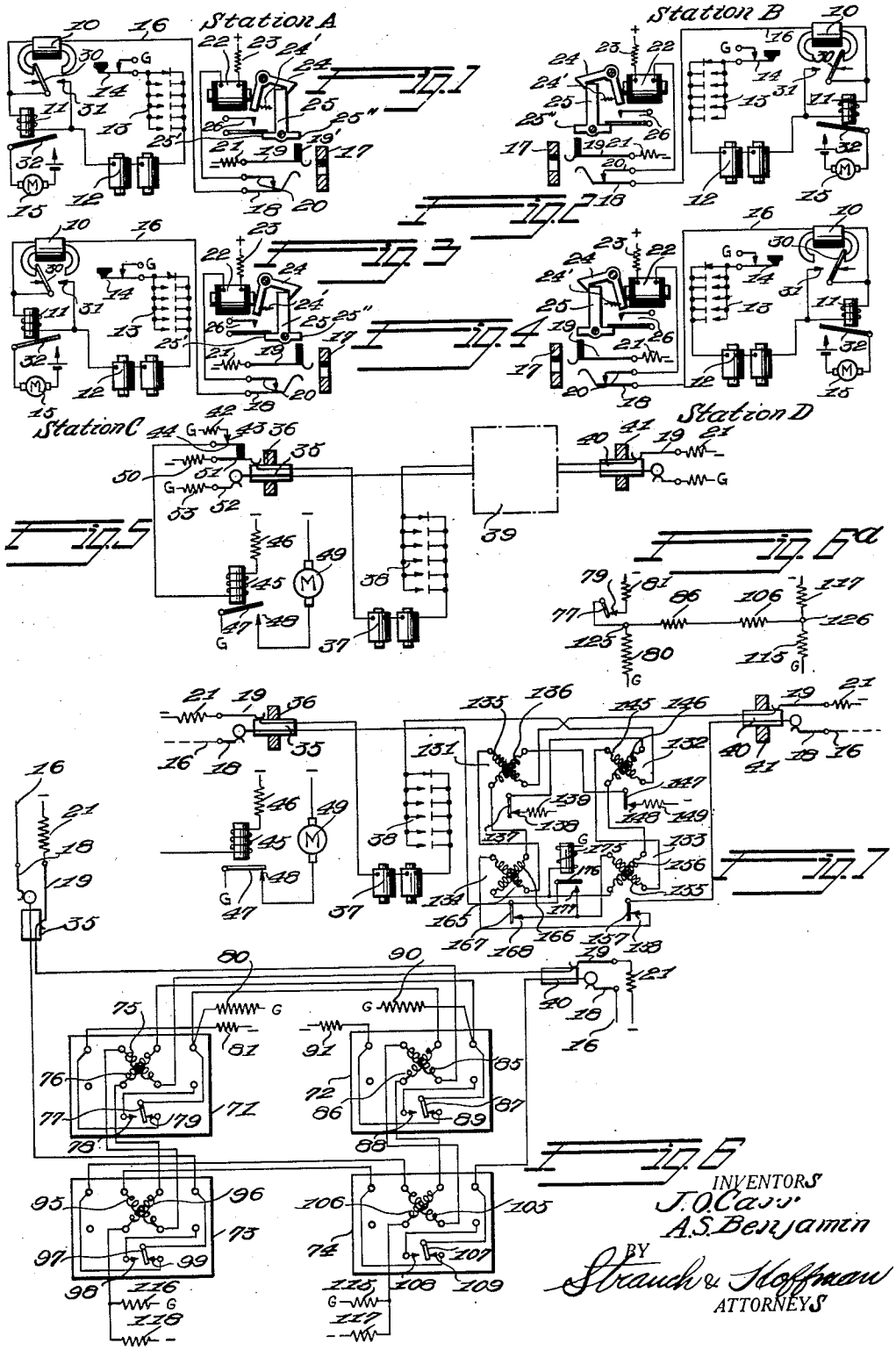
Oct. 25, 1932. J. O. CARR ET AL 1,884,562

