June 24, 1947. R. B. HEARN ET AL 2,422,677

INTERMEDIATE TELEGRAPH REPEATER FOR LONG LINE SPANS

Filed July 1, 1944 2 Sheets-Sheet 1

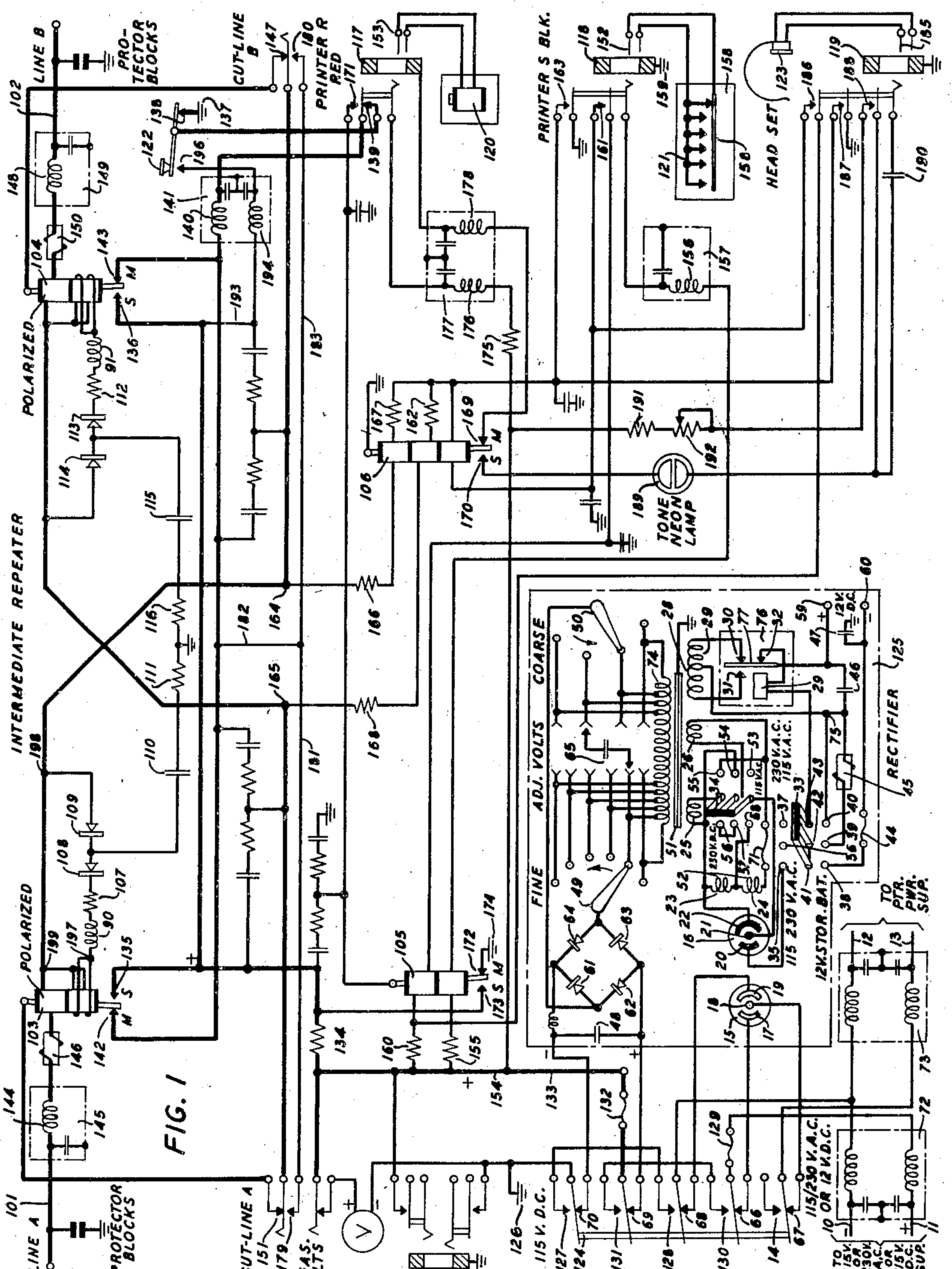

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FIG. 2

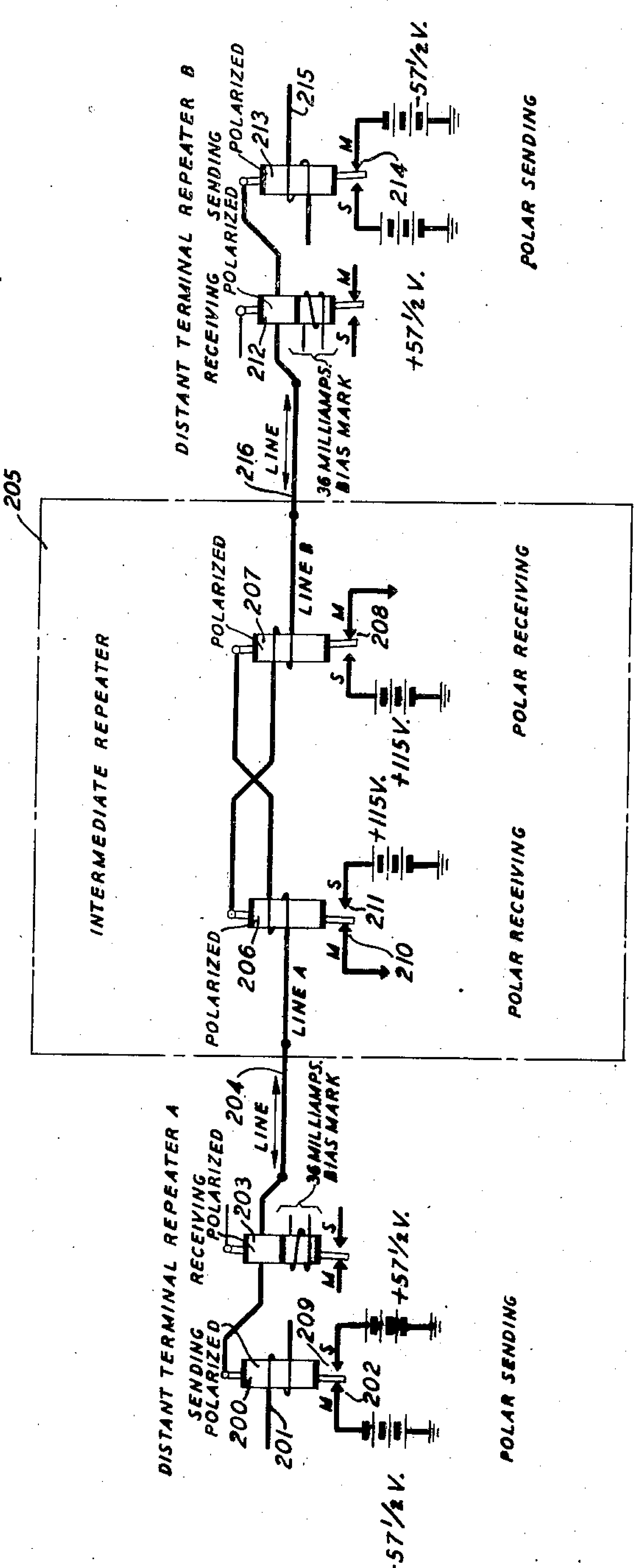


FIG. 4

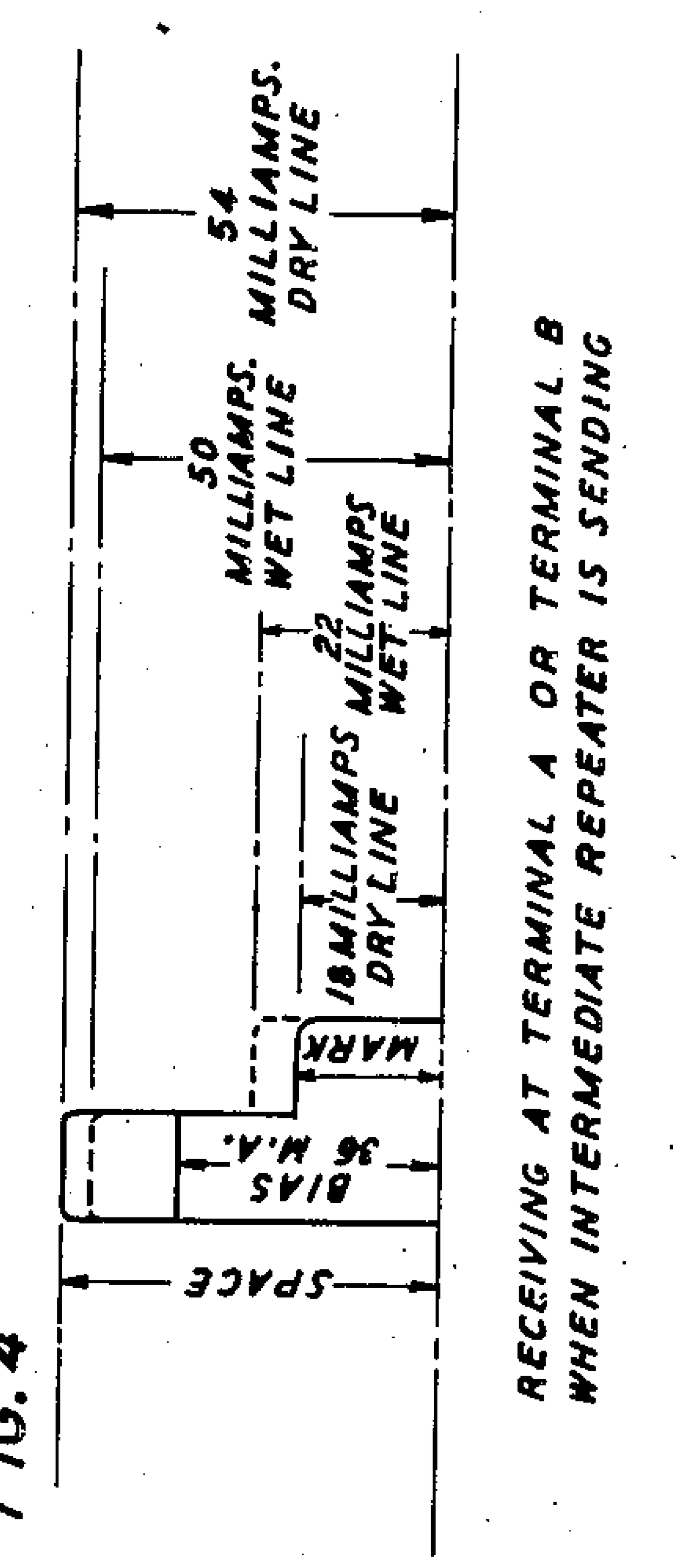
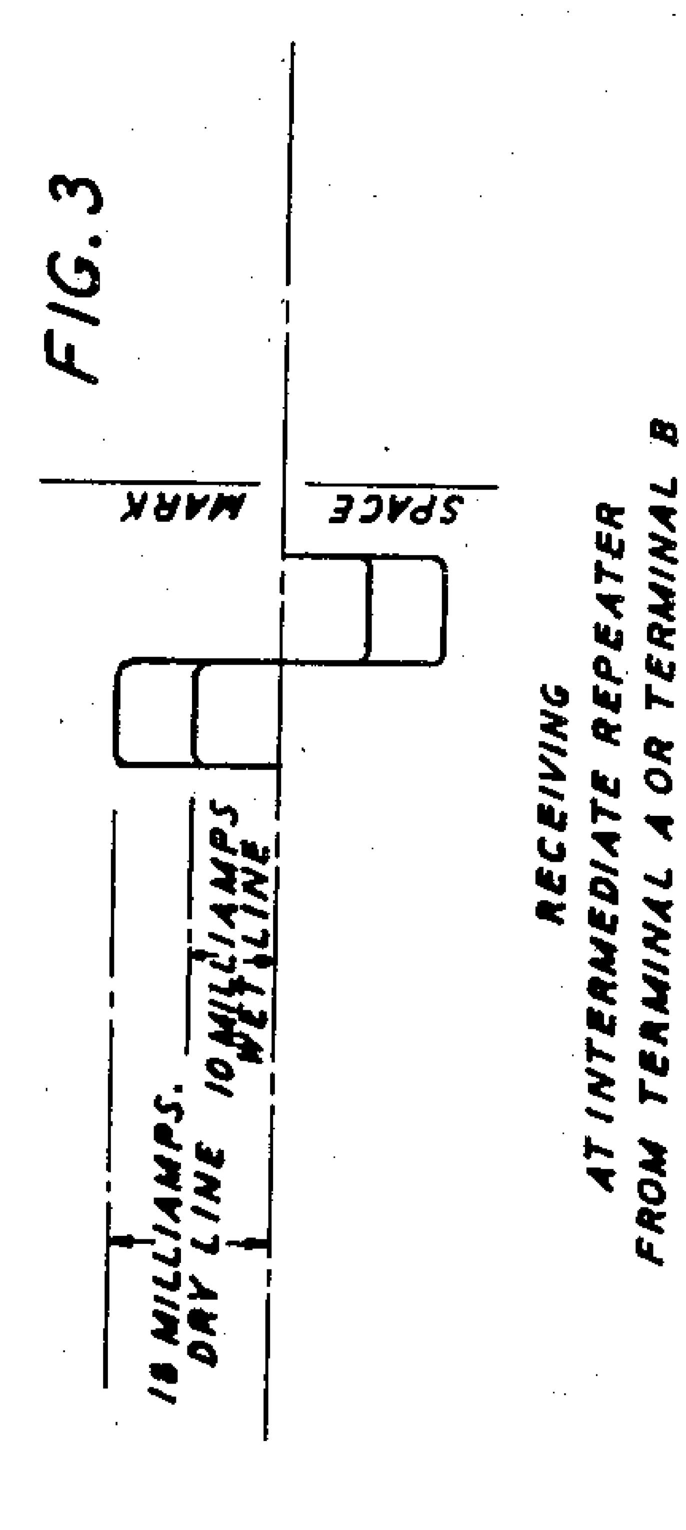


FIG. 3



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INTERMEDIATE TELEGRAPH REPEATER FOR LONG LINE SPANS

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Application July 1, 1944, Serial No. 543,112

12 Claims. (Cl. 178—71)

This invention relates to telegraph systems and particularly to an improved direct current telegraph intermediate repeater capable of receiving from one telegraph line section and retransmitting to another telegraph line section.

