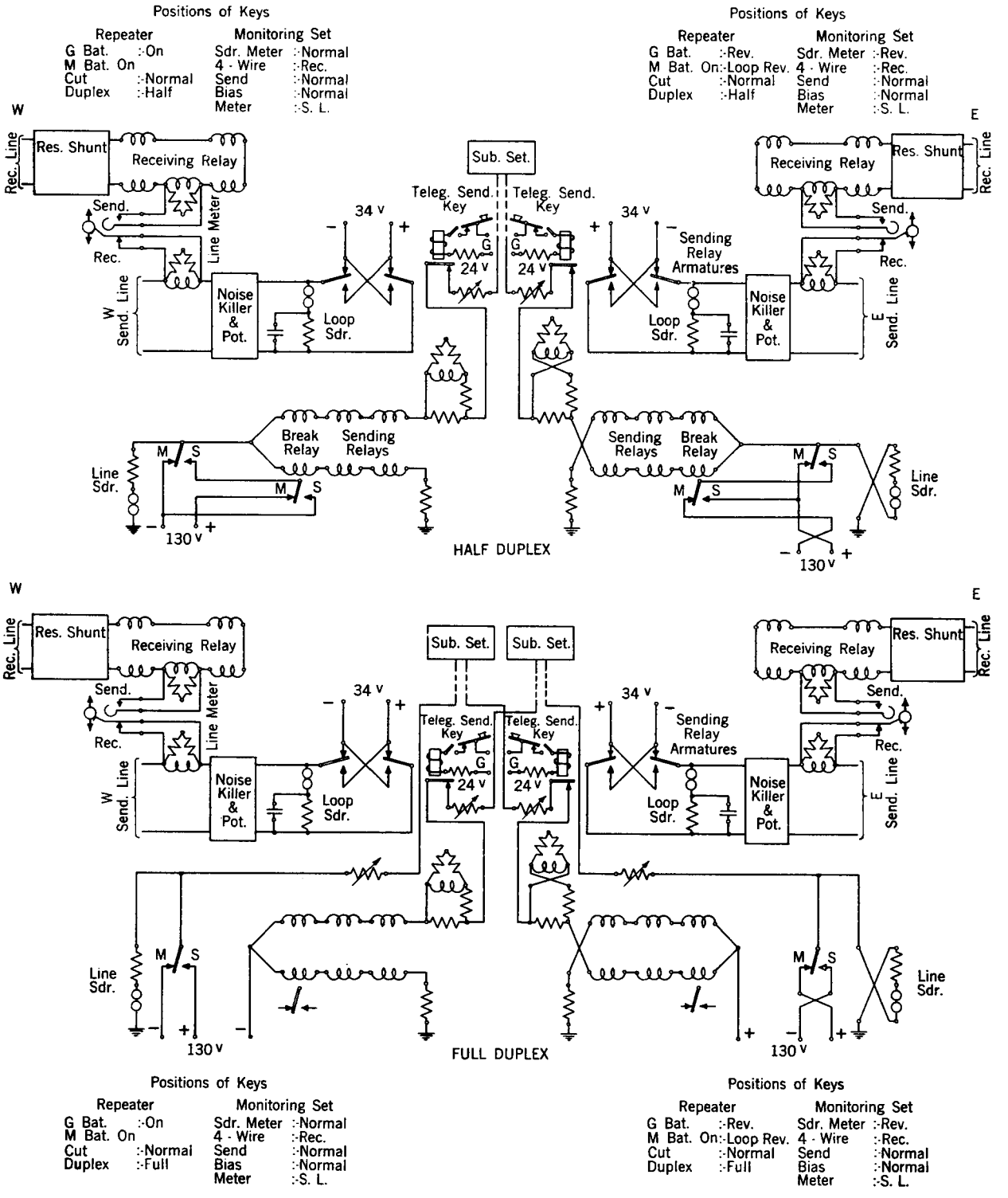


Fig. 17 - 20B1 and 20B2 Terminal Repeaters - Circuit for Measuring Received Bias - Measuring Received Current



NOTE-: "East" & "West" are simply to distinguish repeaters on this drawing and have no directional significance. The repeater with reversed batteries may be one connected to either an East or West line, keeping the proper direction of current thru the TLT jacks.

Fig. 18 - 20B1 and 20B2 Terminal Repeaters - Circuit of Intermediate Operation with Loops

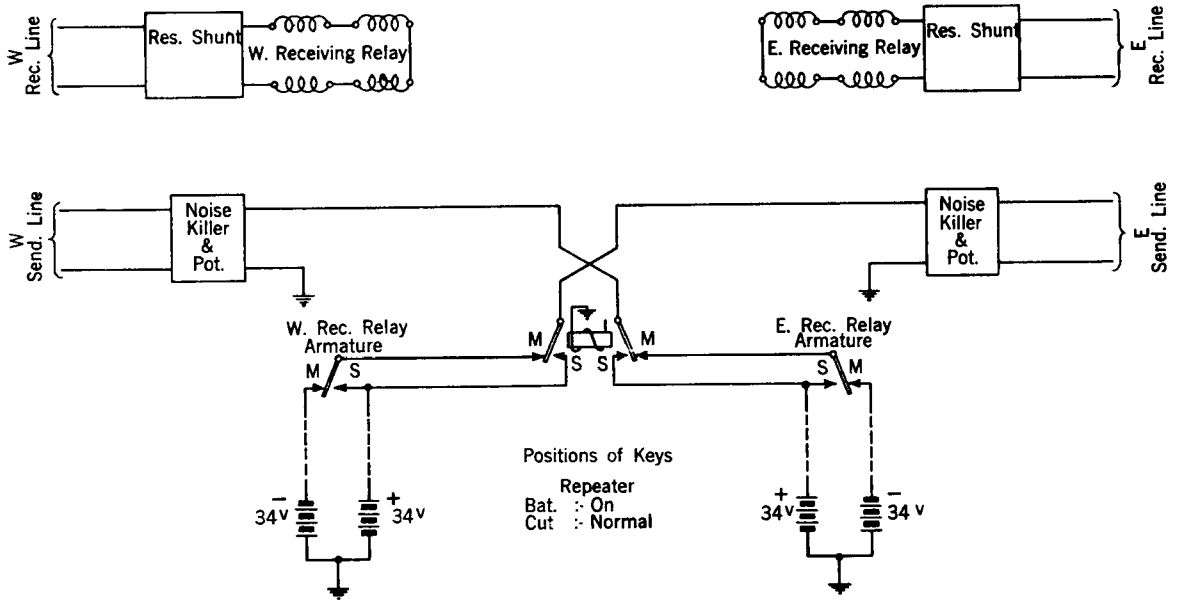


Fig. 19 - Circuit of 20BX2 and 20BX3 Through Repeaters - Monitoring Set Disconnected

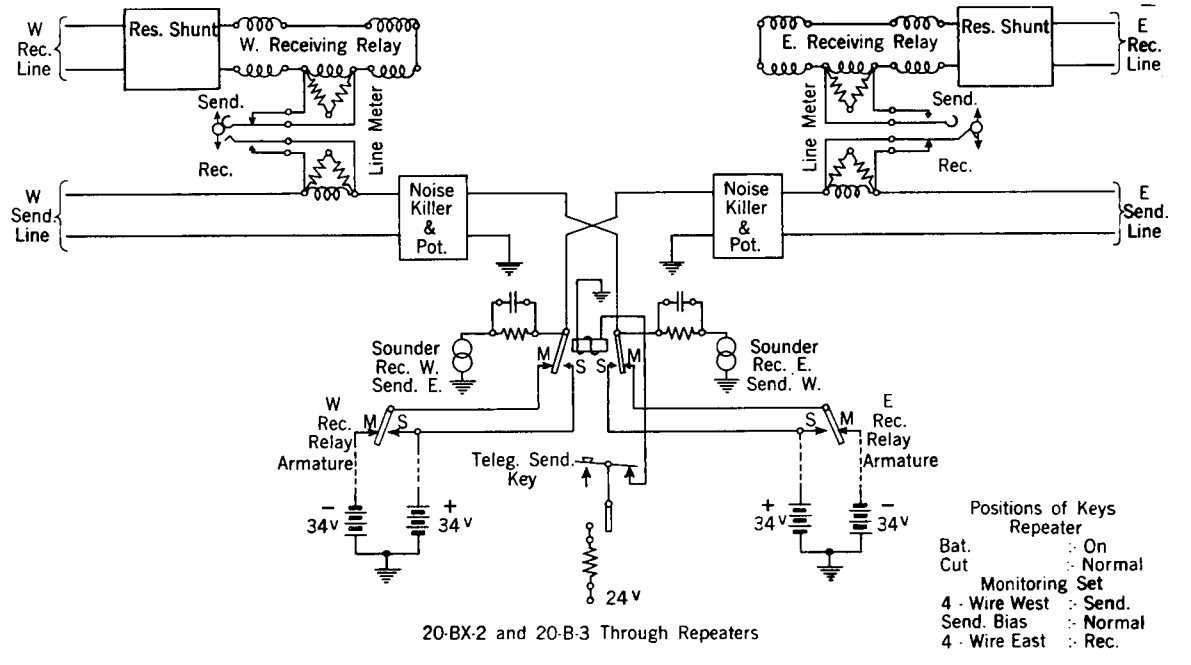


Fig. 20 - 20BX2 and 20BX3 Through Repeaters - Circuit for Sending and Receiving E and W - Measuring Receiving Current E, Sending Current W