SIGNALING SYSTEM

Filed May 27, 1930 3 Sheets-Sheet 1



INVENTORS
J. O. Carr
A. S. Benjamin
BY
Strauch & Hoffman
ATTORNEYS

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SIGNALING SYSTEM

Filed May 27, 1930 3 Sheets-Sheet 2

Fig. 8

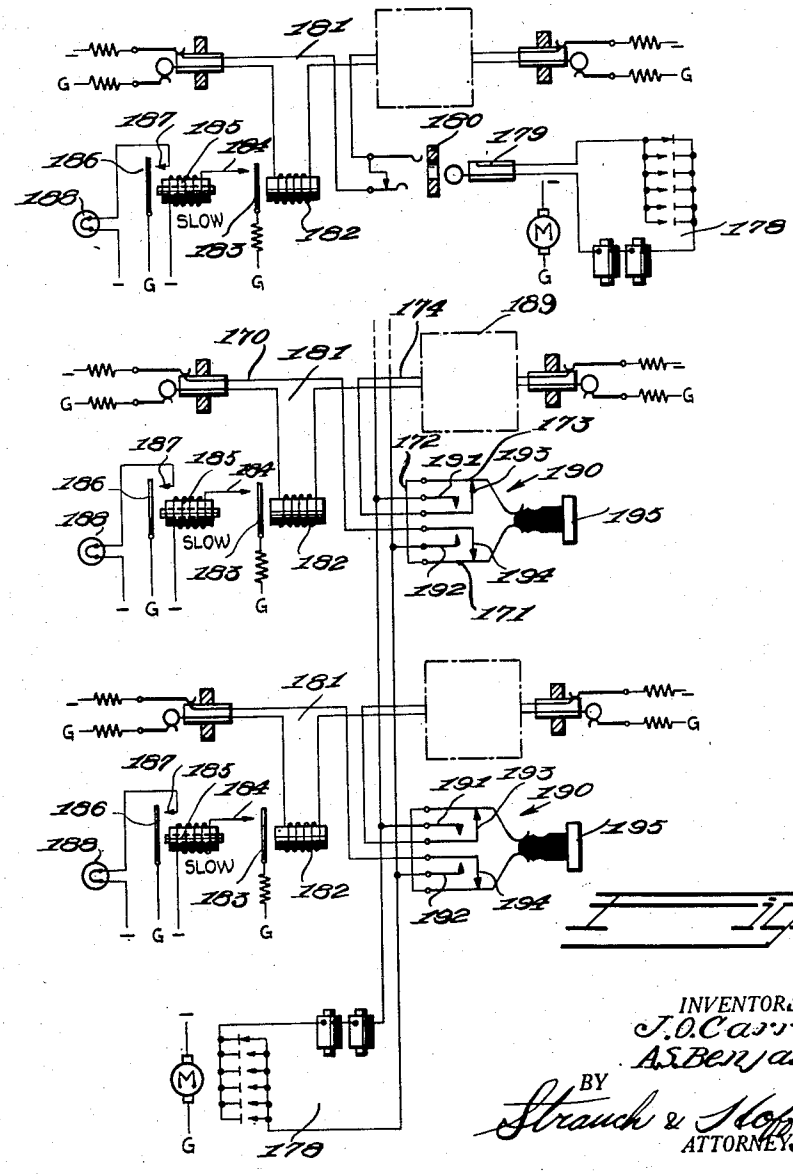

Fig. 9

INVENTORS
J. O. Carr
A. S. Benjamin
BY
Strauch & Hoffman
ATTORNEYS

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SIGNALING SYSTEM

Filed May 27, 1930 3 Sheets-Sheet 3

FIG. 10

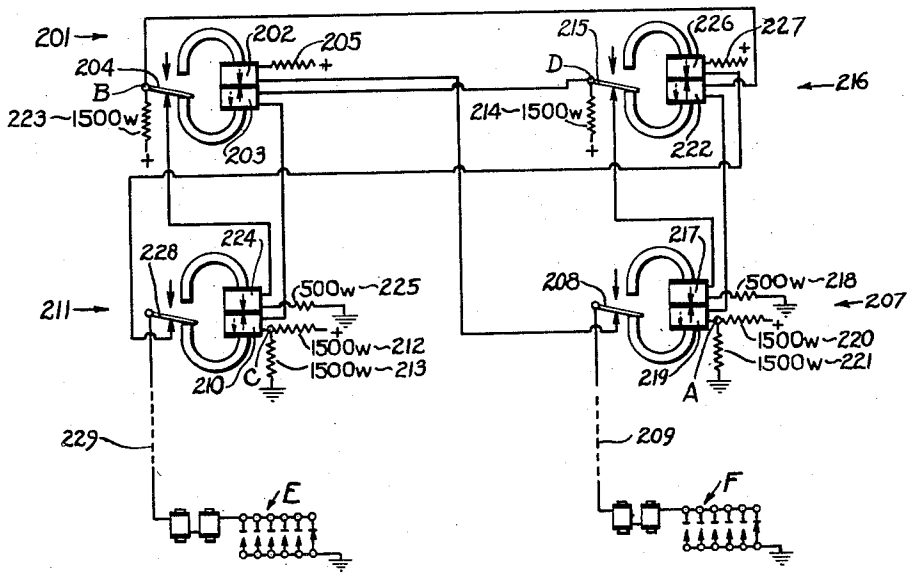
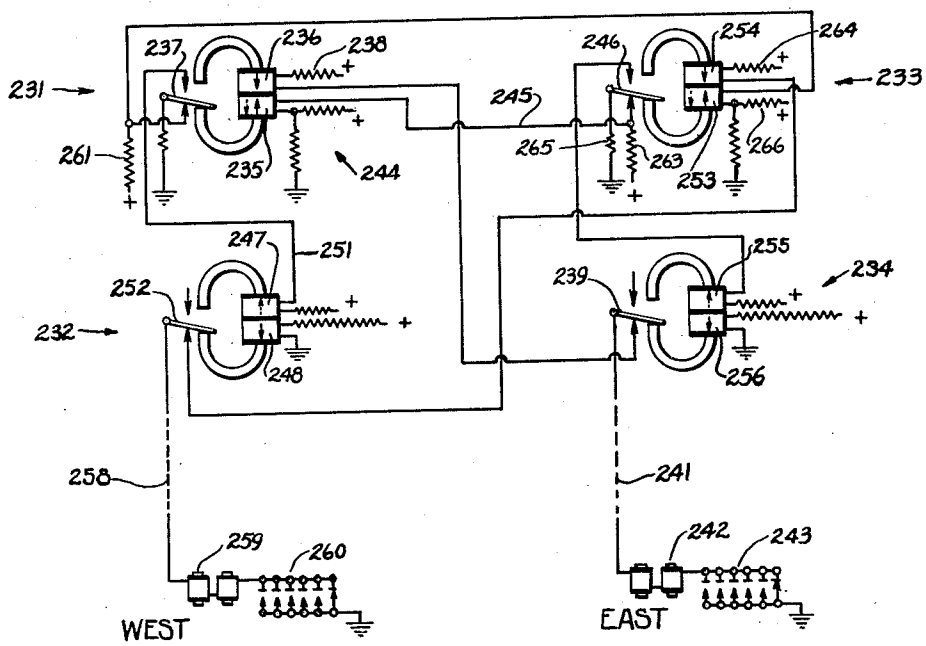


FIG. 11



INVENTORS:
JOHN O. CARR,
ABRAHAM S. BENJAMIN;
BY
Strauch & Hoffman
ATTORNEYS.

Patented Oct. 25, 1932 1,884,562

UNITED STATES PATENT OFFICE

JOHN O. CARR AND ABRAHAM S. BENJAMIN, OF CHICAGO, ILLINOIS, ASSIGNORS TO THE TELETYPE CORPORATION, OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE

SIGNALING SYSTEM

Application filed May 27, 1930. Serial No. 456,207.

This invention relates to signaling systems and more particularly to circuits for establishing manual connections between a plurality of telegraph subscriber lines.

In printing telegraph systems, the power for operating the printers and transmitters at each station is usually supplied by motor mechanism. Where the signaling traffic conditions are such that the telegraph apparatus is substantially in continual use, these motor mechanisms are usually in normal operating condition. Where, however, the telegraph apparatus is used in connection with exchange systems and is only in actual use for intervals, it is desirable to maintain the motor mechanism normally in a nonoperating condition to be started into operation automatically when the printing apparatus thereat is connected for transmission and reception of telegraph code impulses.

In accordance with the present invention, calling devices are provided by which any subscriber may attract the attention of the operator at the central office exchange and connector devices or link circuits are provided by which the manual exchange operator may connect any two subscribers' stations. Each such link circuit has a telegraph repeater associated with a source of electric current in such manner that current is supplied to each of the connected lines. The circuit arrangements are such that the opening of the circuits of one line will open the circuit of its connected line by the functioning of the apparatus at the central office, the source of electrical energy for operating the telegraph sets being located at the central exchange. The system thus becomes a central battery system for the transmission of line signals and the telegraph station requires only a source of mechanical power for the operation of the mechanical telegraph apparatus. For supplying the mechanical power at the telegraph station there is provided an electrical motor driven by any local source and controlled by a relay responsive to currents in the telegraph lines. This relay is controlled by a polar relay responsive to reversals of potential in the telegraph line, the combination thus set up being a system of motor starting controlled by reverse currents. At the central office other means is shown for the starting of the motor of the operator's telegraph set whenever the motor is needed for service.