An object of the invention herein is the improvement of telegraph repeaters. A more specific object of the invention herein is the improvement of intermediate telegraph repeaters so as to insure satisfactory operation on lines of very long span. Another more specific object of the invention is the provision of local communication and monitoring facilities for an intermediate type B polarential repeater.

The improvements herein are shown applied to what is known in the art as a type B polarential telegraph repeater system. Such a system is disclosed in the patent to W. W. Cramer 2,131,870, October 4, 1938. The principles of operation of the type B polarential repeater system to which the invention herein is applied will be described sufficiently so that the manner in which the invention herein cooperates with such a system may be better understood.

The improved intermediate repeater herein provides half duplex operation only. The improvement consists in part in the addition of a monitoring feature to an intermediate repeater in a type B polarential repeater system.

The repeater herein is designed for operation on simplexed field wire line circuits, composited or simplexed open wire and simplexed cable facilities with ground return.

The repeater herein contains a built-in rectifier power unit. It is contemplated that a teletypewriter transmitter and receiver will ordinarily be used with the monitoring facilities. A manual telegraph set integral with the repeater equipment is furnished for use when teletypewriter equipment is not available for service.

The line sides of the repeater are arranged to employ the type B polarential, polar-receiving form of transmission.

The local side of the repeater is arranged for operation with a sending and receiving teletypewriter or a manual telegraph set.

A feature of the invention is an improved monitoring circuit for use with an intermediate repeater.

A further feature of the invention is an improved anti-kickoff feature for use in an intermediate repeater arranged for operation on lines of exceedingly high electrostatic capacity.

A further feature of the invention is a cutting feature arranged to permit communication from the monitoring circuit through the intermediate repeater over one line section when the opposite line section is out of service due to trouble, etc.

A further feature of the invention is an improved power supply arrangement adapted to convert power from a number of different types of sources to power of the characteristics required by the apparatus herein so that the repeater may be readily usuable under different conditions encountered in the field.

A further feature of the invention is a circuit which develops a characteristic tone for use with one form of telegraph signal receiver incorporated in a monitoring circuit associated with an intermediate repeater.

The operation of a system embodying these and other features will become apparent from the following description when read with reference to the associated drawings herein in which Fig. 1 shows the improved intermediate repeater of the invention. Fig. 2 is a circuit used in explaining the principles of operation of a type B polarential telegraph circuit with which the improved intermediate repeater herein is designed to cooperate. Figs. 3 and 4 are diagrams used in explaining the advantages of the type B polarential system per Fig. 2.

General

Before proceeding with a detailed description of the invention herein, the invention will first be described in a general way so that the detailed operation may be better understood.

It is to be understood that the invention herein is shown as applied to an intermediate repeater designed to function in a type B polarential telegraph system. The line side of the intermediate telegraph repeater herein is designed for type B polarential operation (polar sending). Telegraph repeaters using the type B polarential method of transmission do not require service adjustments to compensate for variations in the electrical characteristics of the line due to changes in the leakage resistance and the capacitance to ground as a result of changing weather conditions.

Polarential operation

Fundamentally a circuit operating on a polarential basis employs polar transmission in one direction and differential transmission in the other direction. These two terms have been combined to form the term polarential. In a polar transmission system the marking and spacing line currents are of the same magnitude and flow in opposite directions, and hence the receiving relay operates on the current reversals and requires no local bias circuit. In the differential direction of transmission of the polarential system the marking and spacing line currents flow in the same direction but are different in magnitude, the spacing current being about two and one-half times the marking current. A local biasing current is required at the differential receiving terminal which is fixed at half the sum of the marking and spacing line currents. The relay biasing winding is poled in such a manner as to hold the armature to its marking contact. Since the biasing current is greater than the marking line current the armature is held to its marking contact during a marking line signal. Since the spacing line current is greater than the biasing current the armature moves to the spacing contact during a spacing line signal. Thus the net operating effect on the relay is equivalent to polar transmission. To attain this equivalent in both directions of transmission the opposite ends of a potential circuit are made dissimilar. One end of the circuit applies a negative and positive polarity of the same value to the line during transmission. This end is known as the polar sending or differential receiving end. The other end of the circuit applies ground and positive polarity to the line during transmission. This is known as the differential sending or polar receiving end.

Refer now to Fig. 2, which shows two telegraph terminals connected through an intermediate repeater in a type B polarential telegraph system.

Intermediate repeater receiving from terminal A or terminal B

In Fig. 2 the repeaters at terminal A and terminal B are arranged for polar sending, and the intermediate repeater is arranged for polar receiving with respect to both terminal A and terminal B.

All of the relays shown in Fig. 2 are polar relays. They are shown with their armatures in their marking positions in which positions they will be maintained while the system is idle or while the relay is receiving a marking signal during communication. The armatures of the receiving relays **206** and **207** when they are in engagement with their marking contacts are connected to ground. The armature of the receiving relay **203** at terminal repeater A and of relay **212** at terminal repeater B are maintained in engagement with their respective marking contacts due to the effect of current in their biasing windings which is tending to actuate the armature of each towards its respective marking contact and which effect preponderates over the lesser effect in the line winding of each of these relays which is tending to actuate the armature of each towards its spacing contact. More specifically, to assume values for a typical case, a current of 36 milliamperes flows through the lower or biasing winding of relay **203** and of relay **212** tending to actuate the armature of relay **203** and of relay **212** towards its marking contact. A current of 18 milliamperes flows through the upper or line winding of each of these relays tending to actuate the armatures of each towards its spacing contact.

Armature of sending relay **200** is under control of winding **201**, which actuates the armature of relay **200** between its marking and spacing contacts when signals are originated at distant terminal A. When the armature of relay **200** is actuated to the left to engage its marking contact **202**, a circuit may be traced from ground through negative battery, contact **202**, top winding of relay **203** to the line **204** which interconnects terminal repeater A with the intermediate repeater **305**. The line extends through the winding of receiving relay **206** in the intermediate repeater through the armature of relay **207** and marking contact **208** to ground. When the armature of relay **200** is actuated to engage its spacing contact **209**, positive battery instead of negative battery is connected to the path just traced. The magnitudes of the voltages of the positive and negative batteries connected to the marking and spacing contacts of relay **200** are equal. It will be assumed that each has a potential of 57½-volts.

There is no biasing winding associated with the relays in the intermediate repeater. In response to the connection of negative 57½-volt battery to the marking contact **202** of relay **200**, the armature of relay **206** engages its marking contact **210**. In response to positive 57½-volt battery connected to spacing contact **209**, the armature of relay **206** engages its spacing contact **211**. While terminal repeater A is transmitting to the intermediate repeater, the armature of relay **207** is maintained in engagement with its marking contact **208**, so that ground remains connected to the receiving end of the line from terminal repeater A during transmission from terminal repeater A toward the intermediate repeater. The armature of receiving relay **206** follows the reversals of the armature of relay **200**. While negative 57½-volt battery is connected to line **204** at terminal repeater A the effect of the current in the top winding of relay **203** tends to actuate the armature of relay **203** towards its spacing contact, but as mentioned above the effect of the current in the biasing winding of relay **203** is dominant and the armature of relay **203** is maintained in engagement with its marking contact. When the armature of relay **200** is actuated to engage its spacing contact **209** the effect of the current in the upper or line winding of relay **203** is reversed so that it then tends to actuate the armature of relay **203** to engage its marking contact, augmenting the effect of the current in the lower or biasing winding. As a result of this, the armature of relay **203** is maintained in engagement with its marking contact during transmission from terminal repeater A toward the intermediate repeater.

