Sept. 29, 1936. J. HERMAN 2,055,575

TELEGRAPH REPEATER CIRCUITS

Filed July 5, 1934

FIG. 1

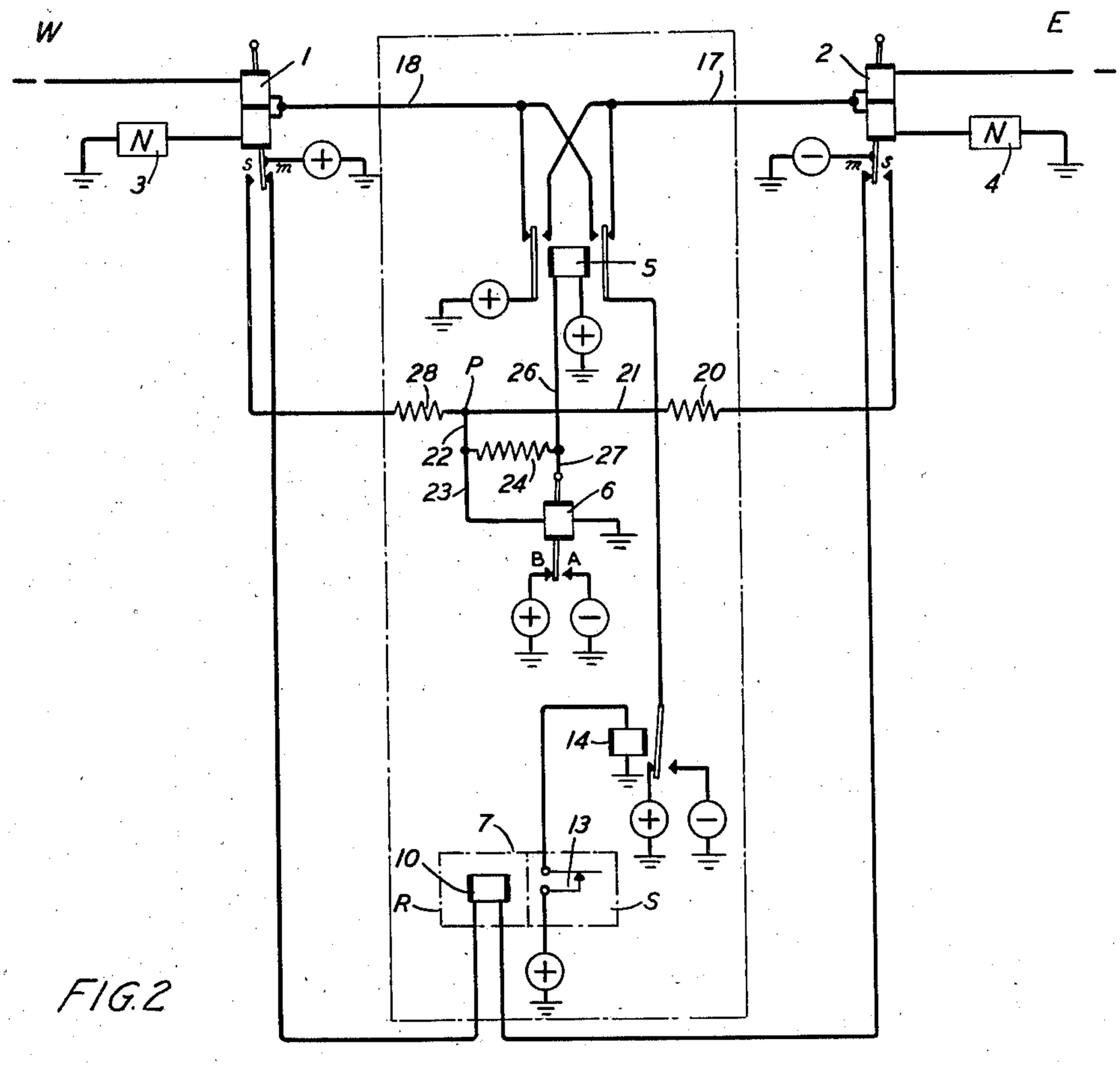
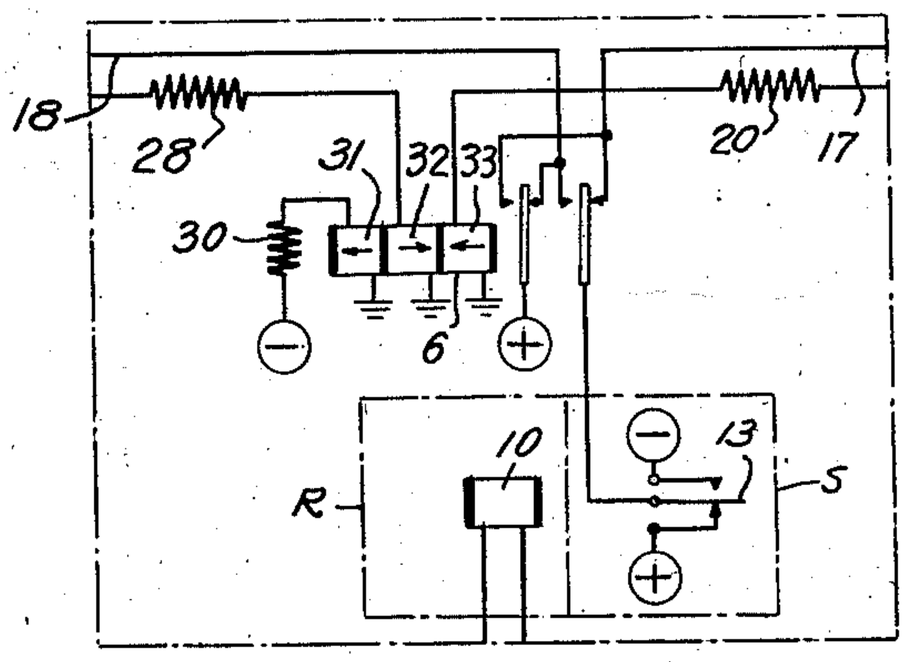