Accordingly, an object of our invention is to provide novel and efficient means for normally maintaining the motor mechanism of telegraph apparatus in non-operating condition, and for starting said motor mechanism into operation automatically in response to a telegraph connection.

Another object of our invention is to provide novel means in a printing telegraph manual exchange system for automatically reversing the direction of current flow to a subscriber's station in response to a telegraph communicating connection therewith, and for signaling with the said currents of reversed polarity and for starting normally nonoperating motor mechanism at the subscriber's station into operation in response to said currents of reversed polarity.

A further object of our invention is to provide novel means in a manual telegraph exchange system for normally maintaining the motor mechanism of the subscriber's apparatus in nonoperating condition and for starting said mechanism into operation in response to a telegraphic connection between two subscribers.

A still further object of our invention is to provide novel means in a manual telegraph exchange system for maintaining a motor mechanism of each subscriber's apparatus in a nonoperating condition, providing circuit connections whereby a subscriber may call the operator at the exchange or be called by the operator at the exchange over the same circuit over which telegraph signaling occurs and for simultaneously starting the normally nonoperating motor mechanism into operation in response to said call.

In printing telegraph signaling systems, provision is usually made for repeating the signals where the signaling lines are long. In the case of manual exchange, it is preferable that these repeaters be provided in the exchange as part of the link circuits. These repeaters must be so arranged so that signals

originating at any one station will be repeated to the other station. In order to prevent the repeater from transmitting signals back to the originating point, we have found special locking circuit arrangements must be made. Where the repeaters are plugged from one signaling line to another, we have also found provision must be made to prevent false operation of the repeater while switching the repeater from one subscriber's circuit into another.

Accordingly, a further object of our invention is to provide novel and effective repeater arrangements in a link circuit for a manual telegraph exchange.

Still another object of our invention is to provide simple and effective two-way repeaters for use in manual telegraph switching systems.

Other objects of the invention will be apparent from the following detailed description of preferred embodiments thereof and from the scope of the appended claims. Referring now to the accompanying drawings.

Figures 1 to 4 are diagrammatic views showing four telegraph stations and their associated lines.

Figure 5 is a similar view illustrating the connective device of the recording type provided with its individual telegraph set.

Figure 6 is a diagrammatic view showing circuits of one form of repeater in detail,

Figure 6ª is a diagrammatic view illustrating the potentiometer system employed in the repeater of Figure 6.

Figure 7 is a similar view showing circuits of a modified form of repeater,

Figure 8 is a diagrammatic view showing a connective device with an individual telegraph set and a jack for connecting the same,

Figure 9 is a diagrammatic view showing a system of two connective devices and one operator's set, each connective device having a manual key by which the operator may be connected.

Figure 10 is a diagrammatic view showing a further modified form of repeater.

Figure 11 is a preferred modification of the repeater shown in Figure 10.

Referring to Figure 1, a subscriber's telegraph set is shown comprising a polar relay 10, a neutral relay 11, a printer magnet 12, a telegraph transmitter 13 and a key 14 all connected in series and a motor 15, controlled by the neutral relay 11. The polar relay 10 controls a shunt circuit around the neutral relay 11 which controls the energizing circuit for motor 15. The motor 15, when rotating, supplies the mechanical power for driving the subscriber's printing telegraph apparatus (not shown) which is variably operated by the printer magnet 12 in accordance with received code combinations of impulse conditions received over line 16.

The line 16 connects the subscriber's telegraph set with the exchange and terminates at a jack 17, which cooperates with a plug, comprising springs 18 and 19 and an intermediate spring 20. Line 16 is connected to spring 18, spring 19 is connected through a resistance 21 to negative battery and spring 20 is connected to a line drop magnet 22 which in turn is connected through a resistance 23 to positive battery. The line drop magnet 22 controls a pivoted latch bar 24 normally urged toward retracted position by spring 24'. The latch bar 24 engages the pivoted shutter 25 at one end as shown.

When the telegraph set is not in use the line circuit is normally closed and extends from positive battery through resistance 23, line drop magnet 22, spring 20 in engagement with spring 18, line wire 16, polar relay 10, neutral relay 11, printer magnet 12, telegraph transmitter 13, calling key 14 to ground.

The direction of current flow through the polar relay 10 at this time is such that its armature 30 remains in the position shown in Figure 1 so that the shunt circuit around the neutral relay 11 is open. Relay 11 is maintained energized and holds its armature 32 away from its back contact thereby maintaining the circuit of the motor 15 open.

Figures 2, 3 and 4 show stations similar to station A of Figure 1 and it is obvious that a large number of such stations may be interconnected through the exchange.

The connecting apparatus at the exchange for connecting any two stations together for telegraphic communication is illustrated in Figure 5. As shown in this figure, the apparatus comprises a plug 35, a jack 36, a printer magnet 37, a transmitter 38, a repeater 39, a plug 40 and a jack 41, Figure 5. When the connecting apparatus is not in use, the plug 35 is kept in the jack 36 whereby a circuit extends from ground through resistance 42, contact 43, spring 44, relay 45 and resistance 46 to negative battery. This circuit maintains the relay 45 energized so that its armature 47 is held out of engagement with its back contact 48 and the circuit of motor 49 is held open. A second circuit extends from negative battery through resistance 50, spring 51, plug 35, printer magnet 37, transmitter 38, repeater 39 and back to the tip of the plug 35 and over spring 52 and resistance 53 to ground. Similarly the plug 40 is kept in jack 41 which forms a circuit through the repeater 39. This circuit is required to control the repeater relays when the plug 40 is used for a message to the central set.

Withdrawal of the plug 35 from the jack 36 breaks the engagement between contact 43 and spring 44 and deenergizes the relay 45 thereby permitting its armature 47 to move into engagement with its back contact 48 and closing the circuit of the motor 49, at the

same time, the circuit for printer magnet 37 is opened.

To call the operator the party at station A momentarily depresses the key 14 opening the line circuit and deenergizing line drop magnet 22 at the exchange and relay 11. The deenergization of line drop magnet 22 releases the latch 24 which moves, under the force of its spring 24', out of engagement with the pivoted shutter 25 permitting the latter to rock clockwise. As the shutter 25 rocks clockwise arm 25' thereof operates to close switch 26 and at the same time arm 25'' moves into engagement with lug 19' on spring 19. Closure of switch 26 operates any well known device for attracting the attention of the operator at the exchange.