Since ground remains connected to marking contact **208** while the polarity of batteries of equal potential at terminal repeater A is reversed in transmitting from terminal repeater A toward the intermediate repeater, the armature of receiving relay **206** will be affected by equal and opposite forces for the marking and spacing condition. As a result of this the armature of receiving relay **206** will respond with the same rate of speed for each signal transition and relay **206** will repeat the signals received from repeater A toward the distant terminal repeater B without difference in the duration of marking and spacing signal elements or without bias as this difference is called.

If the impedance of line A changes due to changed weather conditions, etc., the magnitude of the current received by relay **206** will be changed correspondingly, but the magnitude of the marking and spacing signals will remain equal and thus the operation of relay **206** will not be adversely affected by such change.

The distant terminal repeater B is connected to the intermediate repeater 205 in the same manner as is the distant terminal repeater A and the operation of the circuit when repeater B transmits toward the intermediate repeater is the same as described for the condition wherein repeater A transmits towards the intermediate repeater.

Reference to Fig. 3 shows the effect of weather conditions upon the marking and spacing signals received at the intermediate repeater. When the weather is dry the marking and spacing signal current is 18 milliamperes. When the weather is wet the received currents may be of any value less than 18 milliamperes, but they will be equal for each condition. Under the condition indicated in Fig. 3, it is assumed that 10 milliamperes is being received for each signal for a particular wet condition.

Intermediate repeater sending to terminal A or terminal B

The manner in which the intermediate repeater retransmits signals received from one terminal repeater toward the other terminal repeater will now be described. It will be assumed that terminal repeater A is transmitting toward the intermediate repeater and it will be explained how the intermediate repeater retransmits the signals received from repeater A to terminal repeater B and how terminal repeater B responds to the received signals.

In response to signals received from terminal repeater A the armature of receiving relay 206 in the intermediate repeater is actuated between its opposed contacts 210 and 211. For the marking condition the armature of relay 206 in the intermediate repeater engages its marking contact 210. The armature of sending relay 213 at the distant terminal repeater B will be maintained in engagement with its marking contact 214 under the influence of the current flowing in its winding 215. A circuit may then be traced from ground through marking contact 210 of relay 206 and the winding of relay 207 to line 216 which extends from the station at which the intermediate repeater is located to the station where the distant terminal repeater B is located. The circuit continues through the top or line winding of receiving relay 212 at the distant terminal repeater B and through the armature and marking contact 214 of relay 213 to negative 57½-volt battery and thence to ground. When the armature of relay 206 engages its spacing contact 211 positive 115-volt battery is connected to the circuit just traced.

If it is assumed that the direction of the flow of the current is from the point of higher positive potential toward the point of negative potential, when the armature of relay 206 is in engagement with its marking contact 210, the direction of the flow of current is from the intermediate repeater toward the distant terminal repeater B. When the armature of relay 206 engages its spacing contact 211, the positive 115-volt battery connected to contact 211 is in a series aiding relationship with the negative 57½-volt battery connected to the marking contact of relay 213 at terminal repeater B. The direction of the flow of current will therefore remain unchanged, although its magnitude is increased. The armature of relay 207 will be maintained in engagement with its marking contact 208 by the effect of each of these currents, each of which tends to actuate the armature towards its marking contact 208. In the case of receiving relay 212 at the distant terminal repeater B, for the marking condition the effect of the current in the upper or line winding of relay 212 is tending to actuate the armature of relay 212 towards its spacing contact. However, the effect of the current in the lower or biasing winding of relay 212 is dominant for this condition and the armature is maintained in engagement with its marking contact. For the spacing condition, however, when the voltage applied to the line is increased and the direction of the current in the line winding of relay 212 is the same as for the marking condition, its effect tending to actuate the armature of relay 212 towards its spacing contact is increased and the effect in the upper or line winding becomes dominant so that the armature of relay 212 is actuated to engage its spacing contact.

The total voltage applied to the line 216 during the marking interval is 57½ volts and during the spacing interval is 172½ volts, which is three times the voltage applied to the line during the marking interval. Therefore, the spacing line current is three times the marking line current when the intermediate repeater is sending. For a dry line condition these currents are 18 milliamperes for marking and 54 milliamperes for spacing.

Refer now to Fig. 4. This figure indicates how the signals received from the intermediate repeater at the terminal repeater are not biased as a result of changes in weather conditions. The current in the lower or biasing winding of the receiving relay such as 212 is supplied from a local battery at each terminal. For the constants which are assumed, its magnitude is fixed at 36 milliamperes which is half of the sum of the marking and spacing signal current. When the weather is wet the effect is as though a resistance were connected between the line 216 and ground. Thus the magnitude of the spacing current flowing through the top winding of relay 212 when the two batteries are in series will be decreased.

Assuming that the resistance of each repeater is equal, the voltage at the center of the line would be negative 28¾ volts during the marking interval and positive 28¾ volts during the spacing interval. Therefore, the current through the leakage path would be approximately the same magnitude for the marking or spacing condition if the leakage is lumped at the center or uniformly distributed over the line. Thus if the leakage current is about 4 milliamperes, the marking current in the upper winding of relay 212 is increased by that amount and the spacing current is decreased an equal amount. Under such a condition the magnitude of the spacing current will be 50 milliamperes and the magnitude of the marking current will be 22 milliamperes. The sum of these two currents is still 72 milliamperes as before and the magnitude of the biasing current of course remains 36 milliamperes. The difference therefore between the magnitude of the biasing current and the magnitude of the spacing current remains the same as the difference between the magnitude of the biasing current and the magnitude of the marking current and the receiving relay 212 responds without bias to the signal elements regardless of changing weather conditions.

In transmitting from the intermediate repeater 205 towards terminal repeater A the operation is the same as described for transmission from intermediate repeater 205 towards terminal repeater B.

The invention herein is an improved intermediate repeater which serves the same purpose as the intermediate repeater 205 in the system per Fig. 2 described above. The improved repeater is shown in Fig. 1. The improvements as mentioned above consist chiefly in the provision of, (1) a monitoring circuit arranged to cooperate with such an intermediate repeater as is shown in Fig. 2, (2) an anti-kickoff feature which permits the intermediate repeater of the invention herein to function with lines subject to very heavy current surges due to very high capacity between the line and ground, without preventing its use on lines of low capacity and (3) improved power supply facilities which adapt the intermediate repeater herein for operation with a variety of power supply arrangements such as are encountered by portable telegraph repeaters in the field.