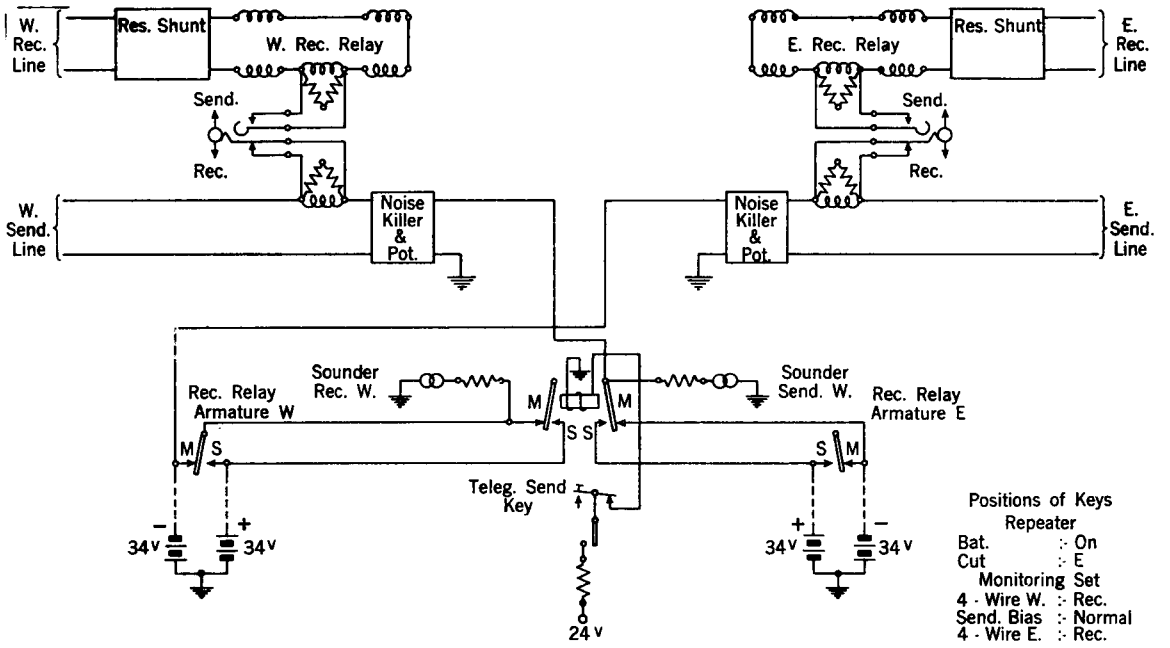


Fig. 21 - 20BX2 and 20BX3 Through Repeaters - Circuit for Cutting E Sending W

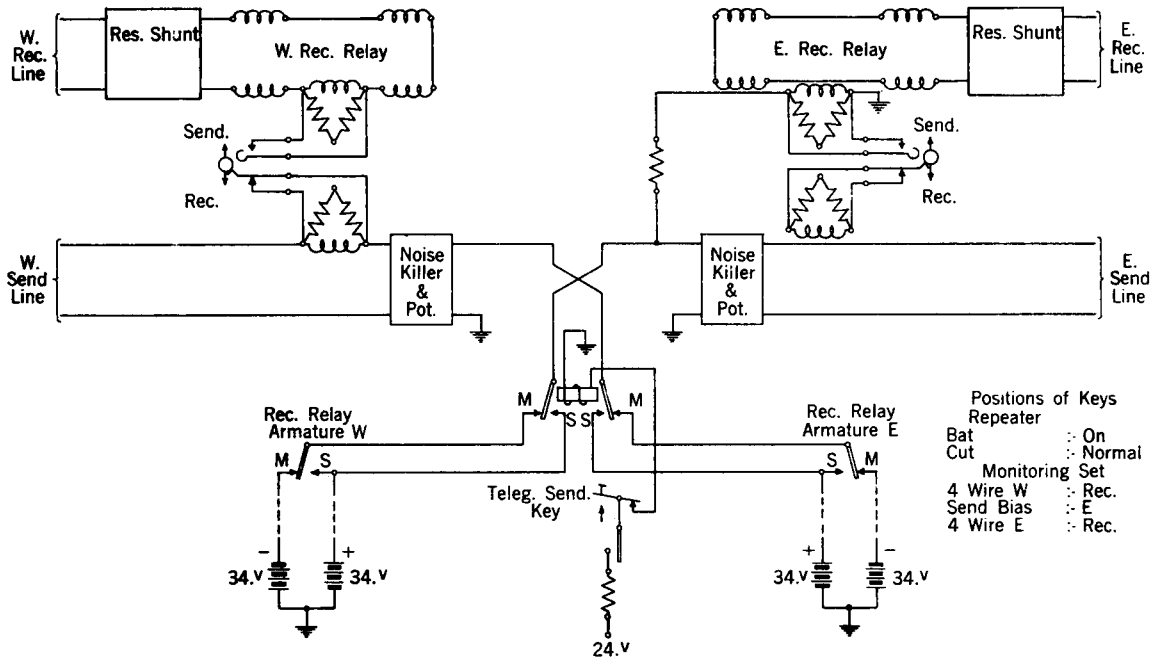


Fig. 22 - 20BX2 and 20BX3 Through Repeaters - Circuit for Measuring Bias W-E

5. 20B3 TERMINAL REPEATER (A & M Only)

5.01 This repeater is a terminal repeater similar to the 20B2 but is arranged so that the equipment and wiring required for 2-wire operation are optional. This permits a saving in case 2-wire operation is not required. If the 2-wire equipment and wiring are not provided at the time of installation they may be added in the field later.

5.02 Four 20B3 repeaters are mounted on a bay of standard relay rack. When the repeater is equipped for both 2- and 4-wire operation the change from one form of operation to the other may be made by strapping on the bay terminal strips.

5.03 Common monitoring is provided to enable the repeater attendant to send and receive on the circuit when lining up the circuit. The monitoring unit is equipped with meters for measuring line and loop currents. The monitoring equipment is mounted on a fiber faced wood panel with a 7-inch shelf.

5.04 The circuits of the 20B3 repeater are shown in Figs. 29 and 31.

6. 20C1 and 20C2 TERMINAL TYPE RACK-MOUNTED REPEATERS

(A) General

6.01 The 20C1 repeater is designed especially for use with the Telegraph Service Board No. 1 and is arranged for 4-wire operation only. It repeats signals between a metallic line circuit and an inverse neutral circuit. It may be operated either full or half duplex. Fig. 32 shows the circuit of the 20C1 repeater.

6.02 The 20C2 repeater is also designed for 4-wire operation only and is similar to the 20C1 repeater except that it is arranged for either inverse neutral or balanced loop operation. Fig. 33 shows the circuit of the 20C2 repeater.

Full Duplex Operation

6.03 In the case of transmission from line to leg, the incoming signals in the receiving pair of the metallic line, which appear as reversals of current in the operating winding of relay (R), operate this relay. Relay (R) operates relay (AUX R) by means of a ± 48 volt polar circuit. The latter relay sends inverse neutral signals to leg "RL".

6.04 In the case of transmission from leg to line, the inverse neutral signals applied to leg "SL" operate sending pole changer relays (PCA) and (PCB). These reverse the polarity of battery applied to the sending pair of the metallic line.

Half Duplex Operation

6.05 In the case of transmission from line to leg, relay (R) operates relay (AUX R) by means of a ± 48 volt polar circuit. The latter relay sends inverse neutral signals into leg "RL" disconnecting the pole changer relays from this leg each time it operates to spacing. Thus the signals transmitted into the leg are not repeated back into the sending pair of the line.

6.06 In the case of transmission from leg to line, inverse neutral signals applied to leg "RL" operate the pole changer relays (PCA) and (PCB). During each spacing signal the current in leg "RL" holds relay (AUX R) to marking, regardless of the operation of relay (R). Thus signals received from the line are prevented from interfering with a break signal from the inverse neutral circuit.