The particular signal operated by shutter 25, advises the operator which is the calling line. The operator then removes the plug 35 from the jack 36 and inserts it into the jack 17 which is connected with station A whereby the contact at the springs 18 and 20 is broken and a new circuit is formed from negative battery through resistance 21, long spring 19 of jack 17, ring of plug 35, printer magnet 37, transmitter 38, repeater 39, tip of plug 35, short spring 18, line 16, polar relay 10, neutral relay 11, printer magnet 12, transmitter 13, key 14 to ground at G. It will be noted that current over the circuit flows from negative battery at the central office instead of from positive battery through the line drop magnet 22 with the result that the polar relay 10 operates its armature 30 into engagement with contact 31 thereby shunting the neutral relay 11. Relay 11 is now maintained deenergized independently of further opening and closing of the line inasmuch as the signals thereafter transmitted are of opposite polarity from the normal holding current.

Insertion of the plug into the jack raises spring 19 and its lug 19' rocks shutter 25 counter-clockwise until it is again latched by latch 24.

The party at the calling station A now operates the transmitter 13 to send impulses over the line 16 to the printer magnet 37 at the exchange for indicating the desired called party and the operator at the exchange can respond by operating the transmitter 38 sending impulses to printer magnet 12.

Should the party at the calling station A desire to be connected to another station as for example station B, (Figure 2) the exchange operator upon receiving this information will remove the plug 40 from its resting jack 41 and insert it into the jack 17 which is connected with station B thus forming a circuit similar to that of plug 35. The relay 10 at station B will operate its armature 30 to close the shunt circuit around the neutral relay 11 deenergizing the latter. Deenergization of neutral relay 11 moves its armature 32 into engagement with its back contact and starts the motor 15. The attention of the party at station B may be attracted by the bell customarily associated with automatic telegraph devices. The station A will then be in communication with the station B through the repeater 39 and messages may be sent in either direction. The printer magnet 37 of the central office is in series with the line connecting stations A and B and a record of all communication is made at the central office.

It will be understood that if the calling party had indicated to the operator that communication was desired with station C or D the operator would have inserted plug 35 in the jack 17 of the desired station.

The repeater 39 may be of the form shown in Figures 6, 7 or 10. In the form shown in Figure 6, the repeater comprises four relays 71, 72, 73 and 74, all being of the polar type and double wound.

The relay 71 comprises a line winding 75, local winding 76 and an armature 77 operating between contacts 78 and 79. The armature 77 is connected to one end of a high resistance 80, the other end of which is connected to ground. The contact 79 is connected to one end of a low resistance 81, the other end of which is connected to negative battery.

The relay 72 comprises a line winding 85, a local winding 86 and an armature 87 operating between contacts 88 and 89. The armature 87 is connected to one terminal of the local winding 76 of relay 71 and to one terminal of a high resistance 90, the other terminal of which is connected to ground. The contact 89 is connected to one terminal of a low resistance 91, the other terminal of which is connected to negative battery.

The relay 73 comprises a line winding 95, a local winding 96 and an armature 97 operating between contacts 98 and 99. The armature 97 is connected to the tip of the plug 35 and the contact 99 is connected to one terminal of the line winding 105 of the relay 74.

The relay 74 comprises, in addition to the line winding 105, a local winding 106 and an armature 107 operating between contacts 108 and 109. The armature 107 is connected to the tip of the plug 40 and the contact 109 is connected to one terminal of the line winding 95 of the relay 73.

In operation, assuming that plug 35 has been inserted into the jack 17 which connects with station A and that the plug 40 has been inserted into the jack 17 which connects with station B and assuming further that the line circuits 16 are closed at both stations a line circuit will be established from negative battery, through resistance 21, spring 19, ring of plug 35, line winding 85, line winding 105, contact 99, armature 97, the tip of plug 35,

spring 18, line 16 leading to station A, winding and points of polar relay 10, shunt wire of neutral relay 11, printer magnet 12, transmitter 13, key 14 to ground. A line circuit also will be established from negative battery through resistance 21, spring 19, ring of plug 40, line winding 75, line winding 95, contact 109, armature 107, tip of plug 40, spring 18, line 16 leading to station B, polar relay 10, printer magnet 12, transmitter 13, key 14 to ground.

In addition to the line circuits, local circuits will be established. One of these extends from negative battery through low resistance 81, contact 79, armature 77, local winding 86, local winding 106, low resistance 115 to ground. The other local circuit extends from negative battery through low resistance 91, contact 89, armature 87, local winding 76, local winding 96 and low resistance 116 to ground. The resistances 80 and 90 are high as compared with resistances 81 and 91. Resistances 115, 116, 117 and 118 are all substantially equal. These elements form a potentiometer system in which the direction of current in the local winding is determined by the position of the armature 77 in one circuit and armature 87 in the other. The potentiometer circuit is diagrammatically illustrated in Figure 6a.

Referring to Figure 6a, when armature 77 is in engagement with contact 79, the difference of potential between junction 125 and G is greater than the difference of potential between junction 126 and G and current will therefore flow from negative battery to G from left to right through the windings 86 and 106. When armature 77 is out of engagement with contact 79, the current will flow from right to left through the windings 106 and 86. The relative values of these two currents may be determined by adjustment of the value of the resistance 80.

The current in the line windings of the relays flows in a direction to hold the armatures 77, 87, 97 and 107 against their operating contacts 79, 89, 99 and 109 respectively and the current in the local windings flows in a direction to oppose the effect of the line current. These currents are regulated so that the line currents dominate the local currents. When the line 16 is opened at station A, current stops flowing in the line windings 105 and 85 of the relays 74 and 72, respectively, and the current in the local windings 106 and 86 of these relays causes the armatures 107 and 87 to move out of engagement with their contacts 109 and 89 respectively. The opening of the contact at armature 107 breaks the line 16 leading to the station B and deenergizes the line windings 95 and 75 of the line relays 73 and 71 respectively. Opening of the contact at armature 87 permits a reduced and reversed current to flow from negative battery, through a resistance 118, local windings 96 and 76 of the relays 73 and 71, respectively, and through high resistance 90 to ground, producing the same magnetic effect as produced by the line current in these relays so that the armatures 77 and 97 of relays 71 and 73, respectively, are not moved but are held against the contacts 79 and 99, respectively.

In order to send a "break in" signal, the operator at station B operates the manual key 14. The line 16 from station B is thereupon opened. If this occurs while armature 107 is out of engagement with its contact 109, no action will result until line 16 from station A is closed and armature 107 engages contact 109. Line 16 from station B being open at this time, windings 95 and 75 will be deenergized, armature 97 will move out of engagement with its contact 99 thus holding line 16 to station A open and sending a "break in" signal to station A.