Improved Intermediate Repeater

Refer now to Fig. 1. In this figure an intermediate repeater is shown in which the basic transmission features are the same as described for intermediate repeater 205 per Fig. 2 but the repeater is equipped with a special monitoring circuit, an improved anti-kickoff circuit and an improved power supply circuit.

In Fig. 1, lines 101 and 102 correspond to lines 204 and 216, respectively, in Fig. 2 and extend to distant terminal repeaters corresponding to distant terminal repeaters A and B, respectively in Fig. 2. Relay 103 corresponds to relay 206 and relay 104 corresponds to relay 207 in Fig. 2. Two new relays, sending relay 105 and receiving relay 106, both of which function in the improved monitoring circuit, have been added to the intermediate repeater. In the case of relays 206 and 207 in Fig. 2 there was but a single winding, namely, the line winding, on each of the relays. Relays 103 and 104 each have two additional windings. In addition to the top or line winding on each of these relays, the two lower windings of each are connected in an improved anti-kickoff circuit comprising the two windings, two resistances such as 107 and 111, two rectifier units such as 108 and 109, a condenser such as 110, and the inductance coil 90 all of which are associated with the anti-kickoff circuit of relay 103.

The intermediate repeater per Fig. 1 may be arranged so that the monitoring facilities are in effect disconnected. Such is the condition when no apparatus is connected to any of the three jacks, 117, 118 and 119 shown at the lower right of the figure. The monitoring circuit is arranged to function either with teletypewriter facilities such as the receiving teletypewriter apparatus, indicated by the receiving magnet 120, and the teletypewriter transmitting apparatus, indicated by the transmitting contacts 121, or with a manual telegraph transmitting key and a telephone headset receiver such as 122 and 123, respectively. All of this apparatus is well known in the art. When no apparatus is connected to jacks 117, 118 and 119, which is the condition shown in the drawing, the circuit per Fig. 1 is arranged to function as an intermediate repeater without monitoring facilities.

As stated above, the circuit per Fig. 1 is arranged to function with various power supply arrangements. For the present it will be assumed that the circuit is to function with a 115-volt direct current supply in which case the power circuit included in rectangle 125 performs no function. Key 124 is actuated so as to engage its upper contacts. The negative terminal of the 115-volt direct current supply is connected to ground 126 through contacts 127 and 128 of key 124 to the negative terminal of the 115-volt direct current supply. From the positive terminal of the 115-volt direct current supply a circuit may be traced through fuse 129, contact 130, contact 131 and fuse 132 to bus bar 133 from which point parallel branches extend. One branch extends through resistance 134 to spacing contact 135 of relay 103 and spacing contact 136 of relay 104. A circuit may also be traced from ground 137 through contact 138 of key 122, contact 139 of jack 117 and through the inductance coil 140 of filter 141 to marking contact 142 of relay 103 and marking contact 143 of relay 104. From this it may be seen that the battery conditions connected to the marking and spacing contacts of relays 103 and 104 are the same as for the corresponding relays in intermediate repeater 205 in Fig. 2.

It was explained above that the distant end of the line 204 in Fig. 2 which corresponds to line 101 in Fig. 1 is connected to negative 57½-volt battery for the marking condition. A circuit may be traced in the intermediate repeater per Fig. 1 through inductance 144 of filter 145, inductance 146, top or line winding of relay 103, contact 147 of the B-cut line key and through the armature of relay 104 which is in engagement with its marking contact 143 from which point the circuit has been traced to ground. On the opposite side of the repeater line 102 which corresponds to line 216 in Fig. 2 is terminated at the distant terminal repeater B in negative 57½-volt battery. The circuit may be traced in the intermediate repeater per Fig. 1 through inductance 148 of filter 149, inductance 150, top or line winding of relay 104, contact 151 of the A-cut line key and the armature of relay 103 which is in engagement with its marking contact 142 from which point the circuit has been traced to ground 137. The effect of the anti-kickoff circuits will be described hereinafter. Disregarding this effect, which tends to counteract heavy line current surges, relays 103 and 104 will operate in the same manner as described above for relays 206 and 207 in the intermediate repeater 205 per Fig. 2.

Monitoring circuit

The manner in which the monitoring circuit functions will now be described. It will be assumed that the teletypewriter monitoring facilities are to be employed. The teletypewriter transmitter and receiver are each equipped with a cord and a plug so that they may be connected to and disconnected from jacks in the monitoring circuit. When the teletypewriter transmitter and receiver are to be used for monitoring, plug 152 is connected to jack 118 to interconnect the teletypewriter transmitter 121 and the monitoring circuit and plug 153 is connected to jack 117 to interconnect the typewriter receiver 120 and the monitoring circuit. When plug 153 is inserted in jack 117, contact 139 is opened and contact 171 is closed. This transfers the path supplying ground 137 to the intermediate repeater to a path that extends through the armature of relay 105 and its marking contact 172 to ground 174. A circuit may now be traced from the positive bus bar 154 through resistance 155, bottom winding of relay 105, inductance 156 of filter 157, tip of jack 118, tip of plug 152, teletypewriter transmitting contacts 158, ring of plug 152, and the ring of jack 118 to ground 159. A circuit may also be traced from the positive bus bar 154 through resistance 160, top winding of relay 105, contact 161 of jack 118, bottom winding of relay 106, and contact 163 of jack 118 to ground. The first of the above two paths extended through the bottom winding of relay 105 and the second extended through the top winding of relay 105. The effect of the current flowing through the bottom winding of relay 105 tends to actuate an armature of relay 105 to engage with its right-hand or marking contact and when teletypewriter contacts 121 are closed, this effect is dominant over the effect of current flowing in the top winding of relay 105 which tends to actuate the armature of relay 105 toward the left to engage with its spacing contact. When the teletypewriter transmitting contacts 121 are open, the circuit through the bottom winding of relay 105 is deenergized and the armature of relay 105 is actuated to close its spacing contact under the influence of the current in its upper winding. The effect of the current flowing through the bottom winding of relay 106 tends to actuate the armature of relay 106 to engage with its right-hand or marking contact.

From junction point 164 in the path extending toward the distant repeater A, a branch extends through resistance 166, top winding of relay 106, resistance 167 and contact 163 to ground. From junction point 165 in the path extending toward the distant repeater B, a branch extends through resistance 168, middle winding of relay 106, resistance 162 and contact 163 to ground. When the distant terminal repeaters are terminated in negative battery for the marking condition, there is no current flowing in each of the two upper windings of relay 106, since the paths from junction points 164 and 165 through each of the two upper windings of relay 106 are shunted by a path to ground which has been traced in the main repeater circuit. For the marking condition therefore the current in the lower winding of relay 106 is holding the armature of relay 106 on its marking contact.

It will be assumed that the armature of the sending relay in distant terminal repeater A impresses positive battery on line 101 to transmit a spacing signal toward the intermediate repeater. As explained above, the voltages impressed on line 101 at the distant terminal are equal in magnitude and of opposite polarity for the marking and spacing conditions. The effect of the current of reversed polarity in the top winding of relay 103 operates the armature of relay 103 to its spacing contact. Operation of relay 103 to its spacing contact removes ground and applies positive 115-volt battery to junction point 165. This causes a current to flow in the middle winding of relay 106 which is poled in such a manner and is of sufficient magnitude to overcome the effect of the current flowing in its lower winding, thus operating the armature to spacing contact 170. When the armature of relay 103 is again actuated to engage its marking contact 142, the conditions prevailing originally in all three windings of relay 106 will be reestablished and its armature will again engage its marking contact.