(B) Description of Circuits (See Fig. 32)

Inverse Neutral Circuit

6.07 During the marking condition no current flows in the inverse neutral circuit. During the spacing condition current flows. Hence the pole changer relays operated by the inverse neutral circuit are equipped with biasing circuits which tend to operate them to marking. The "RL" inverse neutral leg extends through a leg multiple circuit to a single hub in half duplex operation or both inverse neutral legs extend through a leg multiple circuit to separate hubs in full duplex operation.

6.08 Condensers (L) and (M) and resistance (U) serve not only to so shape the waves on legs "RL" and "SL" as to compensate for the travel time of the relays sending into these legs but also to protect the relay contacts.

6.09 Condenser (E) shapes the operating wave for the pole changer relays and condenser (N) shapes the wave sent by relay (AUX R).

Transmitter Branch

6.10 In the marking condition pole changer relays (PCA) and (PCB) connect positive line battery to the tip conductor of the line and ground to the ring conductor. In the spacing condition they connect this battery to the ring conductor and ground to the tip conductor.

6.11 Relays (PCA) and (PCB) are provided with contact protection. The contact protective network also serves to maintain the continuity of the circuit during the travel time of the relays.

6.12 A noise killer comprising coils (A), (B) and (C) serves to limit the telegraph thump on the telephone circuit operated over the same pair of cable conductors. A condenser (J) is bridged across the sending circuit between coils (A) and (B) when transmission takes place into a composite set connected at the output of a 4-wire telephone repeater, or between coils (B) and (C) when transmission takes place into a composite set connected at the input of a telephone repeater. On 2-wire telephone circuits, the condenser is bridged between coils (A) and (B).

6.13 For operation over short cable circuits without equalization a potentiometer may be connected into the sending circuit between the sending relays and the noise killer to limit the metallic line current. No other current adjustments are required and no jacks for measuring line currents are provided in the repeater.

Receiving Circuit

6.14 Relay (R) is provided with a vibrating circuit. This consists of a connection from the armature through the two auxiliary windings of the relay, one of these windings being connected in series with a resistor and the other in series with a condenser. In the steady state condition the vibrating circuit tends to make the armature of the relay leave the contact upon which it is being held by the line current. When a signal transition occurs and the line current decreases and allows the armature to leave a contact, the vibrating circuit accelerates the relay operation. Immediately after the relay armature reaches the opposite contact, the current in the vibrating circuit aids in holding it on this contact. Later, after the vibrating circuit condenser has become charged, the current in the d-c branch again tends to make the relay leave its contact. The vibrating circuit stabilizes the action of the relay, increases its apparent sensitivity and reduces its travel time. Thus it effects a considerable reduction in distortion of the received signals when the relay is operated by a very much rounded wave.

6.15 A coil, D, in series with the line windings of the receiving relay serves as a receiving-end noise killer. Its purpose is to limit telegraph thump caused by induction of the vibrating circuit current into the receiving end of the cable circuit through the windings of the receiving relay.

6.16 A shunt resonant at 135 cycles per second is connected across the line windings of the receiving relay when the telephone circuit uses 135 cycle ringing.

6.17 The armature and contacts of the receiving relay send into both the vibrating circuit and a winding of relay (AUX R). They are equipped with contact protection. Condenser (K) serves to improve the wave which operates the auxiliary receiving relay and thus causes the travel time of this relay to be short.

Duplex Control

6.18 A neutral relay controlled from the leg multiple circuit serves to arrange the inverse neutral side of the repeater for either half or full duplex operation. When the relay is released the repeater is arranged for full duplex; when operated, for half duplex.

(C) Testing Arrangements

6.19 The repeater is equipped with a jack into which a 163B1 test unit may be plugged for purposes of testing or lining up the circuit. The repeater must be arranged for half duplex operation when the test unit is used. The 163B1 test unit provides means for sending and receiving manual telegraph signals on the "RL" leg.

(D) Description of Equipment

6.20 The 20C1 repeater is a single circuit relay rack unit arranged to mount on a standard 19-1/2" bay. The equipment occupies the space of five mounting plates, being 8-3/4" high.

6.21 The 135-cycle resonant shunts are mounted separately, eight of them occupying three mounting plate spaces.

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Attached: Figs. 23 to 33

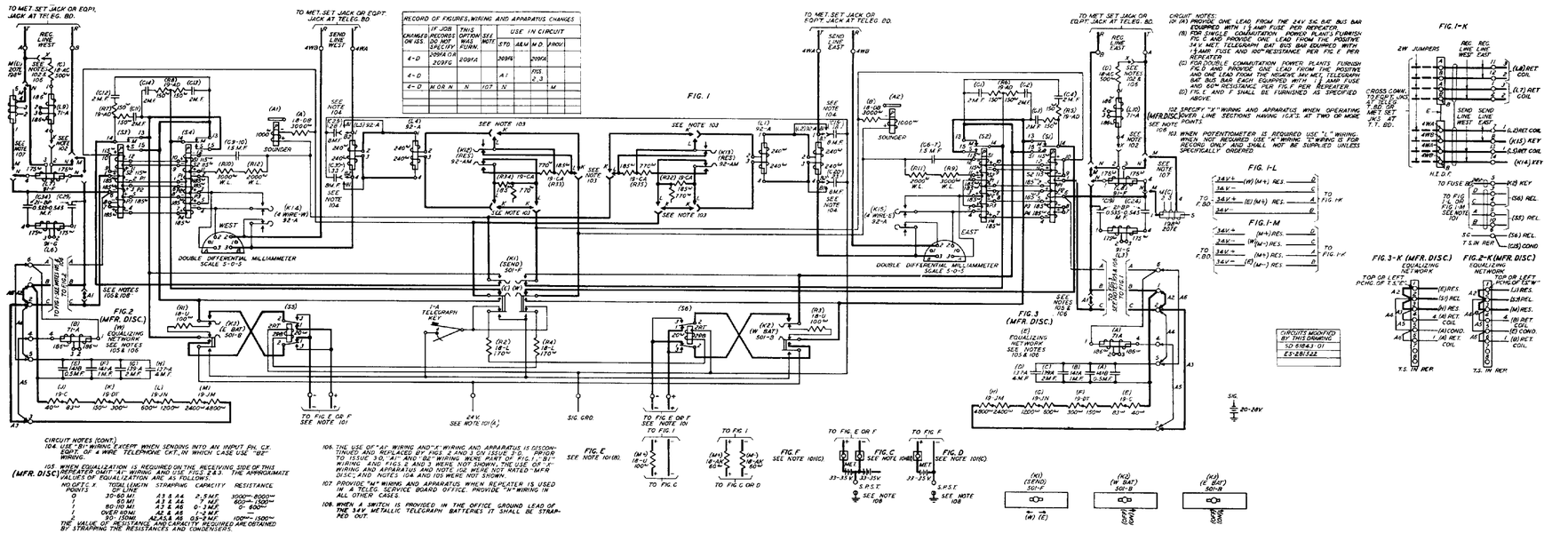


Fig. 23 - 20AX1 (101B) Through Repeater - For Modifying Existing Circuits for 4-Wire Operation

CIRCUIT NOTES:

101. (A) PROVIDE TWO LEADS FROM THE POSITIVE AND TWO LEADS FROM THE NEGATIVE 34 V. METALLIC TELEGRAPH BAT. BUS BARS, EACH LEAD EQUIPPED WITH A 1/4 AMP. FUSE.
(B) PROVIDE ONE LEAD FROM THE MIDPOINT OF THE 34 V. POSITIVE AND NEGATIVE BATTERIES PER CIRCUIT.

102. WHEN POTENTIOMETERS ARE REQ. TO REDUCE THE LINE VOLTAGE USE "N" WIRING, OTHERWISE USE "M" WIRING. "N" WIRING IS SHOWN FOR RECORD ONLY. IN CASE REPEATER HAS ALREADY BEEN MODIFIED IN THIS RESPECT AND SHALL NOT BE SUPPLIED EXCEPT WHEN SPECIFICALLY ORDERED.

(MFR. DISC.) 103. PROVIDE FIG. 3 WHEN REC. WEST LINE HAS I.C.X.'S AT TWO OR MORE POINTS.

(MFR. DISC.) 104. PROVIDE FIG. 4 WHEN REC. EAST LINE HAS I.C.X.'S AT TWO OR MORE POINTS.

105. USE "B1" WIRING EXCEPT WHEN SENDING INTO INPUT PH CX EQPT OF 4 WIRE TELEPHONE CIRCUIT IN WHICH CASE USE "B2" WIRING.

