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2,392,339

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Filed April 24, 1943

2 Sheets-Sheet 1

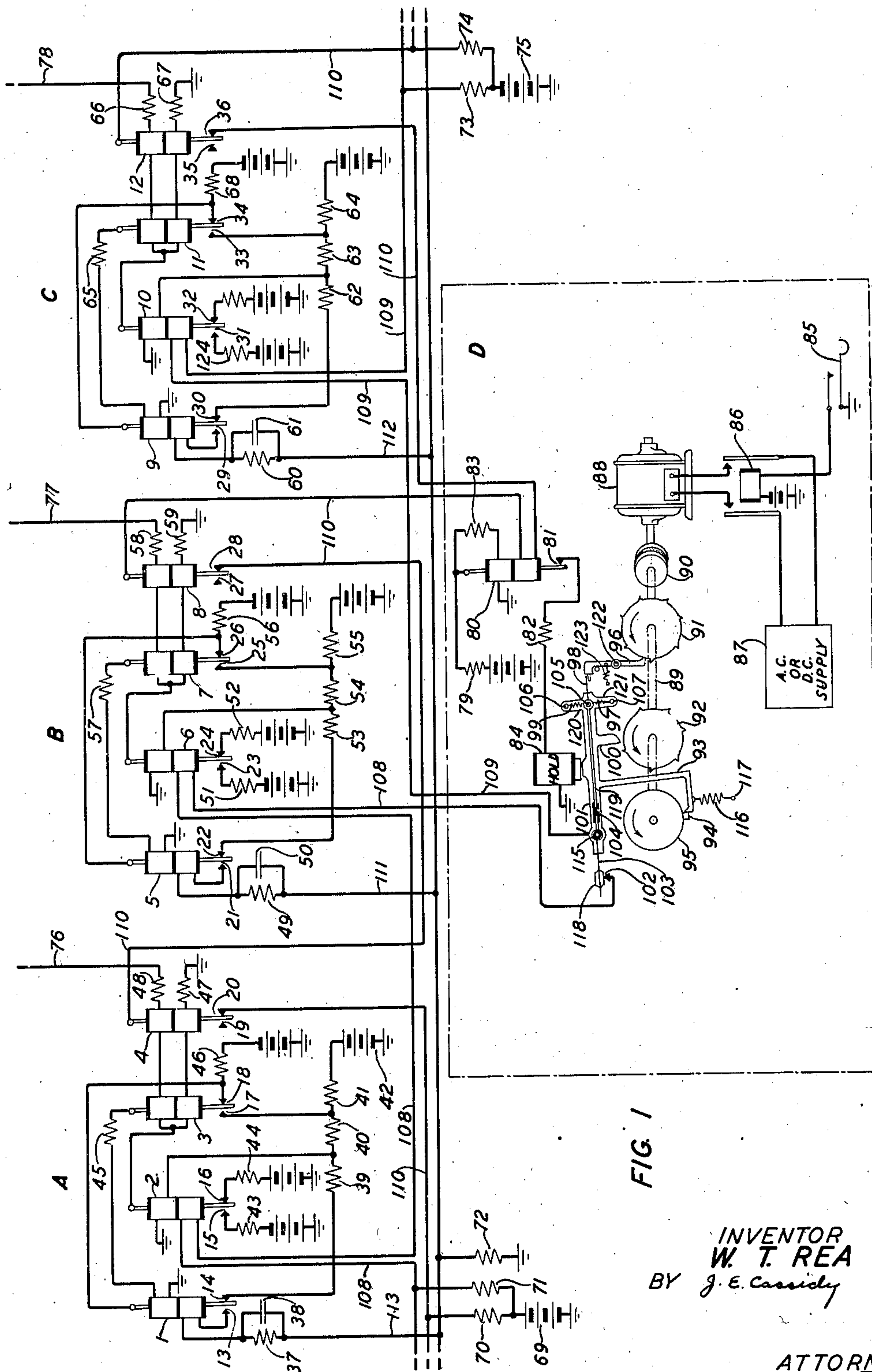


FIG. 1

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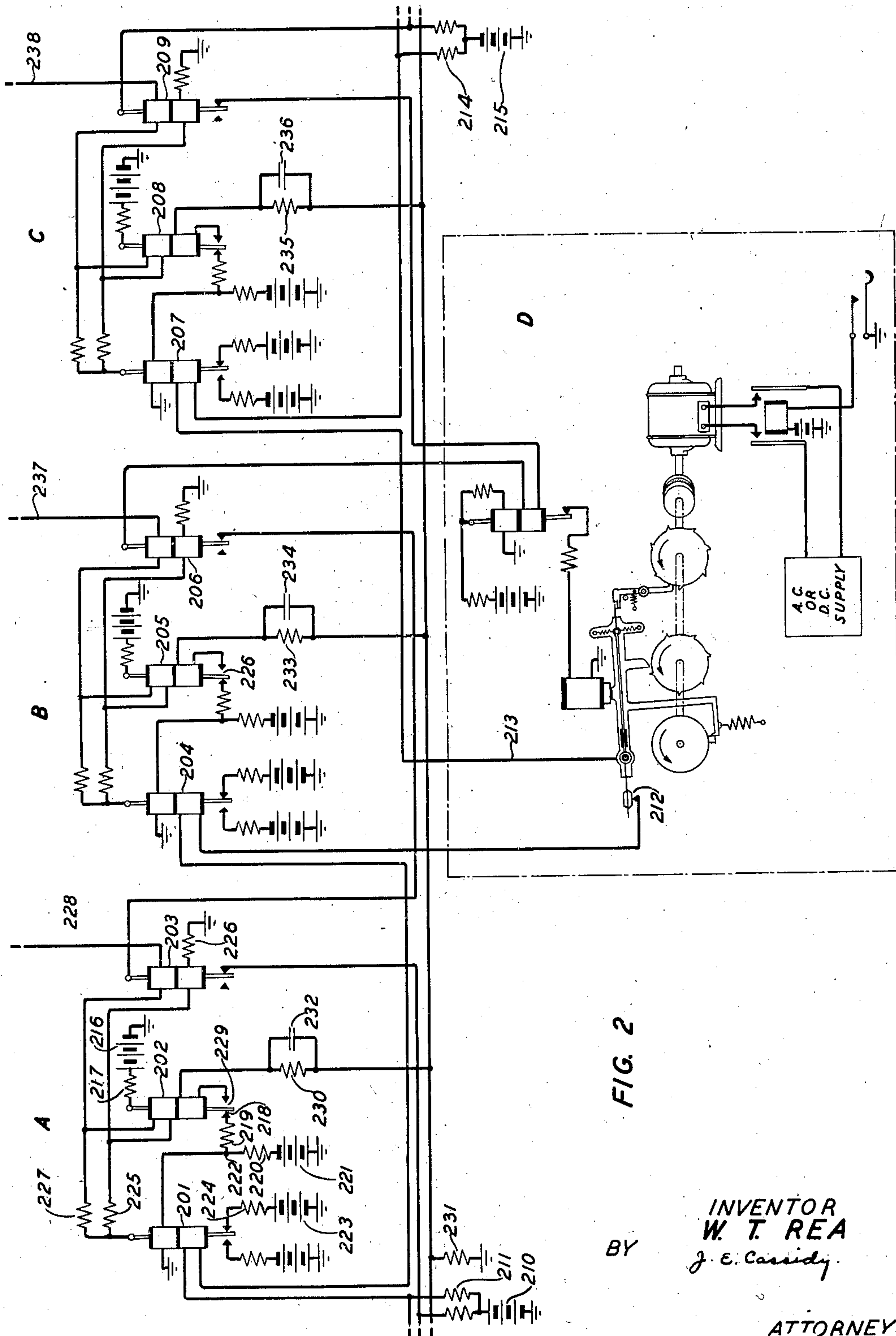