FIG. 2



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TELEGRAPH REPEATER CIRCUITS

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18 Claims. (Cl. 178—71)

This invention relates to telegraph repeater circuits and more particularly to automatic switching arrangements whereby a one-way repeater unit may be used for two-way operation over a line circuit.

It is an object of the invention to provide a two-way signal repeater which is of simple construction, occupies small space and requires comparatively little attention.

It is a particular object of the invention to provide a two-way repeater of the regenerative type in which a single regenerator or regenerative repeating device is made to transmit alternately in both directions by means of a simple and effective switching arrangement.

On long printing telegraph lines it is customary to use regenerative repeaters at one or more intermediate repeater stations in order to reduce the distortion suffered by the signals in transmission over the circuit. A regenerative repeater placed at the end of a line section not only boosts the signals up to their original strength but also restores the signals to their original undistorted shape thereby permitting transmission over another line section without causing excessive distortion of the signals. In this way the length of circuit over which satisfactory telegraph transmission can take place is theoretically unlimited. In teletypewriter systems the operation is usually on a half-duplex basis, that is, transmission takes place over a line circuit in only one direction at a time, but the direction of transmission may be reversed frequently. The telegraph circuits used for these systems are often similar to full-duplex circuits and the signals are transmitted over the circuit in the same manner as they would be transmitted in full-duplex operation, except that they are transmitted in only one direction at a time. The signals pass through an intermediate telegraph repeater over a separate local circuit for each direction of transmission. For examples of such a system reference is made to Patents Nos. 1,771,453, issued on July 29, 1930, and 1,479,845, issued on January 8, 1924 to G. S. Vernam. It has thus been customary to treat the two directions of transmission separately at each regenerative repeater point and to use two regenerative repeating devices, one for each direction of transmission, and to associate them with each other by means of the common duplexing equipment. Such a procedure has been deemed necessary in the past because regenerative repeaters are one-way devices and, therefore, can repeat signals in only one direction.

In systems, such as the teletypewriter system, regenerative repeaters are required in large numbers and thus constitute a heavy first cost. The regenerative repeating device is usually a comparatively complicated mechanism, including a motor driven timing mechanism as well as an interrupting or retransmitting contact device, and requires considerable space and frequent attention, and therefore is the cause of comparatively high running expenses.

In accordance with the invention these costs may be reduced by the use at a two-way repeater station of a single regenerative repeating device which by simple relay means, controlled by the usual line relays, is alternately switched to the two line sections for retransmission in both directions, one at a time.

In accordance with a feature of the invention the receiving side of the repeating device is continuously under control of both line sections and thus requires no switching, and the sending side of the repeating device is switched from one line section to the other by a simple relay switching system which also is continuously under control of both line sections.