106. WHEN EQUALIZATION IS REQUIRED ON THE RECEIVING SIDE OF THIS REPEATER OMIT "A1" WIRING AND USE FIGS. 7 AND 8. THE APPROX. VALUES OF EQUALIZATION ARE AS FOLLOWS:

(MFR. DISC.)

NO. OF I.C.X. POINTS	TOTAL LENGTH OF LINE	STRAPPING	CAPACITY	RESISTANCE
0	30 TO 60 MI.	A3 & A4	2.5 M.F.	3000 TO 8000 OHMS
1	60 MI.	A3 & A4	7 M.F.	600 TO 1500 OHMS
1	80 TO 110 MI.	A3 & A6	0 TO 3 M.F.	0 TO 600 OHMS.
1	OVER 110 MI.	A2 & A6	1 TO 2 M.F.	
2	90 TO 150 MI.	A2, A5 & A6	0.5 TO 2 M.F.	100 TO 1500 OHMS.

THE VALUES OF RESISTANCE AND CAPACITY REQUIRED ARE OBTAINED BY STRAPPING THE RESISTANCES AND CONDENSERS.

107. THE USE OF "A1" WIRING AND FIGS. 3 AND 4 IS DISCONTINUED AND REPLACED BY FIGS. 7 AND 8 ON ISSUE 3-D.
PRIOR TO ISSUE 3-D,
(A) "A1" WIRING WAS NOT DESIGNATED.
(B) FIGS. 7 AND 8 AND NOTES 105 AND 106 WERE NOT SHOWN.
(C) "B2" WIRING WAS PART OF CIRCUIT AND "B1" WIRING WAS NOT SHOWN.
(D) FIGS. 3 AND 4, AND NOTES 103 AND 104 WERE NOT MARKED "MFR. DISC."

108. PROVIDE "S" WIRING AND APPARATUS WHEN REPEATER IS USED IN A TELEG. SERVICE BOARD OFFICE. PROVIDE "R" WIRING IN ALL OTHER CASES.

109. WHEN THE (SW) SWITCH IS PROVIDED IN THE OFFICE GROUND LEAD OF THE 34 V. METALLIC TELEG. BAT. IT SHALL BE STRAPPED OUT.

EQUIPMENT NOTES:

201. PRIOR TO ISSUE 3-D, FIGS. 3K AND 4K WERE PART OF FIG. K, "A1" WIRING WAS NOT SPECIFIED IN FIG. K, AND FIGS. 7K AND 8K WERE NOT SHOWN.

202. PRIOR TO ISSUE 4-D IN FIG. K THE "S" AND "R" WIRING WERE NOT SHOWN "R" WIRING WAS PART OF MAIN FIG. THE RATING "MFR. DISC." WAS NOT SHOWN AT FIGS. 7K AND 8K.

RECORD OF FIGURES, WIRING, AND APPARATUS CHANGES

CHANGED ON ISS.	IF JOB RECORDS DO NOT SPECIFY	THIS OPTION WAS FURN.	SEE NOTE	USE IN CIRCUIT STD.	A&M	M.D.	PROV.	
4-D	209FA OR 209FG REL.	209FA		209FG		209FA		
				A1		FIGS. 7, 8		
	R OR S	R	108	R			S	
	NOTE 109	NONE		109				

CIRCUITS MODIFIED BY THIS DRAWING
ES-60137-01
SD-61842-01

Fig. 24 - 20BX1 Through Repeater - For Modifying Existing 103A and 105A Telegraph Panels for 4-Wire Operation