FIG. 2

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2,392,339

REGENERATIVE REPEATER FOR MULTI-WAY BALANCED LOOP REPEATERS

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15 Claims. (Cl. 178—73)

This invention relates to telegraph systems and particularly to an improved multiway regenerative repeater for use in reshaping and retiming distorted signals in telegraph systems comprising a group of telegraph lines each equipped with an individual balanced loop repeater, which group is interconnected to a single regenerative repeater unit in such manner that any one of the telegraph lines may transmit to all of the others comprising the group simultaneously.

The single regenerative repeater herein is arranged so that it is common to the entire group of balanced loop telegraph repeater circuits. It receives signals transmitted by any of the individual repeaters forming part of the group, reshapes and retimes them and transmits them to all of the other lines forming part of the group simultaneously.

An object of this invention is the improvement of telegraph systems which include regenerative repeaters.

A more particular object of this invention is the provision of a system wherein a single regenerative repeater serves a group of three or more balanced loop telegraph repeaters in such manner that any one of the repeaters forming part of the group may transmit simultaneously to all other repeaters forming part of the group.

A further object of the invention is the provision of a system wherein a group of three or more telegraph lines each including a balanced loop repeater is served by a single regenerative repeater unit and in which the regenerative repeater unit is arranged for open and closed operation in transmitting signals from the regenerative repeater to the balanced loop repeaters in the group.

A feature of this invention is an arrangement wherein a single regenerative repeater unit is arranged to receive telegraph signals from one of a group of telegraph lines each equipped individually with a balanced loop telegraph repeater and transmit regenerative signals to each of the other lines forming part of the group simultaneously.

A further feature of this invention is an arrangement wherein a regenerative repeater designed to serve simultaneously a group of three or more balanced loop telegraph repeater lines transmits open and closed telegraph signals toward the balanced loop repeaters.

The manner in which the invention herein operates may be understood from the following description when read with reference to the associated drawings in which:

Fig. 1 shows three telegraph lines each equipped with a balanced loop telegraph repeater connected to a single regenerative repeater arranged to serve all three lines. In Fig. 1 each of the telegraph repeaters in the lines A, B and C comprises four relays; and

Fig. 2 is another embodiment of the arrangement per Fig. 1 in which only three relays are required in each of the repeaters serving lines A, B and C.

GENERAL DESCRIPTION

Refer to Fig. 1. Balanced loop repeaters A, B and C are each connected to the regenerative repeater D in such manner that any one of them can transmit signals to each of the others simultaneously. Although only three balanced loop repeaters are shown, it is to be understood that any number may be connected to the single regenerative repeater D without limit.

Polar relays 1, 2, 3 and 4 are associated with repeater A. Polar relays 5, 6, 7 and 8 are associated with repeater B. Polar relays 9, 10, 11 and 12 are associated with repeater C. Polar relay 2, 6 or 10 in each of these repeaters is the transmitting relay which transmits the regenerative signals out over the telegraph lines 76, 77 and 78, respectively. Polar relays 4, 8 and 12 are the receiving relays which receive telegraph signals incoming over the associated lines 76, 77 and 78, respectively.

Telegraph signals incoming over telegraph line 76, for instance, will operate receiving relay 4. Receiving relay 4 will impress the signals on receiving relay 80 associated with regenerative repeater D. Receiving relay 80 will, in turn, impress the signals on magnet 84 in the regenerative repeater D. The regenerative repeater D will retime and reshape the received signals in a manner to be described below and will transmit open and closed telegraph signals from contact 102 simultaneously to relays 6 and 10 in repeaters B and C. Relays 6 and 10 will, in turn, transmit simultaneously polar signals from their respective contacts 23 and 24 and 31 and 32 out over lines 77 and 78.

In a similar manner signals received from telegraph line 77 by relay 8 will be regenerated in regenerative repeater D and transmitted by relays 2 and 10 simultaneously over telegraph lines 76 and 78. Signals received by relay 12 from telegraph line 78 will be regenerated by regenerative repeater D and transmitted simultaneously by relays 2 and 6 over telegraph lines 76 and 77.

The invention includes means for preventing

the transmission of signals received over one line, such as line 76, back over the same line after regeneration. Two relays in each of repeaters A, B and C, namely, relays 1 and 3 in repeater A, 5 and 7 in repeater B and 9 and 11 in repeater C cooperate to perform this function in a manner to be explained in detail below.