As the armature of relay 106 follows the received signals, ground connected to the armature is alternately connected to and disconnected from the circuit extending through the winding of the receiving magnet 120. This circuit may be traced for the marking condition from positive battery at bus bar 154 through resistance 175, inductance 176 of filter 177, tip of jack 117, tip of plug 153, winding of the teletypewriter receiving magnet 120, sleeve of plug 153, sleeve of jack 117, inductance 178 of filter 177 and the marking contact 169 of receiving relay 106 to ground energizing magnet 120. When marking contact 169 is opened, the receiving magnet 120 is deenergized.

The manner in which signals are transmitted from the teletypewriter transmitter 121 will now be described. It was explained above that as the teletypewriter contacts 121 were opened and closed, the armature of relay 105 was actuated so as to follow the signals. When the armature of relay 105 is in engagement with its marking contact 172, ground 174 is connected through contact 172 to marking contacts 142 and 143 of relays 103 and 104, respectively. The path has heretofore been traced. When teletypewriter 121 is transmitting, the armatures of relays 103 and 104 remain in engagement with their respective marking contacts. Thus, ground for the marking condition is impressed on lines 102 and 101 simultaneously. When a spacing signal is transmitted from sending relay 105, the armature of relay 105 is actuated to engage its spacing contact 173. Spacing contact 173 is connected to the 115-volt positive battery bus bar 154 through resistance 134. Positive 115-volt battery is thus impressed through marking contacts 142 and 143 of relays 103 and 104 on lines 102 and 101 to transmit a spacing signal to the distant terminal repeaters A and B simultaneously.

Cutting feature

The intermediate repeater herein includes a cutting feature to facilitate the location of trouble and to permit limited communication while trouble conditions prevail. It will be assumed that plugs 152 and 153 remain inserted in jacks 118 and 117 respectively. When the circuit to distant terminal repeater A appears to be in trouble, cut line A key may be operated to its alternate position in order to establish communication with distant terminal repeater B. Operation of cut line key A disconnects the line winding of relay 104 from the armature of relay 103, through the opening of contact 151 and connects it directly, through contact 179, conductors 181 and 182, to the armature of relay 105. In response to the operation of transmitter 121, ground for marking and 115-volt positive battery for spacing will be connected through the contacts of relay 105, contact 171, inductance 140 of filter 141, conductors 182 and 181, contact 179 and the top winding of relay 104 to line 102. Simultaneously, the same signals will also be impressed on line 101 through the normal path for transmission from the monitoring circuit which has been traced through the marking contact of relay 104. If the circuit to distant terminal repeater B cannot be established and communication to distant terminal A is satisfactory cut line B key may be operated to open contacts 147 and close contacts 180. This disconnects the armature of relay 104 in a manner similar to that just described for cut key A. Signals may then be impressed on line 101 from the contacts of relay 105 through contact 171, inductance 140 of filter 141, conductors 182 and 183, contacts 180 and through the top winding of relay 103 to line 101. Simultaneously, the signals will continue to be transmitted to line 102 through marking contact 142 of relay 103. As soon as the circuit is reestablished both circuits will immediately receive signals from the intermediate repeater. Furthermore, even though contact 179 is closed and contact 180 is open, signals incoming over line 102 will be repeated through relay 104 to line 101. Correspondingly, when contact 180 is closed and contact 179 is open signals incoming from line 101 will be repeated to line 102.

Attention is called to the fact that when signals are transmitted from the teletypewriter transmitter 121, operating relay 105, two transmitting paths are established for each of the above-described conditions, each of which paths, in extending from the armature of relay 105 to lines 101 and 102, passes through junction points 164 and 165 in each instance. For the marking condition junction points 164 and 165 are connected simultaneously through contact 172 to ground. For the spacing condition junction points 164 and 165 are connected simultaneously through contact 173 to positive 115-volt battery. Relay 106 will, therefore, follow the signals from teletypewriter transmitter 121 and impress the signals on the teletypewriter receiver magnet 120 to provide a home copy of the message transmitted from the teletypewriter transmitter 121 in the monitoring circuit.

Manual telegraph set circuit operation

When the monitoring circuit is to be arranged for manual operation instead of teletypewriter operation, the teletypewriter receiver 120 and teletypewriter transmitter are not connected through their associated plugs and jacks to the monitoring circuit. Contacts 161, 163 and 171 are open and contact 139 is closed. The headset receiver 123 is connected through plug 185 to jack 119. Contacts 186, 187 and 188 are closed.

The opening of contact 163 and the closing of contact 187 transfer the ground termination of the three right-hand terminals of the three windings of relay 106 from the former to the latter contact. The opening of contacts 161 deenergizes the top or biasing winding of relay 105. The disconnection of plug 152 from jack 118 opens the path through the lower or operate winding of relay 105. Relay 105 plays no part in manual operation of the monitoring circuit. The left-hand terminal of the bottom winding of relay 106 is connected through closed contact 186 of jack 119 to resistance 160, thence to bus-bar 154 which connects to positive 115-volt battery. The reclosing of contact 139 reconnects marking contacts 142 and 143 of relays 103 and 104 to ground 137 for the marking condition. When manual telegraph key 122 is depressed, ground 137 is disconnected from its marking contacts and positive battery from bus-bar 154 is connected through resistance 134, conductor 193, inductance 194 of filter 141, and contact 196 of key 122, from which point the circuit has been traced through marking contacts 142 and 143 of relays 103 and 104 to lines 102 and 101 respectively. Thus ground for marking and 115 volts for spacing are alternately connected to lines 102 and 101 simultaneously through the operation of key 122.

Relay 106 will respond to signals transmitted from key 122. Its operation for manual operation of key 122 is the same as for the operation of teletypewriter transmitter 121 except that changes of potential of points 164 and 165 with respect to ground through the two top windings of relay 106 are controlled by key 122 rather than by relay 105.

Relay 106 will respond to signals incoming from line 101 or line 102. The operation of relay 106 for either the transmitting or receiving condition while the monitoring circuit is arranged for manual operation will cause a tone to be generated in an oscillating circuit when the armature of relay 106 engages its spacing contact. The tone may be heard in the receiver 123. The oscillating circuit comprises the neon lamp 189, resistance 191, adjustable potentiometer 192, condenser 190 and the receiver 123. The circuit may be traced from positive 115 volts at bus-bar 154, through resistance 191, variable potentiometer 192 and contact 188 of jack 117 to parallel branches. One branch extends through condenser 190, tip of jack 117, tip of plug 185, receiver 123, sleeve of plug 185, and the sleeve of jack 119 to ground. The other branch extends through the neon lamp 189 to spacing contact 170. When the spacing contact is closed the branch is terminated in ground. Potentiometer 192 may be adjusted to provide a wide range of frequencies within the audible range. In the idle or marking condition the neon lamp 189 does not function since relay 106 is held to its marking contact by the biasing current in its lower winding. When battery is applied to both the upper windings of relay 106 by operation of the key 122 or to one winding by the operation of relay 103 or 104, contact 170 of relay 106 closes and a tone is heard in the receiver.