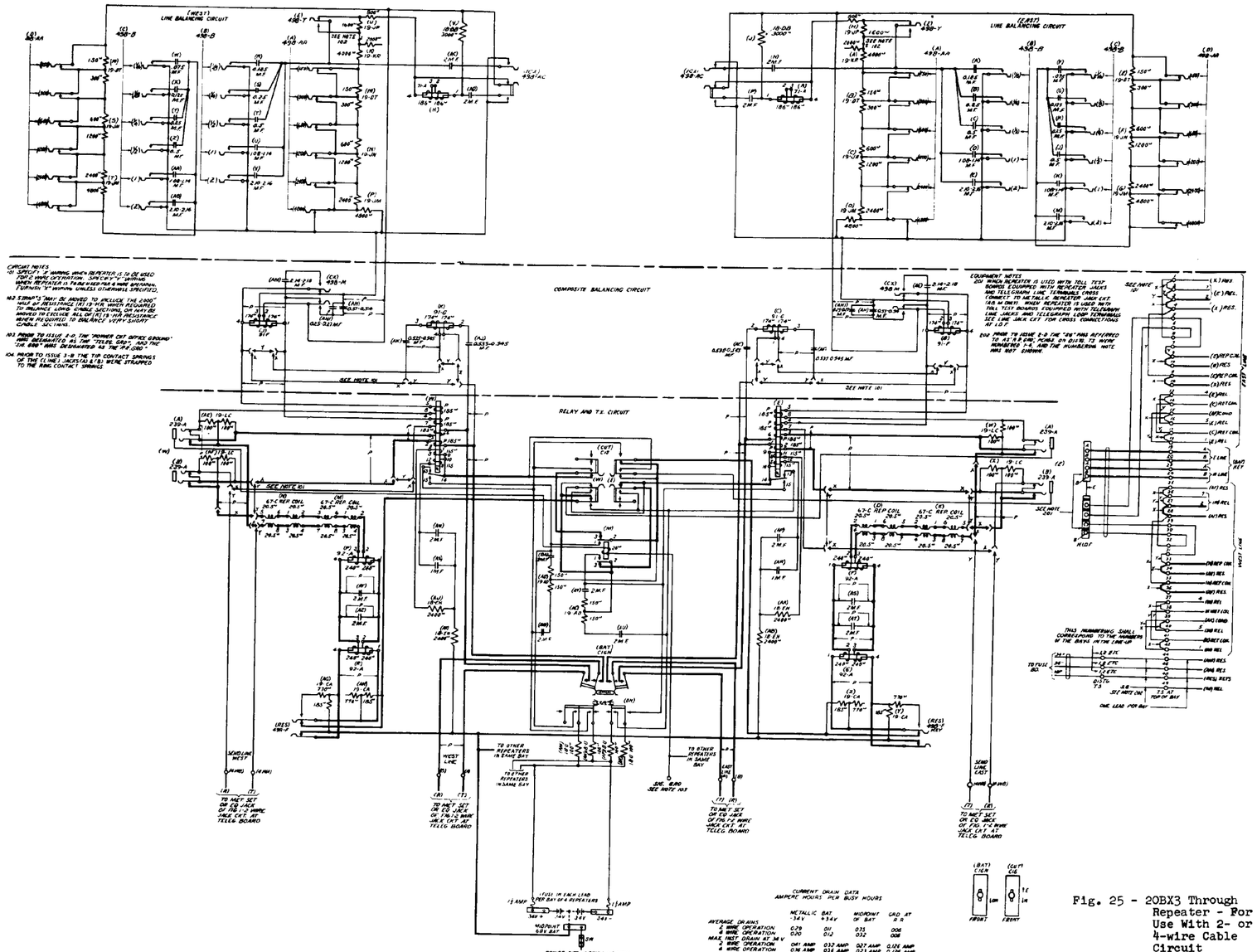


Fig. 25 - 20BX3 Through Repeater - For Use With 2- or 4-wire Cable Circuit

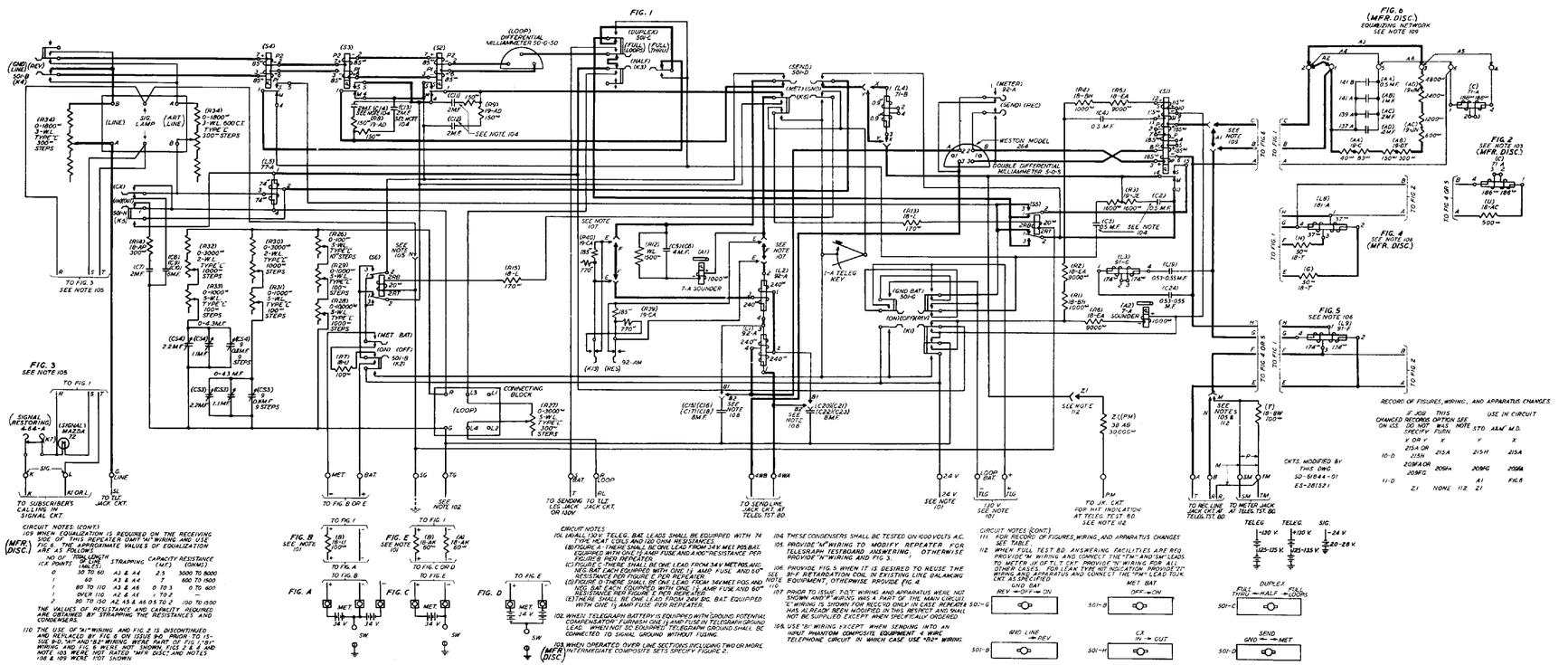


Fig. 26 - 20A1 (102B) Telegraph Panel Terminal Repeater - with or without Telegraph Testboard Answering

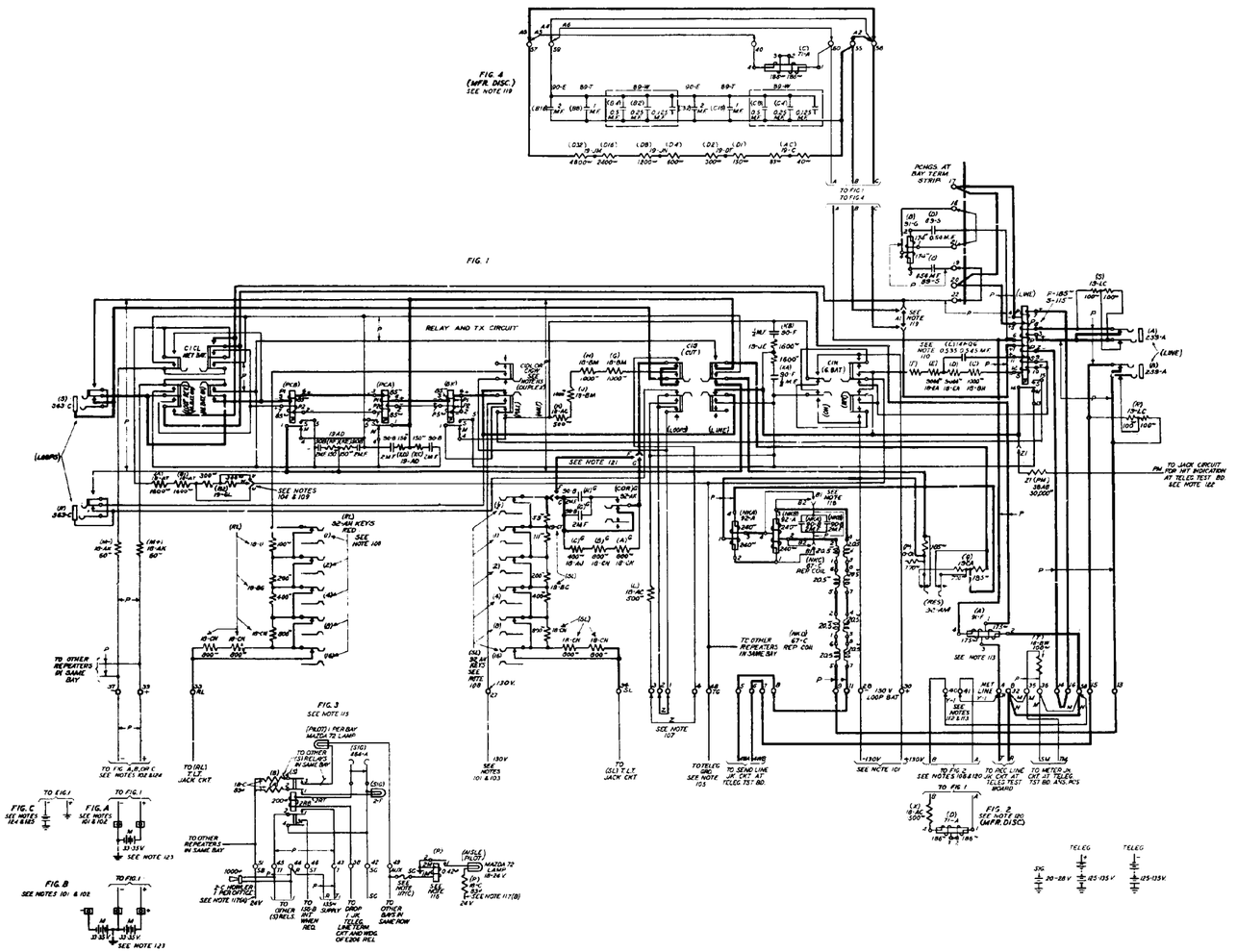


Fig. 27 - 20B1 Terminal Repeater - For use with 4-wire Cable Circuits

RECORD OF FIGURES, WIRING, AND APPARATUS CHANGES

CHANGED ON ISS.	IF JOB RECORDS DO NOT SPECIFY	THIS OPTION WAS FURN	SEE NOTE	USE IN CIRCUIT STD.	A&M	M.D		
7-D	209-FA OR 209-FC	209-FA		209-FC		209-FA		
7-D	W OR V	V	115	W, V				
7-D				A1		FIG. 3		
7-D	Z1	NONE	114	Z1				
7-D	215-A OR 215-H	215-A		215-H		215-A		

CIRCUIT NOTES: (CONT)

114. WHEN FULL TEST BOARD ANSWERING FACILITIES ARE REQUIRED, PROVIDE "M" WIRING AND CONNECT THE "TM" & "SM" LEADS TO METER JK. CKT. OF T.L.T. CKT. PROVIDE "N" WIRING IN ALL OTHER CASES. FOR LEAK TYPE HIT INDICATION CONNECT THE "PM" LEAD TO JK. CKT AS SPEC.

115. USE "V" OR "W" WIRING AS SPEC. BY THE CUSTOMER.

116. WHEN THE (SW) SWITCH IS PROVIDED IN THE OFFICE GROUND LEAD OF THE 34 V. METALLIC TELEGRAPH BATTERIES IT SHALL BE STRAPPED OUT.