DETAILED DESCRIPTION

Regenerative repeater unit

The one-way regenerative repeater unit D employed in this invention is well known in the art. It is described in detail in Patent 2,105,173, W. J. Zenner, January 11, 1938. It will be described herein only in so far as it is necessary to an understanding of the present invention. It is to be understood, however, that the invention is not limited to operation with this particular regenerative repeater but will function with any regenerative repeater.

In order to condition regenerative repeater unit D for operation switch 85 is first operated. This closes a circuit from ground through the contact of switch 85 and the winding of relay 86 to battery operating relay 86. The operation of relay 86 establishes a circuit from the alternating current or direct current supply 87 through the right and left contacts of relay 86 to motor 88. Motor 88 thereafter rotates continuously. The motor-driving shaft and the regenerator unit driven shaft 89 are coupled together by means of a friction clutch 90 of the well-known type. Mounted on and rigidly secured to the driven shaft 89 are three cam discs 91, 92 and 95. Armature 101 is conditioned to rotate in a limited arc about shaft 115. The driven shaft 89 is prevented from rotation by means of a raised surface 94 on the periphery of stop cam 95 which engages the left-hand end of the J-shaped stop arm 93, depending from and integral with armature 101 when armature 101 is in its elevated position.

As has been explained, the signals received by relay 4, 8 or 12 are impressed on polar relay 80, which, in turn, impresses them on magnet 84 of the regenerative repeater D. Depending upon whether the received signal elements are marking or spacing, magnet 84 will be energized or deenergized. The regenerative repeater mechanism D is arranged, in a manner to be explained, so that armature 101 is presented to magnet 84 once for each received signal element. If magnet 84 is energized when armature 101 is presented to it, the armature remains elevated against the tension of spring 116, secured at one end to the lower portion of stop arm 93 and at the other end to a fixed pin 117.

The sending reed 103 is secured by means of a sleeve to shaft 115 in such a manner that it is capable of independent rotation about shaft 115 through a small arc so that its contact 118 mounted at the left-hand extremity of sending reed 103 can make with and disengage from its cooperating contact 102.

An extension of the sending reed to the right of shaft 115 is separated by means of an insulating element 104 from a bar 119 to the right-hand extremity of which is secured a latching element 98. The whole assembly comprising the contacting element 118, the sending reed 103, the sleeve surrounding shaft 115, the insulating element 104, bar 119 and latching element 98 forms a rigid integral structure. If bar 119 is moved upwardly in a manner to be described, contact 118 on sending reed 103 will engage marking contact 102. If bar 119 is moved downwardly contact 118 will

disengage from contact 102. The right-hand end of armature 101 is formed into two arms 120 and 121, one extending upwardly and one downwardly with respect to bar 101. Centered near the upper and lower extremity of arms 120 and 121, respectively, are fixed pins 106 and 107, securing springs 99 and 97, respectively. Each of these springs is attached at its inner end to bar 119. When armature 101 moves upwardly or downwardly the centralizing springs 97 and 99 tend to move bar 119 in the same direction to impart motion to sending reed 103.

When the regenerative repeater D is in the normal stopped position magnet 84 is energized and the driven shaft 89 is stopped. The right-hand end 98 of bar 119 will be latched in its upper position, as shown, by the left-hand projection on the top arm of follower 96. Marking contact 102 is closed.

It is particularly pointed out that the regenerative repeater D is arranged to retime and reshape a train of signal elements comprising a fixed number of elements. The regenerative repeater D in this case is functioning in a system wherein each train of signal elements invariably comprises seven signal elements, namely, a starting signal element, which is always a spacing signal element, followed by five character determining signal elements, each of which may be either marking or spacing signal elements in any combination and a final stop signal element which is always a marking signal element.

The speed of motor 88 is fixed so that shaft 89 will make one complete revolution in an interval equal to the time of transmission of a train of seven unit signal elements. Further, cams 91 and 92 are so cut that the length of each regenerated signal element is the same as its length as originally generated at the distant transmitting stations.

The first signal element in any train of signal elements, as explained, is always a spacing signal element and the circuit herein is arranged in a manner to be described, so that magnet 84 is deenergized for this condition. Armature 101 is moved downwardly when magnet 84 is deenergized due to tension in spring 116. The left-hand end of stop arm 93 disengages from raised surface 94 of stop cam 95. Driven shaft 89 rotates in a counter-clockwise direction as indicated by the arrows.

A downward projection 100 on armature 101 will engage the periphery of cam 92. A short interval thereafter a projection on cam 91 will rotate follower 96 through a small arc in a clockwise direction about its pivot 122 against the influence of spring 123 which spring is attached at its right-hand end to the upper arm of follower 96 and at its left-hand end to a fixed pin. Spring 123 is tensioned. A right-hand projection at the bottom of the lower arm of follower 96 engages cam 91. A left-hand projection at the top of the upper arm of follower 96 forms a latch for the right-hand flattened end 98 of bar 119. When the armature 101 moved into its lower position spring 121 was tensioned while bar 119 was retained in its upper position. Immediately upon the withdrawal of the projection of the upper arm of follower 96 from its position beneath the right-hand flattened end 98 of bar 119, bar 119 will be pulled downwardly by spring 121. An instant later the first projection on cam 91 will have rotated past the projection on the bottom arm of follower 96 and the follower will be rotated in a counter-

clockwise direction by spring 123. The projection on the top arm of follower 96 will engage the top surface of the right-hand end 98 of bar 119, locking the right-hand end of the bar in its lower position. As a result of this contact 102 will be opened.

Bar 119 will be locked in its lower position for an interval equal to the full length of a spacing signal which will be transmitted from contact 102 to the connected repeaters.