In accordance with a further feature only one line relay with the usual single pair of alternate contacts is required in each line section both for the transfer of received signals to the regenerator and for the control of the switching relay system, the transfer circuit being entirely independent of the control circuit.

In accordance with a more specific feature of the invention the marking contacts of the line relays in both line sections are serially included in the operating or receiving circuit of the repeating device, so that either line relay may impress incoming signals upon the regenerator until interrupted by a signal from the opposite line section, thereby providing a very simple "break signal" arrangement.

In accordance with another feature the switching relay system is locked in either position and may be switched into the other position by the operation to the spacing contact of the corresponding line relay only when the other line relay is on its marking contact. Thus switching takes place during a break signal on the outgoing line section when a marking signal arrives over the incoming line section.

General repeater operation

The invention will be described in connection with the accompanying drawing in which Fig. 1 shows a preferred arrangement of the invention as embodied in an intermediate repeater station,

and Fig. 2 shows an alternative arrangement of certain parts of the arrangement in Fig. 1.

The conductors W and E shown in the drawing may be two line wires leading to adjacent repeater or terminal stations, or they may be merely connections to the local circuits of two telegraph repeaters located in the same office and arranged for half-duplex operation in a manner well known in the art.

The conductors W and E are terminated in polar receiving relays 1 and 2, respectively, which each is provided with two windings. One winding of each relay is connected in series with the conductor W or E and the other winding is connected to a balancing network 3 or 4 which simulates the electrical constants of the corresponding conductor and the apparatus connected at its far end. This arrangement is the same as is commonly employed for duplex telegraph operation and permits each of the relays 1 and 2 to be controlled by signals arriving over its respective conductor W or E without being affected by signals transmitted through the relay windings to the conductor E or W and to the corresponding balancing network 4 or 3.

Signals arriving over the conductor W pass through a regenerative repeating device 7, where they are restored to practically perfect form and retransmitted to conductor E. Similarly signals arriving over conductor E pass through the regenerative repeating device 7 and are retransmitted to conductor W. The direction of retransmission is determined by means of a relay 6 which controls a switching relay 5 and thereby properly directs the signals from the repeating device 7 to the conductors W and E in a manner which will be explained later.

The repeating device 7 is shown in schematic form as consisting merely of a receiving side R and a sending side S. The receiving or input side usually includes a relay or magnet which is operated by the received signals and the sending or output side usually includes a set of contacts and a synchronizing mechanism for the retransmission of the signals. Knowledge of the internal mechanism of the regenerative repeating device is not essential to an understanding of the operation of the invention; however, for a description of a device of this type reference may be had to Patent 1,944,218, issued on January 23, 1934 to J. J. Catogge. The device which is used with the invention should operate with a small delay between the reception of a signal at its receiving side and the retransmission of that signal at its sending side. Such a delay is present in the regenerative repeaters commonly employed, because each signal must be at least partly received by the receiving mechanism of the device in order that it may properly control the retransmitting mechanism. The delay is generally equal to the time of about half a dot length or more, a dot length being the shortest pulse or time interval in the signaling code.

The circuit is shown in the drawing in condition for transmission of signals from line W to line E. When signals are not being transmitted over the circuit steady marking currents are received over both lines causing the armatures of relays 1 and 2 to rest on their marking contacts *m*. When signals are received over the line W the relay 1 will be operated to its marking and spacing contacts *m* and *s*, respectively, in accordance with the signals, but the armature of relay 2 will remain on its marking contact *m*.

During the reception of a marking signal over the line W a circuit will be completed from positive potential over the armature and marking contact of relay 1, winding of the receiving magnet or relay 10 of the regenerative repeating device 7, armature and marking contact of relay 2, to negative potential. During the reception of a spacing signal this circuit will be open at the marking contact of relay 1. The receiving magnet or relay 10 of the repeater 7, therefore, will be operated in accordance with the received signals, being energized for marking signals and deenergized for spacing signals. The mechanism of the regenerative repeater 7 will be controlled accordingly and will cause its sending contacts or segments 13 to reproduce the signals in undistorted form, the contacts 13 preferably being closed for incoming marking signals and opened for incoming spacing signals. The operation of contacts 13 correspondingly operates a sending relay 14 which in turn transmits polar signals from its contacts and armature over the right-hand armature and back contact of switching relay 5, conductor 17 and the windings of relay 2 to the conductor E and to the balancing network 4. Because of differential connection of the windings of relay 2 in this circuit the relay 2 will be unaffected by these signals and its armature will remain on the marking contact.