Should line 16 at both stations be opened simultaneously, the relays will open their contacts, the two currents through the resistance 80 and 90 will tend to close all contacts and a vibratory condition will result but will be maintained only so long as the relays vibrate in synchronism, or until a line circuit is closed.

In the form of repeater shown in Figure 6, all of the local circuits are provided with but one source of current and with but one local winding in each of the relays.

In the modified form of repeater, shown in Figure 7, four polar relays are employed as in the repeater shown in Figure 6 and each relay has a local winding and a line winding. The relay 131 comprises a line winding 135, a local winding 136 and an armature 137 adapted to cooperate with a contact 138 which is connected through a resistance 139 to negative battery. The relay 132 comprises a line winding 145, a local winding 146 and an armature 147 adapted to cooperate with a contact 148 which is connected through a resistance 149 to negative battery. The relay 133 comprises a line winding 155, a local winding 156 and an armature 157 adapted to cooperate with a contact 158 which is connected with one terminal of the line winding 165 of the relay 134. Relay 134 comprises, in addition to line winding 165, a local winding 166 and armature 167 having co-operative relation with a contact 168 which is connected to one terminal of the line winding 155 of relay 133. In addition to the four polar relays, a neutral relay 175 is provided having an armature 176 cooperating with a contact 177. The armature 176 is connected with the armature 167 and the contact 177 is connected with the contact 168 so that when the armature 176 is in engagement with the contact

177 a shunt circuit is established around the armature 167 and its contact 168.

In operation, assuming that plug 35 has been inserted into the jack 17 which connects with station A and that the plug 40 has been inserted into the jack 17 which connects with station B, and assuming further, that the line circuits 16 are closed at both stations, a line circuit will extend from negative potential, through resistance 21, ring of plug 35, printer magnet 37, transmitter 38, line windings 145 and 155, contact 168, armature 167, tip of plug 35, line 16 leading to station A and continuing at station A through the polar relay 10, printer magnet 12, transmitter 13 and key 14 to ground. A second circuit extends from negative battery, through resistance 21, ring of plug 40, line windings 135 and 165, contact 158, armature 157, tip of plug 40 and then over line 16 to station B and continuing at this station through polar relay 10, printer magnet 12, transmitter 13 and key 14 to ground. In addition to these line circuits, two local circuits are established, one extending from negative battery through resistance 149, contact 148, armature 147, local winding 136, local winding 166 and through winding of relay 175 to ground. The second local circuit extends from negative battery through resistance 139, contact 138, armature 137, local winding 146, local winding 156 and through winding of local relay 175 to ground. The values of the currents are adjusted by resistances 139 and 149 so that the magnetic effect of the current flowing through the line windings dominates the magnetic effect of the current flowing through the local windings. The line current tends to hold the armatures of the polar relays in engagement with their respective contacts and the local current tends to hold the armature 176 of local relay 175 away from its back contact 177.

When line 16 is opened at station A, the line windings 155 and 145 of the relays 133 and 132, respectively, are deenergized. Deenergization of line windings 155 and 145 removes the magnetic force which tends to hold the armatures 157 and 147 in engagement with their respective contacts. The local windings 156 and 146, being at this time energized over a local circuit, become effective to move the armatures 157 and 147 away from their respective contacts. This local circuit extends from negative battery through resistance 139, contact 138, armature 137, local winding 146, local winding 156, winding of local relay 175 to ground. The movement of armature 157 away from its contact 158 opens the line 16 which leads to station B operating the printer magnet 12 at station B to register the opening of the line circuit 16 at station A. Movement of armature 147 away from its contact 148 breaks the local circuit which includes the local windings 136 and 166 of relays 131 and 134 respectively.

The local relay 175 will be held energized by current flowing through local windings 146 and 156 and through armature 137 of the relay 131. Any opening of the line circuit at station B subsequent to the opening of the line circuit at station A will be ineffective. The reclosing of the line at station A will reclose the contact at relays 132 and 133 and will restore the initial condition.

In the event that the called party at station B should happen to "break in" at the instant when the calling party at station A was beginning a break impulse, the windings 145 and 155 connected in series with the calling party's line are deenergized simultaneously with the windings 135 and 165 connected in series with the called party's line.

As a result of the deenergization of windings 145 and 155 the local windings 146 and 156 become effective to operate their respective armatures 147 and 157 to disengage their contacts while at the same time the local windings 136 and 166 become effective to operate their respective armatures 137 and 167 to disengage their respective contacts. As a result of the operation of these armatures, both the lines are opened at the central station and both the calling and called party would lose control. In order to reoperate the system, someone would then have to go to the central station to reclose one of the party lines.

It is for this condition relay 175 is provided, the armature of which controls a circuit shunting the armature 167 of relay 134. Relay 175 is energized in two multiple circuits as described above. Under normal operations either one or the other of these local circuits should be closed at all times. If, however, both local circuits are opened due to the simultaneous operation described above, relay 175 becomes deenergized. Its armature drops to its back contact shunting the armature 167 of relay 134 thereby closing the circuit at the central station for the line 16 extending to station A. When now the calling party of station A sends a closing impulse by closing the circuit at station A, the line windings 145 and 155 are energized and since the magnetic effect of these windings dominates the magnetic effect of the local windings, armatures 147 and 157 would move back into engagement with their respective contacts. Movement of armature 147 into engagement with its contact 148 recloses the local circuit including windings 136 and 166 and the local relay 175. Operation of armature 157 into engagement with its back contact 158 connects the line 16 leading from station B to the line windings 165 and 135. The repeating system thus will be placed under control of the called party at station B.

The operator at the exchange may desire to "listen in" on one of a plurality of circuits in operation. In such case an arrangement is

employed in which a single telegraph set may be plugged into any link circuit. This arrangement is illustrated in Fig. 8 in which the operator's telegraph set 178 is provided with plug 179 which may be connected into the jack of any link circuit, as for example, the jack 180 of the link circuit 181 shown in Fig. 8.

Apparatus may be provided at the exchange for indicating to the operator the condition of the line circuits. One form of such apparatus is shown in Figure 8 in which a supervisory line relay 182 is connected in the line circuit and its armature 183 cooperates with a contact 184 connecting with the winding of the slow relay 185. The armature 186 of the slow relay 185 cooperates with the contact 187 which is connected to a lamp or other signal 188. Relay 182 responds to all current impulses in the line. The slow relay 185 does not respond to telegraphic signals but will respond to the opening of the manual key 14 at the telegraph substation. When this key is operated to open the line circuit, relay 182 deenergizes and its armature 183 moves into engagement with the contact 184 closing a circuit for the slow relay 185. If the key 14 is held open for a sufficient length of time, the slow relay 185 will become energized and will move its armature 186 into engagement with contact 187 and thereby light the lamp 188. Obviously any other suitable signal device such as a buzzer may be substituted for the lamp 188.