While bar 119 is still locked so as to maintain contact 102 open to transmit the first spacing signal element as a start signal, the pulse corresponding to the first character-forming signal element will be transmitted into the regenerative repeater D. It may be either marking or spacing depending upon the particular character. If it is marking the magnet 84 will be energized. If it is spacing the magnet 84 will be de-energized. At the middle of the pulse, when magnet 84 will have been properly conditioned, the first projection on cam 92 will urge follower 100 upwardly, raising armature 101, which is thus presented to magnet 84. If the magnet is energized the armature 101 will be retained in its upper position. In any case, bar 119 will remain locked in its lower position until the necessary interval for the transmission of a start pulse of proper length has elapsed. Then once more a raised surface on cam 91 will actuate follower 96 unlatching the right-hand end 98 of bar 119. If the armature 101 has remained in its upper position spring 120 is tensioned. As soon as bar 119 is unlatched it will be moved upwardly. After it has completed its upward movement it will be relatched. When bar 119 moves upwardly contact 102 will be reclosed. Thus a train of signals of proper over-all length and each of proper individual length will be transmitted from the regenerative repeater D. Each signal element whether marking or spacing will correspond to the received signal element. The over-all length of the train will be the same as that of the received train, except when the received train is shorter than seven unit pulse length. In the latter case, the regenerator unit will fail to stop but will transmit a train of seven unit pulse lengths in duration. The lengths of the individual signal elements will be determined by the spacings of the raised surfaces on the peripheries of cams 91 and 92. In the event that successive signal elements are of the same nature, that is to say, in the event that successive elements are marking or spacing, although armature 101 may move while the nature of each element is being determined, bar 119 will be locked in position while the armature is moving and the armature will have assumed a final position for the particular element corresponding to that assumed for the preceding element of the same nature before bar 119 is unlatched and bar 119 will therefore remain in the same position for successive marking signal elements or successive spacing signal elements.

As mentioned above, the final signal element of each train is always a marking signal element. Magnet 84 will therefore be energized and armature 101 will be retained in its elevated position for this condition. When follower 96 latches the right-hand end 98 of bar 119, bar 119 will be secured in its elevated position. Under this condition contact 102 is always closed to transmit a marking signal.

Attention is called to the fact that the regenerative repeater mechanism operating as de-

scribed above interposes a fixed delay of approximately one-half the duration of a signal element between its reception by magnet 84 and its retransmission by the regenerative repeater. This is so, because the center portion of each signal element is used to determine the nature of each element. The reason for this is that in order to correctly determine the nature of greatly distorted signal elements it is advisable to use the center portion of the element. A delay is thus interposed, but since all signal transitions are delayed an equal amount the configuration of the signal train is unaffected as the start of transmission of each full length signal element, as transmitted by the opening and closing of contact 102 of the regenerative repeater D, is measured from the reception of the middle portion of each signal element.

Description of operation of circuit per Fig. 1

The operation of the circuit per Fig. 1 will now be described in detail. The condition of the various relays when normal and awaiting transmission from some line forming part of the inter-

communicating group will first be explained. The armature of relay 2 is shown in engagement with contact 16. For this condition a circuit may be traced from positive battery through resistance 44, contact 16 and the armature of relay 2 to a parallel circuit. One branch of the circuit extends through the upper windings of polar relays 3 and 4 in series through resistance 48 and conductor 76 to the distant station, not shown. At the distant station it extends through the winding of a receiving relay to negative battery connected to the marking contact of a sending relay. The second branch of the parallel circuit extends through the bottom windings of polar relays 3 and 4 in series and through resistance 47 to ground. The effect of the current flowing through the bottom windings of relays 3 and 4 tends to actuate the armatures of relays 3 and 4 toward the left to engage their respective spacing contacts 17 and 19. This effect is opposed by the current flowing through the top windings of relays 3 and 4. The effect of the current flowing through the top windings of relays 3 and 4 is dominant and the armatures of relays 3 and 4 are maintained in engagement with their right-hand contacts 18 and 20, respectively.

A circuit in the form of a potentiometer may be traced from negative battery through resistance 46 to parallel branches. One branch extends through the armature and right-hand or marking contact 14 of polar relay 1 and through resistances 39, 40 and 41 in series to positive battery 42. Attention is called to the fact that the positive and negative batteries in this circuit are arranged in series aiding relationship. From the left-hand terminal of resistance 46 a branch of the circuit extends through contact 18, armature of polar relay 3, resistance 45 and the top winding of polar relay 1 to ground. From the junction of resistances 39 and 40 a circuit extends through the top winding of polar relay 2 to ground. The potential between the left-hand terminal of resistance 46 and ground and the direction of the flow of current through the top winding of polar relay 1 is such that the armature of polar relay 1 is maintained in engagement with its right-hand contact 14 for this condition. The circuit through the bottom winding of polar relay 1 is open at contact 13.

A circuit may be traced from positive battery 69 through resistance 71, bottom winding of polar

relay 2, conductor 108, bottom winding of polar relay 6, contacts 102 and 118, sending reed 103, conductor 109, bottom winding of polar relay 10 and resistance 73 to negative battery 75. The current flowing in this path tends to actuate the armatures of relays 2, 6 and 10 to engage with their right-hand or marking contacts 16, 24 and 32, respectively. This effect is opposed by the effect of current flowing through the top windings of relays 2, 6 and 10 which effect tends to actuate the armatures of these relays toward the left to engage with their left-hand or spacing contacts 15, 23 and 31, respectively. The effect of the current in the bottom windings is dominant, however, and the armatures are maintained in engagement with their right-hand or marking contacts. The effects of the currents in the various other windings of the relays in repeaters B and C are the same as described for repeater A.

A circuit may also be traced from positive battery 69 through resistance 70, contact 20, armature of relay 4, contact 28, armature of relay 8, conductor 110, bottom winding of polar relay 80, contact 36, armature of relay 12 and resistance 74 to negative battery 75. The effect of current flowing in the bottom winding of relay 80 tends to actuate its armature toward the right to close its marking contact 81. It is dominant over the effect of current flowing from positive battery through resistance 79, resistance 83 and the top winding of relay 80 which tends to actuate the armature of relay 80 toward the left, so that the armature of relay 80 is maintained in engagement with contact 81 while the circuit through the bottom winding of relay 80 remains closed. While contact 81 is closed, a circuit may be traced from positive battery through resistance 79, armature of relay 80, contact 81, resistance 82 and the winding of magnet 84 to ground energizing magnet 84. If contact 20, 28 or 36 of receiving relays 4, 8 or 12, respectively, is opened in a manner to be described, the bottom winding of relay 80 will be deenergized. The armature of relay 80 will be actuated to the left opening contact 81 and deenergizing magnet 84.