When signals are received over the line E for transmission over the line W the operating circuit for magnet 10 will be opened and closed at the marking contact of relay 2, and the armature of relay 1 will be at rest on its marking contact. In a manner which will be explained later the switching relay 5 will be energized upon the reception of signals over the line E and attracts its armatures. This connects the armature of relay 14 to conductor 18 at the right-hand front contact of relay 5 so that the signals from the regenerative repeater 7 will be transmitted differentially through the windings of relay 1 to the conductor W and balancing net work 3.

It will be noted that while relay 5 was released a steady marking current flowed from positive potential over the left-hand armature and back contact of relay 5, conductor 18 and windings of relay 1 into the line W and network 3. When relay 5 is energized a steady marking current will flow from positive potential over the left-hand armature and front contact of relay 5, conductor 17 and windings of relay 2 into the line E and network 4. This steady marking current over the lines is necessary in order that the distant receiving relay shall be held on its marking contact, since otherwise it might operate to its spacing contact and interrupt the transmission of signals from that station. This condition is peculiar to half-duplex telegraph circuits and is well understood in the art.

The switching operation

It will be assumed that the circuit conditions are as shown in the drawing and that signals are to be transmitted from the distant end of the line E.

The directional polar relay 6 controls the switching relay 5 and thereby the direction of transmission of signals from the repeater. With the circuit in the assumed condition relay 6 is being held on its B contact by a small current from positive potential at this contact over conductor 27, high resistance 24, conductor 23 and the winding of the relay to ground. Relay 5 is short circuited in the circuit from positive potential at the B contact of relay 6 over conductors

27 and 26 and through its winding to positive potential, thereby connecting the repeating device 7 for transmission from line W to line E. Since a steady marking condition prevails over the lines in both directions when signals are not being transmitted, the first signal to be received over line E by the receiving relay 2 will be a spacing signal. In the case of teletypewriter operation this spacing signal will be the so-called start pulse of a teletypewriter signal combination. The reception of this spacing signal causes the armature of relay 2 to open its marking contact and thereby transmit the signal to the regenerative repeating device 7 as previously explained. When the armature of relay 2 reaches its spacing contact a circuit is closed from the negative potential at this contact over resistance 20, conductors 21, 22 and 23, through the winding of the polar relay 6 to ground. The operating current in this circuit is larger than and flows in the opposite direction of the holding current through the winding of relay 6, and consequently operates the armature of relay 6 to the A contact. The locking circuit through resistance 24 and relay 6 now being connected to minus potential at contact A the holding current will be reversed and lock the relay in the new position, even when relay 2 disconnects the negative potential from relay 6 during the subsequent reception of a marking signal.

While the armature of relay 6 rests on its A contact a current also flows from positive potential through the winding of the switching relay 5, conductors 26 and 27 to the negative potential at the A contact. Relay 5 is thereby energized and operates to switch, at its right-hand armature, the signals reproduced by the regenerative repeater 7 from the conductor E to the conductor W, and at the same time to transfer, at its left-hand contact, the steady marking potential from the conductor W to the conductor E. Due to the delay in the transmission of signals through the regenerative repeater 7, these switching operations will be completed before the spacing signal, which initiated the switching operations, is retransmitted to the relay 5 by the regenerative repeater. Consequently, there will be no shortening or distortion of this start signal. The armatures of relays 5 and 6 will remain in position for the transmission of signals from line E to line W until a spacing signal is received over the line W which will be in the nature of a break signal and serve to reverse the direction of transmission.

When such a break signal is received over line W the armature of relay 1 moves to its spacing contact and thereby connects positive potential to the circuit over resistance 28, conductors 22 and 23 and through the winding of relay 6 to ground. The resultant flow of current through the winding of relay 6 will then be reversed so that the armature will operate to its B contact in a manner similar to that described above for the operation from its B contact to its A contact. When the armature reaches its B contact the connection of positive potential to conductor 27 will again short circuit relay 5, thereby releasing relay 5 and arranging the circuit for transmission from the line W to the line E as shown on the drawing.