A modified arrangement for switching the operator's telegraph set into connection with any one of the link circuits is illustrated in Figure 9. According to this modification a plurality of manual switches 190 are provided, each comprising contacts 191 to 194, inclusive. The operator's telegraph set 178 is permanently connected with the contacts 191 and 192 of all of the switches 190 as shown in Figure 9. Also, the contacts 193 and 194 of each manual switch 190 are connected respectively with one of the link circuits. The circuit of one of the lines connected by the link 181 of Figure 9 includes the wire 170, the contact 194, the spring 171, the bridge wire 172, the spring 173, the contact 193, the wire 174, the repeater 189 and the supervisory relay 182. In order to connect the telegraph set 178 into one of the link circuits, without breaking the continuity of the operating circuit, it is only necessary to push the key 195 corresponding to that particular link circuit. This effects engagement between contacts 191 and 193 and simultaneous engagement between contacts 192 and 194 whereby the opterator's telegraph set first is inserted in series with the link circuit 181, but shunted by the wire 172. The further movement of the switch 190 will break the shunt 172, rendering the set 178 effective.

If preferred a simplified form of repeater shown in Figure 10 may be substituted for the repeater of Figures 6 and 7. This repeater shown in Figure 10 comprises four relays of the polar type, each having two windings. The relay 201 has the two windings 202 and 203 and an armature 204 operating between front and back contacts. The winding 202 has one of its terminals connected through a resistance 205 to positive battery and the other terminal connected to the front contact of relay 207, the armature 208 of relay 207 being connected over the line 209 to the station F. The winding 203 of relay 201 has one of its terminals connected to one terminal of the winding 210 of relay 211, the other terminal of winding 210 being connected over a resistance 212 to positive battery and over a resistance 213 to ground. The other terminal of the winding 203 is connected over a 1500 ohm resistance 214 to positive battery and to the armature 215 of the relay 216. The front contact of this relay is connected to one terminal of the winding 217 of relay 207 the other terminal of this winding being connected over a 500 ohm resistance 218 to ground.

The relay 207 has in addition to the winding 217 a winding 219 which has one of its terminals connected over a 1500 ohm resistance 220 to positive battery and over a 1500 ohm resistance 221 to ground. The other terminal of the winding 219 is connected to one terminal of the winding 222 of the relay 216 and the other terminal of the winding 222 is connected to the armature 204 and over a 1500 ohm resistance 223 to positive battery. The front contact of relay 201 is connected to one terminal of winding 224 of relay 211 the other terminal of which is connected through a 500 ohm resistance 225 to ground. The winding 226 of relay 216 has one of its terminals connected through a resistance 227 to positive battery and the other terminal connected to the front contact of relay 211 and the armature 228 of relay 211 is connected over the line 229 to station E. It will be understood that the resistance values herein stated are for the purpose of illustrating comparative values and other desired constants may be substituted therefor in accordance with line conditions.

In operation, assuming that the line 229 at station E is closed, a circuit will extend from positive battery over resistance 227, line winding 226 of relay 216, front contact and armature 228 of relay 211 and over the line 229 to ground at station E. Current flowing through line winding 226 tends to maintain armature 215 in engagement with its front contact. A local circuit extends from positive battery through resistance 220, winding 219, local winding 222, over armature 204 in engagement with its front contact, and through winding 224 and resistance 225 to ground. A multiple circuit extends from

positive battery over resistance 223, armature 204 and through winding 224 and resistance 225 to ground. A circuit extends also from positive battery over resistances 220 and 221 to ground. Since the resistance 221 is greater than the resistance 225 the RI drop across resistance 220 is less than the RI drop across resistance 223. The potential at the point A will therefore, be greater than the potential at the point B producing a flow of current from A, through the windings 219 and 222, to B. The effect of the local current flowing through the local winding 222 is to move the armature 215 away from its front contact, whereas, as above stated, the effect of the line current flowing through the line winding 226 is to move the armature 215 into engagement with its front contact, but the currents are so adjusted that the line current dominates the local current and therefore the armature 215 will be held in engagement with its front contact.

In a similar manner, assuming that the line 209 at station F is closed, a circuit will extend from positive battery over resistance 205, line winding 202 of relay 201, front contact and armature 208 of relay 207 and over the line 209 to ground at station F. Current flowing through line winding 202 tends to maintain armature 204 in engagement with its front contact. Also, a local circuit extends from positive battery through resistance 212, winding 210, local winding 203, over armature 215 in engagement with its front contact, and through winding 217 and resistance 218 to ground. A multiple circuit extends from positive battery over resistance 214, armature 215 and through winding 217 and resistance 218 to ground. A circuit extends also from positive battery over resistances 212 and 213 to ground. Since the resistance 213 is greater than the resistance 218, the RI drop across the resistance 212 is less than the RI drop across resistance 214. The potential at the point C will, therefore, be greater than the potential at the point D producing a flow of current from C, through the windings 210 and 203, to D. The effect of the local current flowing through the local winding 203 is to move the armature 204 away from its front contact, whereas, as above stated, the effect of the line current flowing through the line winding 202 is to move the armature 204 into engagement with its front contact, but the currents are so adjusted that the line current dominates the local current and therefore the armature 204 will be held in engagement with its front contact.

When the line 229 is opened at the station E, the line winding 226 is deenergized and the current flowing through the local winding 222 becomes effective to move armature 215 away from its front contact. Movement of armature 215 away from its front contact opens the circuit of winding 217 of relay 207 and the current flowing through the local winding 219 of the relay 207 becomes effective to move armature 208 away from its front contact. This opens the line 209 leading to station F. Movement of armature 215 away from its front contact changes the difference of potential between the points C and D. The RI drop through resistance 214 now in less than the RI drop through the resistance 212 so that the potential at point D is greater than the potential at the point C. Accordingly a local current will flow from D to C through the windings 203 and 210. This local current is in the reverse direction from that which originally flowed through these windings and accordingly its effect will be to hold the armatures 204 and 228 in engagement with their front contacts. In this manner repeating back of the signal to station E is prevented.

When the line 229 is closed at station E, line winding 226 is again energized and since the effect of this line winding dominates the effect of local winding 222 armature 215 will be moved back into engagement with its front contact thereby closing the circuit for the winding 217 of relay 207. Winding 217 dominates winding 219 so that armature 208 is again moved into engagement with its front contact closing the line 209 to station F. Movement or armature 215 into engagement with its front contact reverses the direction of flow of current through the windings 210 and 203.