FIG. 3 (MFR. DISC.)
SEE NOTE 112

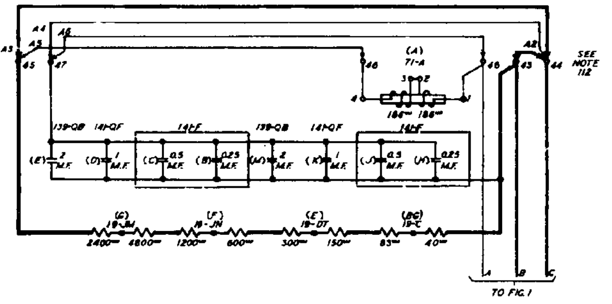


FIG. 1

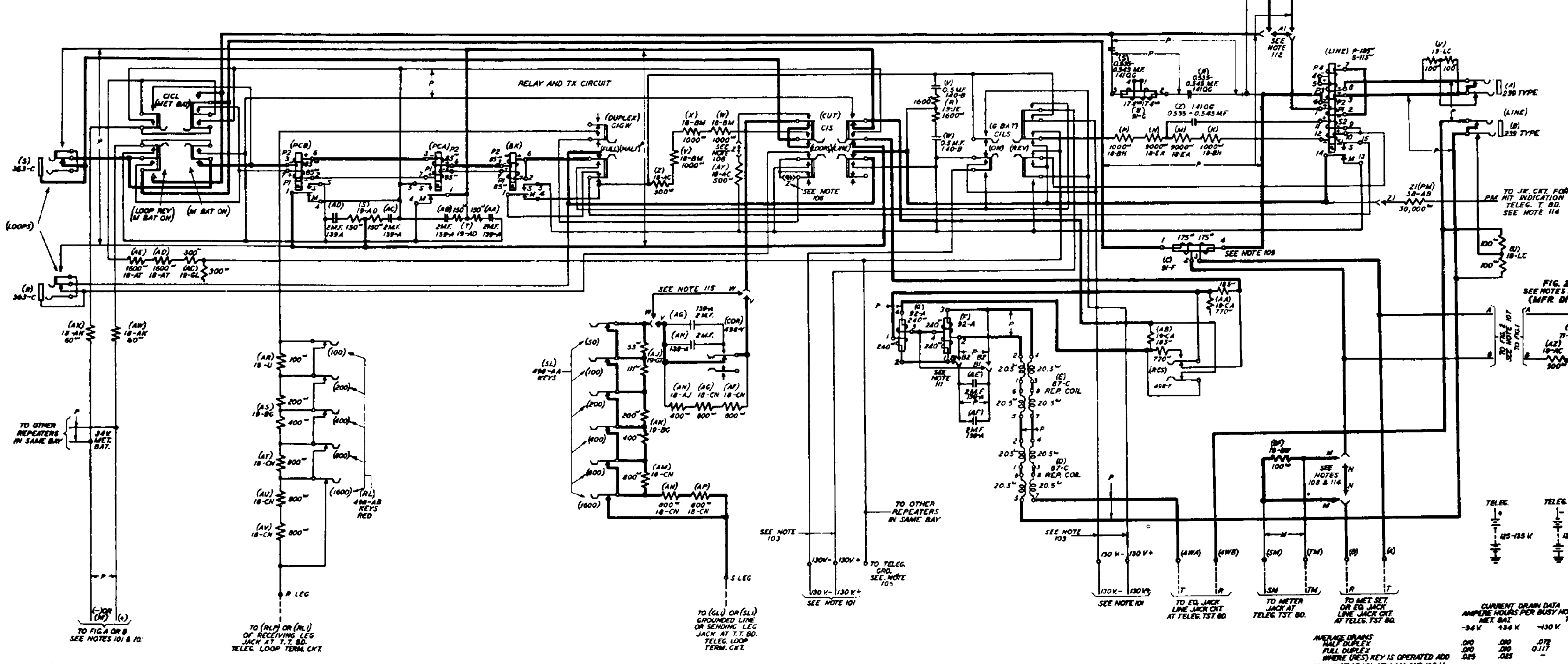
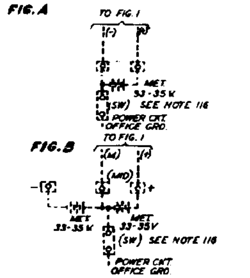


FIG. A

FIG. B



CIRCUIT NOTES:

101. (A) ALL 130 V. TELEG. BAT. LEADS SHALL BE EQUIPPED WITH 74 TYPE HEAT COILS AND 120~ RES.
(B) FOR DOUBLE COMMUTATION POWER PLANTS THERE SHALL BE ONE LEAD FROM POSITIVE AND NEGATIVE 34 V. MET. BAT. EACH EQUIPPED WITH ONE 1½ AMP FUSE FOR EACH BAY OF 4 REPEATERS.
(C) FOR SINGLE COMMUTATION POWER PLANTS THERE SHALL BE ONE LEAD FROM POSITIVE 34 V. MET. BAT. EQUIPPED WITH ONE 1½ AMP. FUSE FOR EACH BAY OF 4 REPEATERS.

102. SPECIFY FIG. A FOR OFFICES EQUIPPED WITH 34 V. DOUBLE COMMUTATION POWER PLANTS.
SPECIFY FIG. B FOR OFFICES EQUIPPED WITH 34 V. + AND − SINGLE COMMUTATION POWER PLANTS.

103. THESE BAT. TAPS MAY BE CONNECTED THRU "LOOP BAT. JACKS" AT T.T. BD. WHEN SPECIFIED. (A & M ONLY).

104.

105. WHERE TELEG. BAT. IS EQUIPPED WITH "GROUND POT. COMPENSATOR" FURNISH ONE 1½ AMP FUSE IN THE TELEG. GROUND LEAD FOR EACH FOUR CKTS. WHEN NOT SO EQUIPPED TELEG. GROUND SHALL BE SIGNAL GROUND WITHOUT FUSING.

106. "Z" WIRING SHOULD BE SPECIFIED WHEN CLOSED LOOPS ARE REQ. IN THE "CUT" CONDITION. NO "Z" WIRING SHOULD BE SPECIFIED WHEN OPEN LOOPS ARE REQ. FURNISH "Z" WIRING UNLESS OTHERWISE SPECIFIED.

(MFR. DISC.) SEE NOTES 112 & 113
107. SPECIFY FIG. 2 WHEN OPERATING OVER LINE SECTIONS HAVING INTERMEDIATE COMPOSITE SETS AT TWO OR MORE POINTS.

108. SPECIFY "M" WIRING AND APPARATUS FOR TELEGRAPH TEST BOARD ANSWERING. OTHERWISE SPECIFY "N" WIRING.

109. PRIOR TO ISSUE 2-D, THE (C) RET. COIL AND "N" WIRING WERE NOT SHOWN AND "M" WIRING AND APPARATUS WERE A PART OF FIG. 1.

110. THIS DRAWING IS PROVIDED FOR MODIFYING 4 WIRE CIRCUITS TO REDUCE TELEGRAPH THUMP IN TELEPHONE CIRCUITS AND TO PROVIDE FOR FULL TELEGRAPH TEST BOARD ANSWERING OR LEAK TYPE HIT INDICATION WHEN REQUIRED. OPTIONAL WIRING OF THE (COR) CIRCUIT IS ALSO PROVIDED.

111. USE B1 WIRING EXCEPT WHEN SENDING INTO AN INPUT PHANTOM COMPOSITE EQUIPMENT 4 WIRE TELEPHONE CIRCUIT IN WHICH CASE USE B2 WIRING.

(MFR. DISC.)
112. WHEN EQUALIZATION IS REQUIRED ON THE RECEIVING SIDE OF THIS REPEATER OMIT A1 WIRING AND USE FIGURE 3. THE APPROXIMATE VALUES OF EQUALIZATION ARE AS FOLLOWS:

NO. OF ICX POINTS	TOTAL LENGTH OF LINE (MILES)	STRAPPING	CAPACITY (M.F.)	RESISTANCE (OHMS)
0	30-60	A3 & A4	2.5	3000-6000
1	60	A3 & A4	7	600-1500
1	80-110	A3 & A6	0-3	0-600
1	OVER 110	A2 & A6	1-2	—
2	90-150	A2, A5 & A6	0.5-2	100-1500

THE VALUES OF RESISTANCE AND CAPACITY REQUIRED ARE OBTAINED BY STRAPPING THE RESISTANCES AND CONDENSERS.

113. THE USE OF "A1" WIRING AND FIG. 2 IS DISCONTINUED AND REPLACED BY FIG. 3 ON ISSUE 6-D. PRIOR TO ISSUE 6-D, "B1" AND "B2" WIRING WERE PART OF FIG. 1, "B1" WIRING AND FIG. 3 WERE NOT SHOWN, FIG. 2 AND NOTE 107 WERE NOT RATED "MFR. DISC.", AND NOTES 111 AND 112 WERE NOT SHOWN.

CURRENT DRAIN DATA
AMPERE HOURS PER BUSY HOURS

	MET. BAT. −34 V	MET. BAT. +34 V	TELEG. BAT. −130 V	TELEG. BAT. +130 V*	GRD.**
AVERAGE DRAINS					
HALF DUPLEX	.010	.010	.072	.077	.088
FULL DUPLEX	.010	.010	0.117	.082	.089
WHERE (RES) KEY IS OPERATED ADD	.025	.025	—	—	—
MAX. INST. DRAIN AT 34 V. AND 130 V.					
HALF DUPLEX	.01 AMP	.01 AMP	.07 AMP	.08 AMP	.04 AMP
FULL DUPLEX	.01 AMP	.01 AMP	0.12 AMP	.08 AMP	.04 AMP
WHERE (RES) KEY IS OPERATED ADD	.03 AMP	.03 AMP	—	—	—

* INCLUDES T.L.T. BAT. DRAINS
** GROUND MAY BE EITHER TELEG. OR A.R.