Antikick-off feature

The intermediate repeater of the invention herein is arranged to insure against false operation of relays 103 and 104 due to current surges of very high magnitude caused by exceeding high capacity between the lines 101 or 102 and ground.

Previously in the art, when operating over lines having appreciable capacity, it was customary to provide a balancing network with constants approximating the constants of the line so that surge currents were applied through a balancing winding on the relay to balance out the effect of surge currents through the operating winding. The present circuit uses an arrangement whereby a heavy charge is stored in a condenser to hold the relay armature on its marking contact during the interval while a heavy surge through the operating winding is tending to kick the armature toward the spacing contact. This permits the operation of this repeater on lines having a wide range of capacity without the necessity for making adjustments to compensate for the capacity.

The manner in which the improved antikick-off feature of the invention herein functions will now be explained for the case of relay 103.

It will be assumed that the current and voltage conditions have become stabilized for the marking condition. Negative battery is connected to the left-hand terminal of the top winding of relay 103 and ground is connected to its right-hand terminal. The effect of the current in the top winding of relay 103 tends to actuate the armature of relay 103 to the left to engage its marking contact 142. When conditions are stabilized for the marking condition there is no current flowing in the two bottom windings of relay 103. Attention is called to the fact that these two windings are connected in parallel and the effect of each of the two antikick-off windings is the same as the effect of the other. Junction points 198 and 199 are each at ground potential as the armature of relay 104 is connected to ground. Both terminals of condenser 110 are substantially at ground potential.

When the armature of relay 104 engages its spacing contact the potential of junction points 198 and 199 becomes approximately 115 volts positive. Rectifier 109 is poled so that it passes current from battery of positive polarity. The current charges condenser 110. No current flows through the two antikick-off windings for this condition as rectifier 108 is poled so that it does not pass current due to positive potential applied between junction point 199 and ground. Current flowing through rectifier 109 to the condenser 110 could pass through rectifier 108 but junction points 198 and 199 are at the same potential. During the spacing interval line 101 becomes charged. The portion of line 101 adjacent the intermediate repeater per Fig. 1 will be heavily charged positively with respect to ground. When the armature of relay 104 is again actuated to engage its marking contact, line 101 will be grounded. A heavy surge of current due to the discharge of the positively charged line will be conducted from the left-hand to the right-hand terminal through the top winding of relay 103. Since positive potential when applied to the right-hand terminal of the top winding of relay 103 tends to actuate the armature of relay 103 to engage its marking contact, the effect of the positive potential applied to the left-hand terminal of the top winding of relay 103 will tend to actuate its armature falsely to its spacing contact for an interval until conditions become stabilized. The length of the interval will depend on the magnitude and duration of the discharge surge.

The constants of the antikick-off circuit are so chosen that they produce an effect on relay 103 which preponderates over the effect of the kick-off surge. When in effect marking ground is connected to junction points 198 and 199, condenser 110 discharges. The discharge current cannot flow through rectifier 109 as it is so poled that it cannot pass current of positive polarity which will be applied from the left-hand terminal of condenser 110. Rectifier 108 is so poled that it passes current of positive polarity from the left-hand terminal of condenser 110. The terminals of the two bottom windings of relay 103 are so connected that the effect of the current flowing through rectifier 108 from condenser 110 and the two bottom windings of relay 103 in parallel tends to maintain the armature of relay 103 on its marking contact, during the interval while the kick-off current surge persists. Resistance 107 and inductance 90 assist in controlling the rate of discharge of condenser 110 through the lower windings of relay 103.

The presence of rectifier 108 in series with the lower windings of relay 103 materially lessens the shunting effect of the condenser 110 with its discharge circuit, on the windings of relay 103. Without the rectifier 108 this effect would have a very detrimental influence in that it would make relay 103 very sluggish so that it would not follow the signals received from the line with the same degree of accuracy achieved through the use of rectifier 108. This permits operation over lines having appreciably higher capacity than would otherwise be possible.

Power supply circuit

Attention was called in the foregoing to the fact that the intermediate repeater per Fig. 1 was arranged to be supplied with power from a number of different sources. It has been assumed heretofore that the power was obtained directly from a 115-volt direct current source. For this condition rectifier circuit 125 was not required and switch 124 was actuated upwardly. The power circuit 125 is arranged so that it can, for example, convert 115-volt or 230-volt alternating current into 115-volt direct current. Further, the power circuit is arranged so that it can convert current from a relatively low voltage direct current source into direct current of a higher voltage. For instance 12-volt direct current may be converted into 115-volt direct current to operate the repeater herein. Conductors 10 and 11 may be connected to a 115-volt alternating current or a 230-volt alternating current, or to a 115-volt direct current supply. If the source is 115 volts direct current, switch 124, as mentioned above, is operated upwardly. Power rectifier circuit 125 is not involved under this condition. Conductor 10, which is grounded through contacts 128 and 127 at 126, connects to conductor 12 which forms one of the power supply conductors for the teletypewriter transmitter and receiver. Conductor 11 extends through fuse 129 and contact 14 of switch 124 to conductor 13 to form the other power supply conductor for the printer. 115-volt direct current is furnished as a power supply for the teletypewriter for this condition.

If conductors 10 and 11 are connected to a 115-volt alternating current supply switch 124 will be in the position shown. Plug 15 will be inserted in jack 16. Switch 33 will be closed to engage its upper contacts 35, 36 and 37. Switch 34 will be closed to engage its right-hand contacts 53, 54 and 55. Conductor 10 connects to conductor 12 which forms one of the two power supply conductors for the printer. Conductor 10 also extends through contact 68, contact 19, contact 22, coil 25 of transformer 51, the top switch blade of switch 34, contact 55, fuse 71, contact 36, middle switch blade of switch 33, contact 42, contact 41, left-hand switch blade of switch 33, contact 35, contact 20, contact 17, contact 66, and fuse 129 to conductor 11. Coil 26 of transformer 51 is connected in parallel with coil 25 across contacts 20 and 22 through the middle blade of switch 34 and contact 54. Conductors 11 and 13 are joined in the following manner: From conductor 11, through fuse 129, contact 66, contact 17, contact 20, contact 35, left-hand blade of switch 33, contact 41, contact 42, middle blade of switch 33, contact 36, fuse 71, contact 53, bottom blade of switch 34, contact 21, contact 18 and contact 67 to conductor 13. 115-volt alternating current power is supplied to the teletypewriter for this condition. The voltage impressed through coils 25 and 26 in parallel induces a voltage in the secondary 74 of the transformer 51. Various taps from the secondary of transformer 74 are brought out to contact points on switches 49 and 50. Switch 50 provides a coarse voltage adjustment and switch 49 provides a fine voltage adjustment. The voltage output from the switches is impressed across the input of the rectifier bridge comprised of rectifiers 61, 62, 63 and 64. The rectified output of the rectifier bridge is impressed through contacts 69 and 70 between ground 126 and bus-bar 154. The constants of the rectifier circuit are chosen so as to translate the 115-volt alternating current supply into 115-volt direct current voltage. Shunt condenser 48 and the series inductance filter out any alternating current in the output of the rectifier bridge.