In Figure 11, I have shown a preferred modification of the circuit arrangement shown in Figure 10. As in Figure 10, the repeater unit comprises four polarized relays 231 to 234. The relay 231 is provided with windings 235 and 236 and an armature 237 operating between front and back contacts.

The winding 236 has one of its terminals connected through a resistance 238 to the positive side of a battery and has the other terminal connected to the front contact of an armature 239 of relay 234, armature 239 being in turn connected to a conductor 241 which extends to a receiving mechanism 242 and transmitter 243 of any well known construction, located at the east station.

The winding 235 of relay 231 has one of its terminals connected to the mid point of a potentiometer 244 which comprises two resistances of 1500 ohm resistance each connected to a battery at one terminal and to ground at the other terminal. The other terminal of the winding 235 is connected over conductor 245 to the front contact of armature 246 of relay 233. Armatures 237 and 246 are both connected through resistances of 500 ohm each, to ground and their front contacts are connected through resistances of 1500 ohms each to the positive side of a battery.

Relay 232 is also provided with windings

247 and 248 one of the terminals of the winding 247 being connected to the positive side of the battery through a 1500 ohm resistance and the other terminal of which is connected over conductor 251 to the back contact of armature 237. The winding 248 is connected to one side of the battery through a 4000 ohm resistance and at its other terminal to ground and is normally biased to hold its armature 252 in engagement with its front contact as will appear hereinafter. When the winding 247 is energized, the current in this winding flows in a reversed direction from that of the current flowing in winding 248 and will be of sufficient strength to throw the armature 252 to its back position against the action of the biasing winding.

The relay 233 is provided with windings 253 and 254, having connections equivalent to those described for the relay windings 235 and 236 respectively, and windings 255 and 256 are connected in a manner equivalent to the connections described for windings 247 and 248.

In operation with the keys at each of the stations closed and all of the apparatus in normal condition, the current flowing through the biasing windings 248 and 256 of relays 232 and 234, respectively, are such as to hold their respective armatures 252 and 239 in engagement with their front contacts. Current then flows from ground at the west station through transmitter 260, receiver 259, armature 252 and its front contact through the winding or relay 233 and through the resistance 264 to positive battery. The winding 254 is energized holding its armature 246 in engagement with its front contact.

Similarly a circuit is completed from transmitter 243 and receiver 242 at the east station, conductor 241, armature 239, and its front contact through the winding 236 and resistance 238 to positive battery. Relay 231 is energized and operates its armature 237 to engagement with its front contact.

Circuits are also completed for the windings 235 and 253, respectively, the circuit for the winding 235 extending from positive battery through the potentiometer 244 and through the winding 235 to the front contact of armature 246 at which point the current from positive battery flowing through the 1500 ohm resistance 263 forms a juncture therewith to flow through the front contact and armature 246 and the 500 ohm resistance 265 to ground. The current flowing through winding 235 as a result of the above circuit is such as to tend to operate the armature 237 to its back contact, but is not sufficient to overcome the effect of the current through the winding 236 and accordingly the armature 237 remains in engagement with its front contact.

Similarly, the winding 253 is energized by current flowing from positive 1500 ohm resistance 266 and winding 253 to form a juncture with current flow from battery through resistance 261. Current flowing through the winding 253 as a result of this circuit is in such a direction as to tend to make the armature 246 engage its back contact but is not sufficient to overcome the effects of the current flow through the winding 254. The armatures 237, 252, 246, and 239 are accordingly all engaging their front contacts as described hereinbefore.

It will be assumed for purpose of illustration that the operator at the west station desires to communicate with the operator at the east station and to this end will operate his key 260 to open the signalling line 258. Current will cease to flow through the winding 254 and the current flowing in the winding 253 as described hereinbefore will now become effective to operate armature 246 to its back contact.

As a result of movement of the armature 246 to its back contact, an obvious energization circuit is completed for the winding 255 of the relay 234. The current in the winding 255 as a result of this circuit, flows, it will be noted, in a reversed direction from that which flows through the biasing winding 256 and the value of the current will be greater than that in winding 256 as will be obvious from the smaller value of ohm resistance connected serially in the circuit as compared to the resistance connected serially to the winding 256. As a result, relay 255 will overcome the effects of the biasing winding 256 and will throw its armature 239 to its back contact, opening the circuit over conductor 241 extending to the east station and accordingly repeating the spacing impulse transmitted from the west station.

A further result of the operation of armature 246 to its back contact is to cause a reversal in the direction of current flowing through the winding 235. It will be recalled that with armature 246 engaging its front contact, the current from positive battery flowing through 1500 ohm resistance 263 took the path of least resistance and over the front contact of armature through the 500 ohm resistance 265 and accordingly the current through winding 235 flowed from the positive battery and through potentiometer 244. When now the armature 246 disengages its front contact, the current from positive battery and resistance 263 flows through winding 235 reversing the direction of current flow through winding 235 and this winding which had previously been tending to throw armature 237 to its back contact now acts to aid winding 236 to hold armature 237 in engagement with its front contact. Armature 237 is accordingly prevented from disengaging its front contact so that relay 232 is not affected and the im-

pulse is not repeated back over the line 258. To transmit a marking impulse, the operator at the west station recloses his key, and current again flows through the winding 254 operating armature 246 to its front contact. The current through winding 235 is again in the same direction as originally and the current for winding 255 is opened so that the winding 256 again becomes effective to operate its armature 239 into engagement with its front contact.

For signaling from the east station, similar operations occur. On receipt of each spacing impulse from the east station, winding 236 is open circuited and the winding 235 becomes effective to throw armature 237 to its back contact, completing in turn an energizing circuit for the winding 247. Winding 247 when energized overcomes the effect of the biasing winding 248, operating armature 252 to its back contact to repeat the spacing impulse to the west station. At the same time the movement or armature 237 to its back contact causes a reversal of current to flow through winding 253 and thereupon this winding aids the winding 254 in holding armature 246 in engagement with its front contact so that even though that winding 254 is open circuited now, armature 246 remains in engagement with its front contact. For the transmission of a marking impulse from the east station, the line circuit 214 is closed, energizing the winding 236 which operates armature 237 to its front contact again deenergizing winding 247 and the biasing winding 248 thereupon operates armature 252 to its front contact repeating the marking impulse to the west station. The operation of armature 237 to its front contact again reverses the direction of the current through winding 253, so that this winding again tends to throw armature 246 to its back contact. At this time, however, the winding 254 is energized and armature 246 is held in engagement with its front contact.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What we claim and desire to secure by United States Letters Patent is:—

1. In a telegraph system, a first signaling line, a second signaling line, a repeater interposed therebetween comprising a pair of relays individual to each of said signaling lines, a pair of windings in each of said relays one of said windings of one of said relays being connected in series with its associated signaling line, means including circuit connections controlled by said one relay for operating said second relay and means including circuit connections controlled by said one relay for preventing operation of said other relay associated with said other signaling line.