Let it be assumed that the armature of the sending relay at the distant station connected to conductor 76 is either open or connected to positive battery for the transmission of a spacing signal, so that no current flows through the top windings of relays 3 and 4. The armatures of relays 3 and 4 will be actuated to engage their left-hand or spacing contacts 17 and 19, respectively, under the influence of current in their bottom windings. This results in the opening of contact 81 as heretofore explained. When contact 81 is opened magnet 84 is deenergized and armature 101 is released to initiate the starting signal element as heretofore described.

When the armature of polar relay 3 is actuated to the left in response to the reception of the first spacing signal element a circuit is established which may be traced from positive battery through resistance 41, contact 17, armature of polar relay 3, resistance 45 and the top winding of polar relay 1 to ground. This reverses the effect of the current flowing through the top winding of relay 1 and the armature of relay 1 is actuated to the left to engage contact 13. The armature of relay 1 is locked in engagement with contact 13 by the effect of current flowing in a circuit which may be traced from negative battery through resistance 46, armature of relay 1,

contact 13, bottom winding of relay 1, and resistances 37 and 72 in series to ground.

The opening of contact 14 of polar relay 1 reverses the effect of the current flowing through the top winding of polar relay 2. As a result of this the armature of polar relay 2 will be maintained in engagement with its marking contact 16 when regenerated signals are transmitted from regenerative repeater D in a manner to be described.

When, approximately a half pulse length later, transmitting contact 102 of regenerative repeater D is opened, the path through the bottom windings of relays 2, 6 and 10 is opened. If the direction of current flowing through the top windings of these relays remains unchanged the armatures of these relays will be actuated to the left to transmit a spacing signal over the associated line. However, in the case of repeater A which is receiving a spacing signal over conductor 76, the direction of the current flowing through the top winding of relay 2 has been changed, as described, so that the armature of relay 2 is maintained in engagement with its right-hand or marking contact 16. The armatures of relays 6 and 10, however, will be actuated toward the left to engage their respective contacts 23 and 31. As a result of this the polarity of the voltage connected to the armatures of relays 6 and 10 is changed. Negative battery is connected through resistance 51 and contact 23 to the armature of relay 6. Negative battery is also connected through resistance 124 and contact 31 to the armature of relay 10. Spacing signals are therefore transmitted over lines 77 and 78, respectively, to the distant stations connected to repeaters B and C. The armatures of relays 7, 8, 11 and 12 will be maintained in engagement with their respective contacts 26, 28, 34 and 36 due to the reversal of the effect of the current in their bottom windings.

Since the armature of relay 2 in repeater A is maintained in engagement with its contact 16 the spacing signal transmitted by regenerative repeater D in response to the spacing signal received over conductor 76 cannot be retransmitted by repeater A toward the distant station connected to conductor 76.

The circuit will remain unchanged until the next marking signal element is received. When the distant end of conductor 76 is again reconnected to negative battery to transmit a marking signal element toward repeater A the armatures of relays 3 and 4 will be actuated to reengage contacts 18 and 20, respectively. The armature of relay 1 will be maintained in engagement with its contact 13 and the armature of relay 2 will be maintained in engagement with its contact 16. The reclosing of contact 20 of relay 4 will reenergize the bottom winding of relay 80. Contact 81 will be reclosed. Magnet 84 will be reenergized. About a half pulse length later contact 102 will be reclosed. The armatures of relays 6 and 10 will be actuated to reengage their contacts 24 and 32, respectively. As a result of this a marking signal will be transmitted over conductors 77 and 78. The marking condition will be maintained for conductor 76. It is particularly pointed out that after the reception of the first or starting signal element which is always a spacing signal element the succeeding five signal elements may be either marking or spacing in any combination and the signals received by polar relay 4 and retransmitted from contact 102 of regenerative repeater D will depend upon the particular char-

acter which is to be formed in accordance with the five-element permutation code. The last signal element of each train as heretofore described is always a marking signal.

Since repeaters A, B and C are identical, when signals are received by repeater B or C over conductor 77 or 78, repeater B or C will operate in the same manner as described for repeater A. The manner in which repeaters B and C function, therefore, may be understood from the description of the operation of repeater A.

Station connected to repeater A stops transmitting, station connected to repeater B starts transmitting, Fig. 1

In describing the operation of repeater A above it was explained that as soon as the first spacing signal element is received over conductor 76 the armature of relay 1 is locked in engagement with its contact 13. Further, it was explained that as a result of this the direction of the flow of current through the top winding of relay 2 was changed from its normal direction so that its effect tended to maintain the armature of relay 2 in engagement with contact 16 during the entire interval while signals were received by repeater A over conductor 76. During the reception of regenerated marking signal elements by relay 2 the effect of the current in both the top and bottom windings of relay 2 is in the same direction so that for a marking signal element the armature of relay 2 is maintained against its contact 16 by the effect of the current in both windings. For a spacing signal element the effect of the current in the top winding alone performs this function as no current flows through the bottom winding.

It is particularly pointed out that as long as reception of signals by repeater A over conductor 76 continues and when reception is terminated, unless there has been an interruption by the reception of a breaking signal over conductor 77 or 78, the armature of relay 1 will remain locked in engagement with contact 13 and the armature of relay 2 will be maintained in engagement with contact 16.