When conductors 10 and 11 are connected to

230-volt alternating current, switch 124 is in the position shown. Plug 15 is inserted in jack 16. Switch 33 is operated to engage contacts 35, 36 and 37. Switch 34 is operated to engage contacts 56, 57 and 58. This results in the connection of coils 25 and 26 in series through the two top blades of switch 34 across the contacts 20 and 22 across which the 230-volt alternating current is impressed over a circuit which should be obvious from the foregoing. Coils 23 and 24 of autotransformer 52 are also bridged across the 230-volt alternating current supply contacts 20 and 22. A tap from the mid-point of these coils supplies 115-volt alternating current voltage to the teletypewriter for this condition, over a path through the bottom blade of switch 34 to contact 21, from which point the circuit has been traced to lower conductor 13 of the printer power supply circuit. When coils 25 and 26 are connected in series across a 230-volt alternating current power supply the output between ground and bus-bar 154 is 115-volt direct current voltage as formerly.

When a 12-volt direct current power supply is used the teletypewriter is not used and no power is supplied to conductors 12 and 13. The 12-volt direct current is translated into 115-volt direct-current in the following manner. Switch 124 is in the position shown. Plug 15 is not connected to jack 16. Switch 34 stands open as shown. Switch 33 is actuated to engage contacts 38, 39 and 40. The 12-volt direct current supply is connected across contacts 59 and 60. A circuit may now be traced from contact 60, through fuse 44, contact 38, left-hand blade of switch 33, contact 41, contact 42, middle blade of switch 33, contact 40 and inductance coil 45 to junction point 75 where parallel branches are formed. One branch extends through contact 40, right-hand blade of switch 33, contact 43, winding 29 of vibrator 76 and contact 32 to contact 59. The second branch extends from junction point 75 to the mid-point of coils 27 and 28 of transformer 51. When contact 30 is closed the circuit continues through coil 27 and contact 30 to contact 59. Coil 27 is energized. Winding 29 is energized actuating armature 77 to open contact 30 and close contact 31. Coil 28 is energized and its effect is in a direction the reverse from that of coil 27 when coil 27 was energized. When contact 32 opens magnet 29 is deenergized to reestablish the original circuit. The result is the impressing of an alternating voltage on the secondary 74 of transformer 51 which is translated into 115 volts direct current and applied between bus-bar 154 and ground.

What is claimed is:

1. In a direct current telegraph system, a pair of terminal telegraph repeaters, an intermediate telegraph repeater, a telegraph path interconnecting said terminal repeaters extending through said intermediate repeater, means in said system for transmitting polar telegraph communication signals from said terminal repeaters toward said intermediate repeater, means in said systems for transmitting a first and a second communication signal each of the same polarity but each of different magnitude from said intermediate repeater toward said terminal repeaters and a monitoring circuit bridged directly to said intermediate repeater for monitoring on signals transmitted over said system.

2. In a type B polarential telegraph system, an intermediate telegraph repeater, a local monitoring circuit bridged directly to said intermediate repeater, means in said local circuit for receiving signals transmitted through said system, and means in said circuit for transmitting signals from said circuit to said system.

3. In a polarential telegraph system, an intermediate telegraph repeater, means in said repeater for transmitting telegraph communication signals of different magnitudes and of the same polarity to a distant repeater, means in said repeater for receiving polar telegraph signals from said distant repeater, a local telegraph monitoring circuit bridged directly to said intermediate repeater, means in said local circuit for receiving signals transmitted through said intermediate repeater, and means in said local circuit for transmitting signals of the same polarity and of two different magnitudes through said intermediate repeater to said distant repeater.

4. An intermediate telegraph repeater, means connected to said repeater for impressing polar telegraph signals on said repeater, means in said intermediate repeater for transmitting two telegraph communication signals each of the same polarity and each of a different magnitude in response to said impressed signals, a local monitoring circuit bridged directly to said repeater, a telegraph receiving relay and a telegraph transmitting relay in said monitoring circuit, means connected to said repeater for operating said receiving relay in response to said signals impressed on said repeater, and means in said monitoring circuit for transmitting two communication signals each of the same polarity and each of a different magnitude from said transmitting relay through said intermediate repeater.

5. A direct current telegraph repeater system comprising an intermediate telegraph repeater, a first means for receiving polar signals in said repeater from a first distant repeater, a second means for transmitting a signal current of a first magnitude and a signal current of a second magnitude, different from said first magnitude, both of said currents of the same polarity, from said intermediate repeater to a second distant repeater in response to said received signals, a monitoring circuit bridged directly to said intermediate repeater, teletypewriter transmitting and receiving means in said monitoring circuit, means for operating said teletypewriter receiving means in response to said polar signals received by said intermediate repeater, and means responsive to the operation of said teletypewriter transmitting means for transmitting a signal of a first magnitude and a signal of a second magnitude, different from said first magnitude, both signals of the same polarity, through said intermediate repeater to each of said distant repeaters simultaneously.

6. A system in accordance with claim 5 including means for operating said teletypewriter receiver in response to signals transmitted from said teletypewriter transmitter also.

7. A system in accordance with claim 5 including also additional means for transmitting signals from said monitoring circuit to both of said distant repeaters, said additional means comprising a manually operable telegraph key.

8. A system in accordance with claim 5 including also additional means for receiving signals in said monitoring circuit, said additional means comprising a telephone receiver.

9. A system in accordance with claim 5 including an additional telegraph signal transmitter in said monitoring circuit, and means for operating a telegraph receiving device in said moni-

toring circuit in response to the operation of said additional transmitter.

10. In a direct current telegraph signal repeater system, an intermediate telegraph repeater, a local telegraph signal transmitting and receiving monitoring circuit bridged directly to said intermediate repeater, a telegraph signal receiving relay in said monitoring circuit, a biasing winding on said relay, a first line winding on said relay connected to a telegraph line extending in a first direction from said intermediate repeater, a second line winding on said relay connected to a telegraph line extending in a second direction from said intermediate repeater, and means interconnecting said line windings and said repeater for energizing said second winding when a signal is received from said first line to reproduce said signal in said monitoring circuit.

11. In a direct current telegraph signal repeater system, an intermediate telegraph repeater, a local telegraph signal transmitting and receiving monitoring circuit to said intermediate repeater, a telegraph signal receiving relay in said monitoring circuit having a first line winding connected directly to a line connected to a first side of said repeater and a second line winding connected directly to a line connected to a second side of said repeater, means for transmitting a spacing signal through said second winding in response to a spacing signal received from said first line, and means for transmitting a spacing signal through said first winding in response to a spacing signal received from said second line.

12. In a direct current telegraph signal repeater system, an intermediate telegraph repeater, a local telegraph signal transmitting and receiving monitoring circuit bridged directly to said intermediate repeater, a telegraph relay in said monitoring circuit, three windings on said relay, two of said windings connected directly to lines connected to said intermediate repeater, means for transmitting current through each of said windings, each of said currents having an effect tending to operate the armature of said relay in the same first direction for a first signaling condition received by said repeater, and means for reversing the effect of current in each of said line windings in response to a signal received from one of said lines for a second signaling condition received by said repeater.

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