2. In a telegraph system, first and second signaling lines, a two-way repeater interposed therebetween comprising a pair of relays associated with each of said signaling lines, circuit connections whereby one of said relays is operated under control of signals received over one of said signaling lines, means including circuit connections whereby said operated relay controls the other of a pair of relays and means including circuit connections whereby said relays associated with the other of said signaling lines are rendered nonresponsive.

3. In a telegraph system, a first signaling line, a second signaling line, a two-way repeater associated with said signaling lines, said two-way repeater comprising a line responsive relay and a repeater relay associated with each of said signaling lines, means including circuit connections whereby said line responsive relay responds to impulses received over one of said lines, means including signaling circuits whereby said repeater relay is operated in accordance with the operation of the line responsive relay and means including circuit connections whereby the relays associated with the other of said signaling lines is rendered non-responsive to said impulses.

4. In a telegraph system, a first signaling line, a second signaling line, a line responsive relay and a repeater relay associated with each of said signaling lines, each of said line responsive relays comprising a winding connected in series with one of said signaling lines over the armature of the repeater relay associated with the other signaling line and comprising also a second winding connected in series with a winding on said repeater relay and under control of the armature of the line responsive relay associated with the other of said signaling lines, each of said repeater relays comprising a second winding controlled by the armature of one of said line responsive relays, means including circuit connections whereby the electro-magnetic action of the line windings of the line responsive relays overcomes the magnetic effect of the local windings thereof, means for operating one of said line relays in accordance with impulses transmitted over one of said lines, means including circuit connections responsive to the operation of said line responsive relay for repeating said impulses over the other of said lines and a second winding associated with the other of said line responsive relays for reversing the magnetic effect of the local winding thereof, whereby said line re-

sponsive relay is nonresponsive to said repeated impulses.

5. In a telegraph system, a first signaling line, a second signaling line, a line responsive relay and a repeater relay associated with each of said signaling lines, each of said line responsive relays comprising a winding connected in series with one of said signaling lines over the armature of the repeater relay associated with the other signaling line and comprising also a second winding connected in series with a winding on said repeater relay and under control of the armature of the line responsive relay associated with the other of said signaling lines, each of said repeater relays comprising a second winding controlled by the armature of one of said line responsive relays, means including circuit connections whereby the electro-magnetic action of the line windings of the line responsive relays overcomes the magnetic effect of the local windings thereof, means for operating one of said line relays in accordance with impulses transmitted over one of said lines and means including circuit connections responsive to the operation of the said line responsive relay for repeating said impulses over the other of said lines.

6. In a signaling system; a first circuit; a second circuit; a repeater comprising a relay having two windings, one of said windings being connected to a continuously closed circuit for normally biasing said relay; and a receiving relay for controlling the circuit for the second of said windings, the receiving relay comprising a winding connected in the second circuit and a second winding connected in a local biasing circuit.

7. In a signaling system; a first circuit; a second circuit; a repeater comprising a relay having two windings, one of said windings being connected to a continuously closed circuit for normally biasing said relay; a second relay for controlling the circuit for the second of said windings; the second relay comprising a winding connected in said second circuit and a second winding connected in a local biasing circuit; and means for reversing the direction of current in the second winding of said second relay.

8. In a signaling system; a first circuit; a second circuit; a repeater comprising a relay for each of said circuits, each relay having two windings, one of said windings being connected to a continuously closed circuit for normally biasing said relays; a receiving relay individual to each circuit for controlling the circuit for the second of said windings; each receiving relay comprising a winding connected in said circuits and a second winding connected in a local biasing circuit; and means for reversing the direction of current in said second receiving relay windings, said means comprising the receiving relay associated with the other circuit.

9. In a telegraph repeater, a first polar relay, a first local circuit through said polar relay, a first line-circuit controlling said polar relay, a first signal-sending relay controlled by said polar relay, a second line-circuit controlled by said first signal-sending relay, a second polar relay, a second local circuit through said second polar relay, said second line-circuit controlling said second polar relay, a second signal-sending relay controlled by said second polar relay and controlling said first line-circuit whereby one said line-circuit may control a said polar relay to control a signal-sending relay to send a signal upon the other line-circuit, and means whereby each said polar relay controls the local circuit of the other polar relay to prevent reflection signals.

10. In a telegraph system, two signaling lines, a repeater comprising a pair of polar signal-receiving relays one individual to each signaling line, a pair of windings on each of said relays, one of said windings in each of said relays being connected in series with one of said lines, the second winding of each of said relays being connected in a local circuit controlled by the other of said relays, and a second pair of relays whose circuits are entirely local for repeating signals received by said polar relays.

11. In a telegraph system, a first signaling line, a second signaling line, a repeater interposed therebetween comprising a pair of polar relays one individual to each of said signaling lines, a pair of windings in each of said relays one of said windings of each of said relays being connected in series with its associated signaling line, means including circuit connections controlled by one of said relays for restraining the other of said relays and a further relay for each said line for repeating signals into the other line.

12. In a telegraph repeater, two polar receiving relays, biasing circuits for each relay comprising each an unbalanced Wheatstone bridge circuit, each receiving relay operative to reverse the balance of the bridge circuit of the other relay, each relay being inoperative when its own bridge circuit is reversed in balance, two lines controlling said two polar relays respectively and two signal-repeating relays each controlled by a polar relay and each controlling a line circuit.

13. In a telegraph system, a first line circuit, a second line circuit, polar receiving relays, one for each circuit, biasing windings one for each relay, means whereby the operation by one line circuit of either receiving relay opens the other line circuit and reverses the bias of the other receiving relay, said means comprising in part unbalanced Wheatstone bridge circuits, each bridge con-

trolled by one of said receiving relays and containing the biasing winding of the other receiving relays, sending relays one for each line circuit and each controlled by the polar relay of the other line circuit.

14. In a telegraph repeater, a first normally closed line circuit, a polar receiving relay controlled by said line circuit, a polar signal-repeating relay controlled by normally open points of said polar receiving relay and a second normally closed line-circuit controlled by normally open points of said polar signal-repeating relay, whereby the mechanical transit time of the armature of said polar receiving relay delays the repeating of a line-opening signal-change and the mechanical transit time of the armature of said polar signal-repeating relay delays the repeating of a line-closing signal-change and whereby with symmetrically adjusted relays the time length of any signal will be unchanged by the repeater.

In testimony whereof I affix my signature.

JOHN O. CARR.

In testimony whereof I affix my signature.

ABRAHAM S. BENJAMIN.