It will be assumed that the reception of signals over conductor 76 by repeater A is terminated and that some other station connected to one of the other repeaters such as the station connected by conductor 77 to repeater B starts to transmit. In response to the reception of the first spacing signal over conductor 77 the armatures of relays 7 and 8 will be actuated to engage with their contacts 25 and 27, respectively, in the same manner as described for relays 3 and 4 in repeater A. In response to this the armature of relay 5 will be actuated to engage with its contact 21. The direction of the current flowing through the top winding of relay 6 will thereupon be changed so that its effect maintains the armature of relay 6 in engagement with contact 24. When the armature of relay 5 engages with contact 21 the circuit extending from negative battery through resistance 46, armature of relay 1, contact 13, bottom winding of relay 1, resistance 37 and conductor 113 to the top terminal of resistance 72 is shunted by the path extending from negative battery through resistance 56, armature of relay 5, contact 21, bottom winding of relay 5, resistance 49 and conductor 111 to the top terminal of resistance 72. As a result of this the current through the bottom winding of relay 1 is reduced. As a result of this reduction, the effect of the current flowing through the top winding of relay

1 becomes dominant over the effect of the current through the bottom winding of relay 1 and the armature of relay 1 will be actuated to reengage with its contact 14. As the armature of relay 1 leaves contact 13 the current in the bottom winding of relay 5 will increase locking the armature of relay 1 in engagement with contact 21.

When the armature of relay 1 reengages with contact 14 the direction and magnitude of the current flowing in relay 2 are restored to their original conditions. That is to say, the effect of the current flowing through the top winding of relay 2 tends to actuate the armature of relay 2 to engage with its contact 15. The current will therefore be effective to actuate the armature of relay 2 to engage with contact 15 when there is no current in the bottom winding of relay 2 which is the condition when contact 102 of regenerative repeater D is open. In other words, repeater A is conditioned to transmit regenerated signals over conductor 76 in response to signals received over conductor 77 by repeater B.

Relays 1, 5 and 9 are high speed polar relays. Condensers 38, 50 and 61 shunt resistances 37, 49 and 60, respectively. Each of these resistances is in series with a bottom winding of the high speed polar locking relay in each repeater. When any of the relays, such as 1, 5 and 9, is locked and the armature of another of these relays is operated to engage its spacing contact, not only is the current through the bottom winding of the original locked relay reduced by the shunting effect of the second, but a surge of current due to the shunting condenser is passed through the bottom winding of the original locked relay. Its effect is to speed the unlocking of the relay.

Station connected to repeater A is transmitting and station connected to repeater B breaks, Fig. 1

It will now be assumed that the distant station connected to repeater A over conductor 76 is still transmitting to repeater A and that another station, for instance, the station connected to repeater B by conductor 77, starts to transmit to repeater B. If this breaking operation occurs when a marking signal is being received by repeater A the operation will be the same as described above for the condition wherein repeater B starts to receive from line 77 after reception by repeater A from line 76 has terminated. But the condition wherein the other station, such as the station connected to repeater B by conductor 77, starts to transmit while repeater A is receiving a spacing signal from conductor 76 is different and will now be explained.

During a breaking operation, say by repeater B, if a spacing signal is being received at the instant by repeater A from its distant station, which has theretofore been transmitting, the armature of relay 3 in repeater A will be in engagement with its contact 17. The effect of the current flowing through the top winding of the relay 1 for this condition, as has been explained, tends to actuate the armature of relay 1 to engage with its contact 13. Therefore, if a spacing signal is being received by repeater A over line 76 when the breaking signal is received from repeater B, the armature of relay 1 will be maintained in its locked condition against contact 13 until the next marking signal element is received over line 76 by relay 3. When, in response to this, the armature of relay 3 is actuated to engage its marking contact 18, the direction and effect of

the current through the top winding of relay 1 is reversed. This effect will be dominant over the reduced opposing effect in the bottom winding of relay 1 and the armature of relay 1 will be operated to engage its contact 14. In other words, a break from line 77, if occurring while a spacing signal is being received over line 76, will not be instantaneous. It will not be effective to interrupt signals incoming over conductor 76 until the next marking signal is received over conductor 76. In this respect the system herein resembles other half duplex systems.

Embodiment per Fig. 2

Fig. 2 shows another embodiment of the invention herein. In this embodiment only three relays are required in each repeater instead of the four relays shown in each repeater in the embodiment per Fig. 1. The regenerative repeater D operates in the same manner as described for the embodiment per Fig. 1.

The three relays in repeater A, in the embodiment per Fig. 2, are relays 201, 202 and 203; in repeater B, relays 204, 205 and 206; in repeater C, relays 207, 208 and 209. Relays 203, 206 and 209 are the relays which receive signals incoming from the distant connected station. Relays 201, 204 and 207 are the relays which transmit toward the distant station. Relays 202, 205 and 208 in repeaters A, B and C, respectively, perform the function of preventing the retransmission of signals received by a particular repeater from its distant associated station back toward the transmitting station. These relays function also to prevent mutilation of the first portion of a signal element which is being transmitted toward the last distant station which has been transmitting. Each of these relays, therefore, performs the function for which two relays are required in the embodiment per Fig. 1. That is to say, relay 202, for instance, in repeater A, per Fig. 2, corresponds in its function to relays 1 and 3 in repeater A per Fig. 1. The operation of Fig. 2 may be generally understood from the description of the operation of Fig. 1 above. Its operation will be described therefore only in so far as it is necessary to point out the distinctions in the two embodiments.

The current conditions and their effects in the various windings of the relays in the embodiment per Fig. 2 will first be described.

A circuit may be traced from positive battery 210 through resistance 211, bottom winding of relay 201, bottom winding of relay 204, contact 212, conductor 213, bottom winding of relay 207, and resistance 214 to negative battery 215. The effect of current flowing through the bottom winding of relays 201, 204 and 207 tends to actuate the armatures of these relays to engage with their respective right-hand or marking contacts. A circuit may also be traced in each repeater corresponding with the circuit which extends from positive battery 216 through resistance 217, armature of relay 202, contact 218, resistance 219 and resistance 220 to negative battery 220. This circuit is, in effect, a potentiometer. A circuit may be traced extending from junction point 222 between resistances 219 and 220 of this potentiometer through the top winding of relay 201 to ground. The effect of current flowing through the top winding of relay 201 tends to actuate the armature of relay 201 toward the left. The effect of the current flowing in the bottom winding of relay 201 is dominant, however, and the armature of relay 201 is maintained

in engagement with its right-hand or marking contact. This applies equally to relays 204 and 207 in repeaters B and C, respectively. When the armature of relay 201 is in engagement with its right-hand contact, a circuit may be traced from positive battery 223 through resistance 224 and the armature and right-hand contact of relay 201 to parallel branches. One branch extends through resistance 225, bottom winding of relay 203 and resistance 226 to ground. A second branch extends through resistance 227 and the top winding of relay 203 to conductor 228. Conductor 228 extends to a telegraph repeater in a distant telegraph station, not shown. It extends through the winding of a receiving relay and the armature of sending relay and is terminated in negative battery connected to the marking contact of the sending relay. The effect of the current flowing through the bottom winding of relay 203 tends to actuate the armature of relay 203 to engage with its left-hand or spacing contact but the effect of the current flowing in the top winding of relay 203 tending to actuate the armature of relay 203 towards its right-hand or marking contact is dominant and the armature is maintained in engagement with its right-hand or marking contact.