CIRCUITS MODIFIED BY THIS DRAWING
SD-62651-01-012

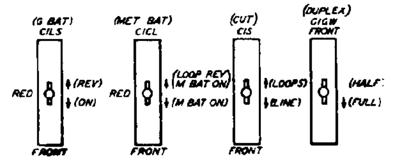


Fig. 28 - 20B2 Terminal Repeater - For Use with 4-wire Cable Circuits

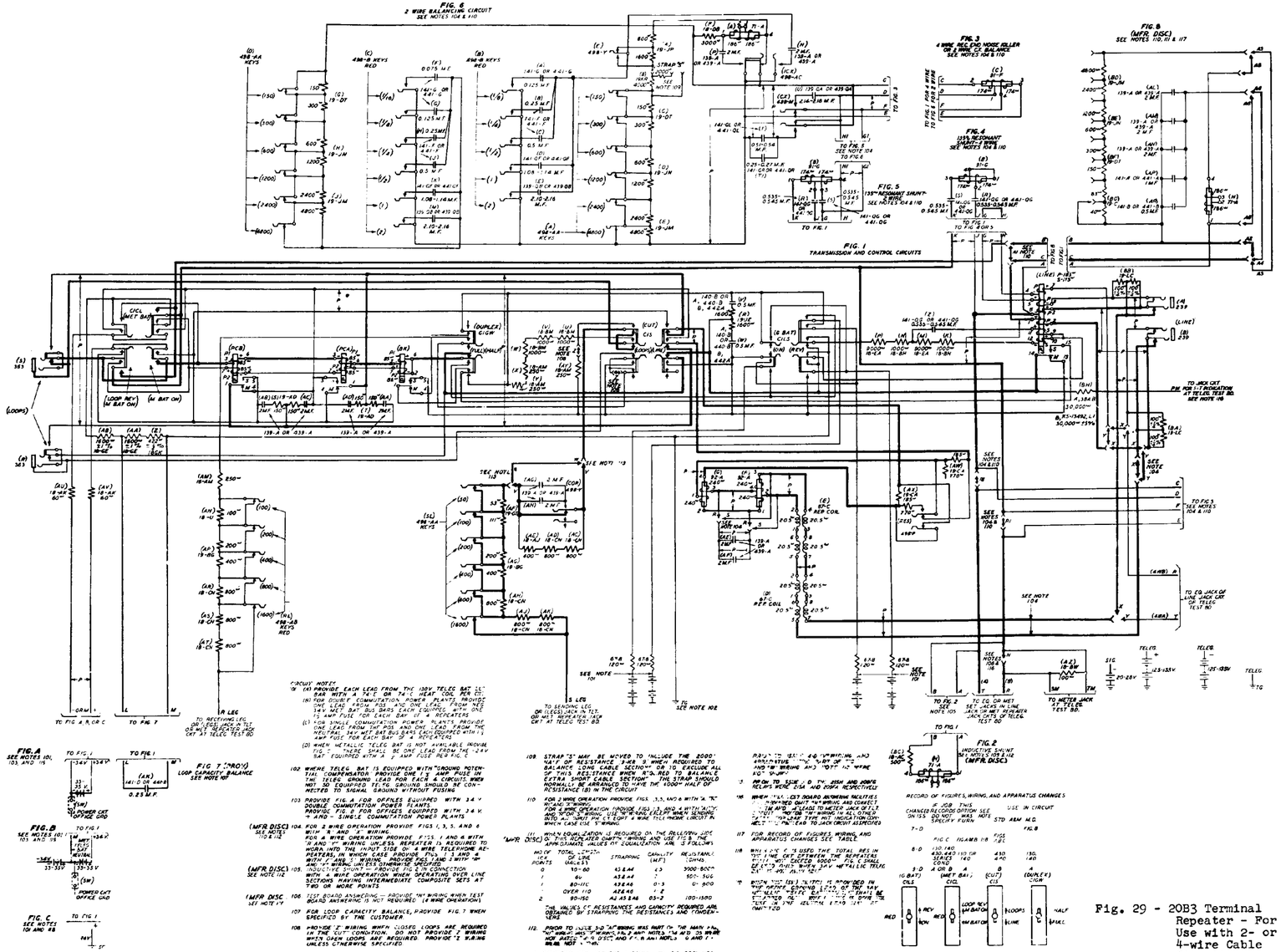
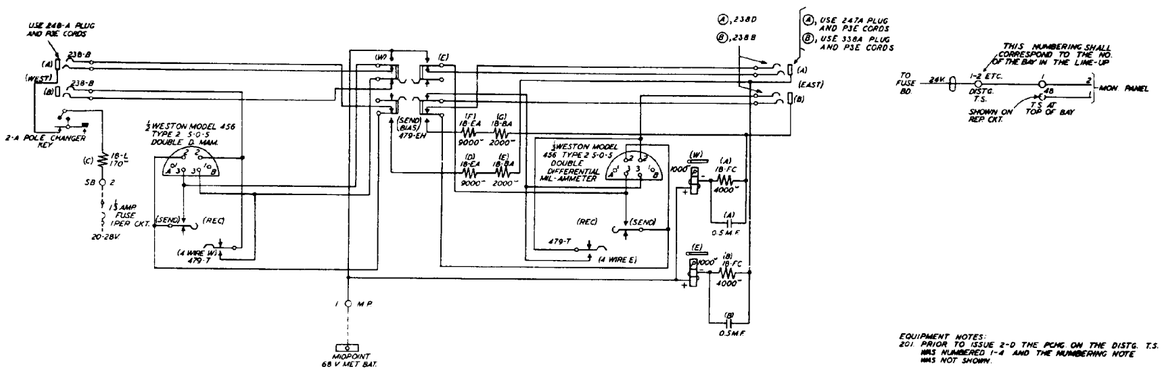
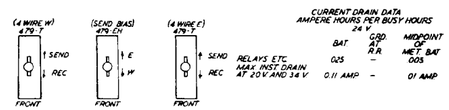


Fig. 29 - 20B3 Terminal Repeater - For Use with 2- or 4-wire Cable Circuits



EQUIPMENT NOTES:
201. PRIOR TO ISSUE 2-D THE PCMC ON THE DISTG. T.S. WAS NUMBERED 1-4 AND THE NUMBERING NOTE WAS NOT SHOWN.

RECORD OF FIGURES, WIRING, AND APPARATUS CHANGES								
CHANGED ON ISS.	IF JOB RECORDS DO NOT SPECIFY	THIS OPTION WAS FURN.		SEE NOTE	USE IN CIRCUIT			
					STD.	A&M	M D	
6-D	A OR B	A			B		A	

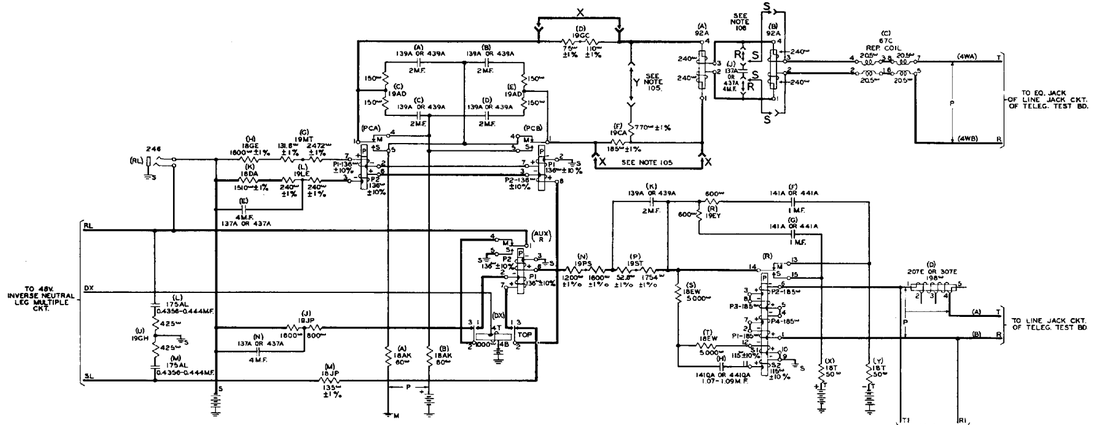


CURRENT DRAIN DATA
AMPERE HOURS PER BUSY HOURS

	RELAYS ETC. MAX INST. DRAIN AT 20 V AND 34 V	24 V BAT.	GRD. AT R.R.	MIDPOINT OF MET. BAT DOS
		GDS	-	
	0.11 AMP	-		01 AMP

Fig. 30 - 20BX3 Through Repeater - Monitoring Unit

FIG. 1



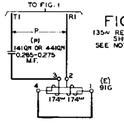


FIG. 2
135∼ RESONANT SHUNT
SEE NOTE 107

RECORD OF FIGURES, WIRING AND APPARATUS CHANGES							
IF JOB CHANGED ON 15, DO NOT SPECIFY	THIS OPTION WAS FURN.	SEE NOTE	USE IN CIRCUIT				
			STD.	A&M	M.D.		
130E AND 430 & 440 SERIES CONE	130E AND 430 & 440 SERIES		430 440		130 140		
207E OR 307E REL	207E REL		307E		207E		

CIRCUIT NOTES:

101. PROVIDE ONE LEAD FROM THE NEG. AND ONE LEAD FROM THE POS. 48 V. TELEG. BAT. BUS BAR, EACH EQUIPPED WITH A ½ AMP FUSE PER CKT.