The top and bottom terminals of the top winding of relay 202 are connected to the right-hand terminals of resistances 227 and 225, respectively. There is a difference in potential between these terminals and the effect of the resultant current through the top winding of relay 202 maintains the armature of relay 202 in engagement with its left-hand contact for this condition.

It will now be assumed that signals are transmitted from the distant station connected to repeater A. In transmitting spacing signals from the distant station toward repeater A the armature of the sending relay at the distant station is connected either to positive battery or to an open circuit so that no current flows in the top winding of relay 203. As a result of this the armature of relay 203 will be actuated toward the left under the influence of current flowing through its bottom winding. This results in the transmission of a spacing signal into regenerative repeater D in the same manner as for the embodiment per Fig. 1. The transmission of a spacing signal from the distant station connected to repeater A also effects a reversal in the direction of current through the top winding of relay 202 and the armature of relay 202 is actuated to engage its right-hand contact 229. A circuit may thereupon be traced from positive battery 216, through resistance 217, armature and contact 229 of relay 202, bottom winding of relay 202, resistance 230 and resistance 231 to ground. The effect of this current locks the armature of relay 202 to contact 229. When the armature of relay 202 breaks from its contact 218 the polarity of the current flowing through the top winding of relay 201 is reversed and its effect is thereupon changed so that it tends to actuate the armature of relay 201 to engage with its right-hand contact. When transmitting contact 212 of regenerative repeater D is opened to transmit the regenerated spacing signal an interval equal in duration to at least one-half the duration of a signal element will have elapsed. During this interval relay 201 will be conditioned, as described above, so that when the circuit through its bottom winding is opened its armature will be maintained in engagement with its marking contact. It will, therefore, be impossible to transmit the regenerated signal back

towards its originating source in the distant office connected to conductor 228. Relays 204 and 207, however, which correspond to relay 201 will respond to the spacing signal under the influence of the current flowing through their respective top windings and their respective armatures will be operated simultaneously to engage their spacing contacts to transmit a spacing signal to their distant respective connected stations.

A station in group per Fig. 2 starts to transmit while others are idle

When the distant station connected to conductor 228 ceases to transmit the armature of relay 202 will remain locked in engagement with its right-hand contact 229 and the current through the top winding of relay 201 will consequently be maintained in a direction such that its armature is maintained in engagement with its right-hand or marking contact. If under these circumstances a signal is transmitted from the distant station connected to repeater B or repeater C the armature of relay 206 or 209 will be actuated to engage with its left-hand or spacing contact, transmitting a spacing signal into the regenerative repeater D. Simultaneously the armature of relay 205 or 208 will be actuated to the right to engage with its right-hand contact. The corresponding sending relay 204 or 207 will be conditioned due to the change in the direction of the current through its top winding so that its armature is maintained in engagement with its right-hand or marking contact. The effect of the operation of the armature of either relay 205 or 208 to engage its right-hand contact is to establish a shunting path for the path extending through the bottom winding of relay 202, thus reducing the current flowing through the bottom winding of relay 202. The effect of the reduced current flowing through the bottom winding of relay 202 tending to maintain the armature of relay 202 in engagement with contact 229 is less than the opposing effect of the current flowing through the top winding of relay 202 and the armature of relay 202 is operated to the left to engage its contact 218. This permits the current to increase in the lower winding of relay 202 locking its armature in engagement with contact 237. Relay 202 is a high speed polar relay. Condensers 232, 234 and 236 shunt resistances 230, 233 and 235, respectively, which are connected in series with the bottom windings of high speed polar relays 202, 205 and 208. The effect of the condensers is to generate a transient surge of unlocking current through the bottom windings of relay 202, 205 or 208 when any of these relays have been locked and the armature of any other of these relays is subsequently operated to engage with its respective locking contact.

Breaking operation per Fig. 2

It will be assumed that signals are incoming over line 228 to repeater A in Fig. 2 and that the station connected to conductor 237 breaks, that is, starts to transmit. If the break occurs when a marking signal is being received over conductor 228 the operation is the same as described under the preceding heading. If, however, the operation occurs when a spacing signal element is being received over line 228 the effect of the current in the top winding of relay 202 will be in a direction to actuate the armature of relay 202 toward its locking contact 229. The break will not occur, therefore, until a marking signal is being received by relay 202 and its effect is tending to operate the armature of relay 202 toward contact

218. This effect will be dominant over the reduced effect of the current in the bottom winding of relay 202 tending to maintain the locked condition and the lock will be opened. The armature of relay 202 will engage contact 218. The polarity of the current in the top winding of relay 201 will be reversed and repeater A will be conditioned to transmit over conductor 228.

What is claimed is:

1. In a telegraph communication circuit, at least three telegraph lines interconnected through individual repeaters to a single one-way regenerative repeater common to all of said lines, means in said circuit for regenerating signals incoming from any one of said lines in said regenerative repeater and transmitting them simultaneously to more than one of the others, a telegraph signal receiving relay in each of said individual repeaters, a contact on each of said relays controlled by each of said relays, and a single common path extending through all of said contacts in series to the input of said regenerative repeater.

2. In a telegraph communication circuit, at least three telegraph lines interconnected through individual repeaters to a single one-way regenerative repeater common to all of said lines, means in said circuit for regenerating signals incoming from any one of said lines in said regenerative repeater and transmitting them simultaneously to more than one of the others, a telegraph signal sending relay in each of said individual repeaters, a winding on each of said relays and a single common path extending through all of said windings in series to the output of said regenerative repeater.

3. In a telegraph communication circuit, at least three telegraph lines interconnected through individual repeaters to a single one-way regenerative repeater common to all of said lines, means in said circuit for regenerating signals incoming from any one of said lines in said regenerative repeater, and transmitting them simultaneously to more than one of the others, a telegraph signal receiving relay in each of said individual repeaters, a contact on each of said relays, a single common path extending through all of said contacts in series to the input of said regenerative repeater, a telegraph signal transmitting relay in each of said individual repeaters, a winding on each of said receiving relays and a single common path extending through all of said windings in series to the output of said regenerative repeater.

4. In a telegraph communication circuit, at least three telegraph lines interconnected through individual repeaters to a single one-way regenerative repeater common to all of said lines, means in said circuit for regenerating signals incoming from any one of said lines in said regenerative repeater and transmitting them simultaneously to more than one of the others, a receiving relay in each of said individual repeaters, a contact on each of said relays, a single common path extending through all of said contacts in series to the input of said regenerative repeater, a telegraph signal transmitting relay in each of said individual repeaters, a winding on each of said transmitting relays, a single common path extending through all of said windings in series to the output of said regenerative repeater, and means in said repeaters for preventing the retransmission of signals received through a particular individual repeater back through the same individual repeater.

5. In a telegraph system, at least three telegraph lines each comprising an individual repeater connected to a single one-way regenerative repeater arranged to serve all of said lines in common, means in said system for repeating signals received from any one of said lines through said regenerative repeater, to all of the other lines simultaneously, telegraph signal receiving means in each of said individual repeaters, a single common path extending through all of said receiving means in series to the input of said regenerative repeater, telegraph signal transmitting means in each of said individual repeaters, a single common path extending through all of said transmitting means in series to the output of said regenerative repeater, and means in each of said individual repeaters for preventing the mutilation of the first signal element transmitted through said system whenever the transmitting path through said system is changed.

6. A multiway regenerative telegraph repeater system, a single common path extending through individual telegraph signal receiving elements in at least three individual repeaters in said system all in series to the input of a single one-way regenerative repeater, and means for transmitting telegraph signals received from any one of said individual repeaters to more than one of the others simultaneously.

7. In a telegraph system, at least three telegraph relay repeaters interconnected through a single one-way regenerative repeater, means in said system for receiving signals from any one of said relay repeaters and repeating regenerated signals from said regenerative repeater to all others of said relay repeaters, a single common path extending in series through contacts on telegraph receiving relays in each of said relay repeaters to the input of said regenerative repeater, a single common path extending in series through windings of transmitting relays in each of said relay repeaters to the output of said regenerative repeater, a relay locking circuit for preventing the retransmission of signals received by one of said relay repeaters back through the same repeater and a high speed unlocking circuit connected to said locking means.

8. In a telegraph system, a first, second, and third balanced loop telegraph repeater each connected individually to a telegraph line extending to a distant station and all connected through a single common continuous path in series to a single regenerative repeater, means for receiving telegraph signals in any one of said balanced loop repeaters from its associated connecting station, means for impressing said received signals on the input of said regenerative repeater, and means for transmitting regenerated open and closed circuit telegraph signals from the output of said regenerative repeater to the other two of said balanced loop repeaters simultaneously.

9. In a telegraph system, at least three balanced loop telegraph repeaters each connected to individual telegraph channels extending to distant telegraph stations, means comprising a single continuous common circuit for connecting all of said repeaters in series to a single regenerative repeater, means for receiving signals in any of said balanced loop repeaters and impressing them through said circuit on the input of said regenerative repeater, means for transmitting open and closed telegraph signals from the output of said regenerative repeater to all of said balanced loop repeaters simultaneously, and means for

transmitting polar signals in response to said regenerated signals from all except the one of said balanced loop repeaters from which the original signals were received.

10. In a telegraph system, a multiway regenerative telegraph repeater system, a single common continuous path extending in series through individual telegraph signal receiving elements in at least three individual repeaters in said system to the input of a single one-way regenerative repeater, means for transmitting telegraph signals received from any one of said individual repeaters to more than one of the others simultaneously and a locking circuit comprising individual branches connected in parallel to a relay in each of said individual repeaters for preventing the retransmission of signals received from a particular one of said individual repeaters back through the same individual repeater after regeneration.

11. A first, second and third telegraph line repeater connected to a regenerative repeater, means for impressing signals from any one of said line repeaters on said regenerative repeater, and means connected to said regenerative repeater, said means comprising a continuous circuit extending through a winding on a relay in each of said line repeaters in series, for impressing regenerated open and closed signals on the other two of said line repeaters simultaneously in response to said impressed signals.

12. A multiway regenerative repeater system, at least three line repeaters therein individually connected intermediate three telegraph lines and a single regenerative repeater mechanism, means in said system, comprising a first single continuous circuit extending through a contact on a receiving relay in each of said line repeaters and through a winding on a receiving element in said mechanism, for receiving telegraph signals from any of said lines through its individual repeater and impressing them on said mechanism and means in said system, comprising a second single continuous circuit extending through a winding on a transmitting relay in each of said line repeaters and through a transmitting contact in said mechanism, for impressing regenerated signals on all of the other of said lines through their individual repeaters in response to said signals impressed on said mechanism.

13. A system in accordance with claim 12 including, in combination, a device for increasing the speed with which a line which is transmitting into said mechanism is conditioned to receive signals when another line begins to transmit into said mechanism.

14. A system in accordance with claim 12 including, in combination, also a device for speeding the reversal in direction of transmission of said line repeaters, said device comprising, in each of said line repeaters, a first relay, operating in unison with a receiving relay, and a second relay, responsive to said first relay, for controlling a transmitting relay.

15. A system in accordance with claim 12 including also a device for speeding the reversal in direction of transmission of said line repeaters, said device having one control relay in each line repeater directly responsive to signals incoming from any line connected to said line repeaters and a transmitting relay in each line repeater directly responsive to its corresponding said one control relay.

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