102. PROVIDE ONE LEAD FROM THE POS. 24 V. METALLIC TELEG. BAT. BUS BAR EQUIPPED WITH A ½ AMP FUSE PER CKT.

103. PROVIDE ONE LEAD FROM THE NEG. 48V. SIG. BAT. BUS BAR EQUIPPED WITH ½ AMP FUSE PER CKT.

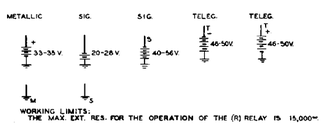
104. PROVIDE ONE LEAD FROM THE NEG. 24V. SIG. BAT. BUS BAR EQUIPPED WITH 1½ AMP. FUSE PER CKT. TOGETHER WITH THE ASSOCIATED LEG MULTIPLE CKT.

105. ON VERY SHORT CABLE CKTS. (35 MILES OR LESS OF NO. 19 GAUGE CABLE OR ITS EQUIVALENT) PROVIDE "Y" WIRING AND OMIT "X" WIRING TO LIMIT THE LINE CURRENT. IN ALL OTHER CASES PROVIDE "X" WIRING AND OMIT "Y" WIRING.

106. USE 19∼ WIRING EXCEPT WHEN MOUNTING INTO AN INPUT PH. CK. EQPT. 4-WIRE TELEPHONE CKT. IN WHICH CASE USE 14∼ WIRING. THE CHANGE FROM "R" TO "S" WIRING IS MADE ON THE TERMINALS OF COIL (B).

107. PROVIDE FIG. 2 WHEN REQUIRED TO ELIMINATE 135 CYCLE INTERFERENCE.

108. WHEN A SWITCH IS PROVIDED IN THE OFFICE GROUND LEAD OF THE 24 V. MET. TELEG. BATS. IT SHALL BE STRAPPED OUT.



WORKING LIMITS:
THE MAX. EXT. RES. FOR THE OPERATION OF THE (R) RELAY IS 15,000∼
THE TOTAL RES. INCLUDED IN LEAD "SL" OR LEAD "RL" BETWEEN THE REPEATER UNIT AND THE HUB SHALL IN NO CASE EXCEED 25∼

Fig. 32 - 20C1 Terminal Repeater - For Use with 4-wire Cable Circuits - Inverse Neutral Operation - 48 volts legs

CIRCUIT NOTES:

101. PROVIDE FUSING FOR LINE BATTERY SPECIFIED AS FOLLOWS:

FIG. SPEC.	AMP.	POTENTIAL FUSED	ONE PER
A	3/4	+34V. MET. TELEG.	CKT.
B	W	-24 V. SIG.	CKT.

4 FUSED WITH FIG. 3 OR 4

102. WHEN FIG. 3 IS USED, PROVIDE FUSING AS FOLLOWS:

AMP.	POTENTIAL FUSED	PER CKT.
74C OR 74E	+130V. TELEG.	2
HEAT COILS	-130V. TELEG.	2
1 1/3	-24V. SIG.	1

103. WHEN FIG. 4 IS USED PROVIDE FUSING AS FOLLOWS:

AMP.	POTENTIAL FUSED	ONE PER
1/2	+48V. TELEG.	CKT.
1/2	-48V. TELEG.	CKT.
1/2	-48V. SIG.	CKT.
1 1/3	-24V. SIG.	CKT. INCLUDING LEG. MULT. CKT.

104. WHEN FIG. 3 IS USED AND TELEGRAPH BAT. IS EQUIPPED WITH GROUND POTENTIAL CORRECTOR PROVIDE ONE 1½ AMP. FUSE IN TELEGRAPH GROUND LEAD PER CKT. OTHERWISE TELEGRAPH GROUND SHALL BE CONNECTED TO SIGNAL GROUND WITHOUT FUSING.

105. ON VERY SHORT CABLE CKTS., (.35 MILES OR LESS OF NO 19 GAUGE CABLE OR ITS EQUIVALENT) PROVIDE "I" WIRING AND OMIT "M" WIRING TO LIMIT THE LINE CURRENT WHEN F.D.A.R. IS USED. IN ALL OTHER CASES PROVIDE "A" WIRING AND OMIT "I" WIRING.

106. USE "B" WIRING EXCEPT WHEN SENDING INTO AN INPUT PH. CX. EQPT. 4 WIRE TELEPHONE CKT. IN WHICH CASE USE "D" WIRING. THE CHANGE FROM "A" TO "D" WIRING IS MADE ON THE TERMINALS OF COIL (B).

107. PROVIDE FIG. 2 WHEN REQUIRED TO ELIMINATE 135 CYCLE INTERFERENCE.

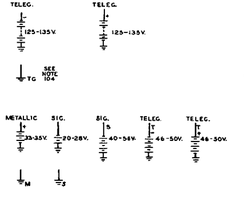
108. WHEN A SWITCH IS PROVIDED IN THE OFFICE GROUND LEAD OF THE 34V. MET. TELEG. BAT., IT SHOULD BE STRAPPED OUT.

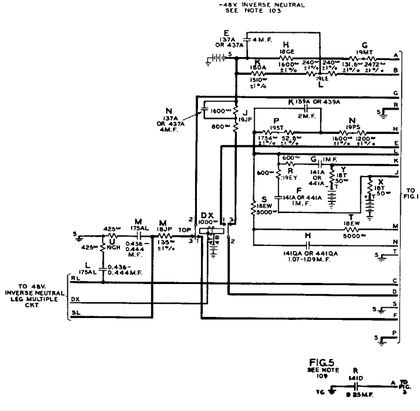
108. PROVIDE FIG. 5 WHEN REQUIRED TO PREVENT NICK-OFF ON LONG LOOPS.

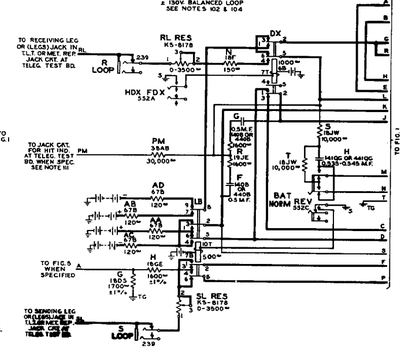
110. WHEN FIG. B IS USED THE TOTAL RESISTANCE IN THE LINE CKT. BETWEEN THE REPEATERS SHALL NOT EXCEED 8000 OHMS AND SHALL BE USED ONLY WHEN 34V. MET. TELEG. BAT. IS NOT AVAILABLE.

111. WHEN LEAK TYPE HIT INDICATION IS REQUIRED, CONNECT THE "PM" LEAD TO JACK CKT. AS SPECIFIED.

112. THE USE OF "W" OPTION IS "PROVISIONAL."







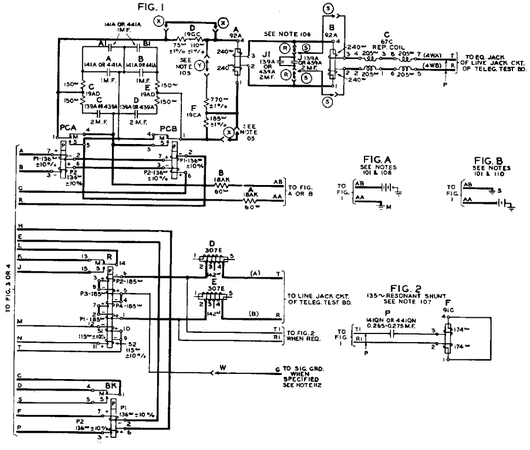


Fig. 33 - 20C2 Terminal Repeater - For Usw with 4-wire Cable Circuits - 130 Volt 60 Milliampere Loops or 48 Volt Inverse Neutral Operation