In the transmission of a long spacing or break signal over the line circuit to interrupt the operator who is sending, it may happen that the break signal will reach the regenerative repeater station during the reception of a spacing signal from the sending operator. Under this condition the armatures of the receiving relays 1 and 2 will both be on their spacing contacts thereby connecting both positive and negative potentials to one side of the winding of relay 6. These potentials being equal and opposite with respect to ground and connected to the relay 6 through equal low resistances 20 and 28 the locking current through relay 6 will be somewhat reduced, since the potential of point P will have a tendency to approach a neutral or ground value. However, enough current will flow through relay 6 to hold its armature on whichever contact it happens to be resting on. On account of the high value of the resistance 24 the current through the switching relay 5 remains unaffected by fluctuations in the potential of point P. When now a marking signal arrives from the sending operator the switching operation will take place as described above. It will be seen that the break signal will be held in the manner which is usual at repeater stations and terminal stations in half-duplex systems.

While the invention has been described as embodied in a specific form, which is deemed desirable, it should be understood that it is capable of embodiment in other and varied forms without a departure from the spirit of the invention as it is defined by the appended claims.

It is, for example, evident that, whereas relay 6 is, preferably, of the polarized type, it may be of the neutral type, as shown in Fig. 2, in which case it may be provided with a sufficient number of armatures and contacts to provide for the switching operations performed by relay 5, thereby obviating the need for this relay; with relay 6 of the neutral type it may also be arranged with separate operating and locking windings thus providing for resultant operating magnetic fluxes instead of resultant operating currents in a single winding, as is well known in the art.

It is furthermore evident that transmitting relay 14 may be dispensed with in the case where the contact device 13 is of such a construction that it can be connected to supply two different potentials in response to marking and spacing conditions, respectively, impressed upon the receiving magnet 10.

Thus, in the arrangement shown in Fig. 2, the relay 6 is of the neutral type and has a locking winding 31 and operating windings 32 and 33. The currents in these windings are adjusted by means of resistances 20, 28 and 30, respectively, to be approximately equal and each of sufficient strength to hold the armatures attracted but of insufficient strength to separately attract the armatures. The fluxes produced by the windings are directed, as indicated by the arrows and as is well-known, so that the permanent flux produced by the winding 31 will be practically neutralized by the pulsating flux produced by winding 32, thereby causing retraction of the armatures; but the flux produced by winding 31 will be aided by the pulsating flux produced by winding 33 to such an extent that the combined fluxes will cause the attraction of the armatures.

The arrangement shown in Fig. 2 is intended to replace the portion of the circuit in Fig. 1 enclosed within the large square and thus cooperates with the line relays 1 and 2 in a manner similar to that described for Fig. 1.

Relay 6 is shown in Fig. 2 in a position for transmission in the direction west to east. When relay 1 receives a spacing signal, current will flow from its spacing contact through winding 32 of relay

6, which remains unaffected by signals incoming from west. A break signal arriving from east will operate relay 2 to spacing, causing current to flow in winding 33 of relay 6. If, at this time, a spacing signal be received from west the windings 32 and 33 oppose each other and the relay remains unaffected. However, when the west spacing signal ceases, the relay operates by the aiding fluxes of windings 32 and 33 to switch the repeater for transmission from east to west. When the break signal from east ceases, the locking winding 31 will hold the armatures attracted and the relay remains unaffected by signals from east. If, now, a break signal arrives from west, relay 1 will operate to spacing and current will flow through winding 32. If at this time a spacing impulse is being received from east, the fluxes from windings 32 and 33 neutralize and relay 6 remains energized. However, when the spacing signal from east ceases, the windings 31 and 32 produce neutralizing fluxes and the relay deenergizes and switches the repeater for transmission from west to east.

What is claimed is:

1. A two direction telegraph repeater system comprising signal repeating means having an output circuit, switching relay means for directing repeated impulses from said output circuit to east or west, said repeating means including receiving means permanently connected to be continuously responsive to signals incoming from both east and west to control said switching relay means.

2. A two direction system in accordance with claim 1, in which said signal repeating means also includes signal regenerating means used alternately for both directions of transmission.

3. A one-way telegraph signal repeating device for operation between two adjacent line circuits, relay means for making said device continuously responsive to signals on both of said two line circuits, and switching means responsive during transmission in either direction to a signal on the outgoing line circuit to condition said device for retransmission into the incoming line circuit.

4. An east line relay and a west line relay each having a set of marking and spacing contacts, a one-way telegraph signal regenerator connected to both of said line relays for continued control by said marking contacts, switching means for conditioning said regenerator to retransmit through either one of said line relays, said switching means being connected for control by the spacing contacts of said line relays.

5. A telegraph signal repeater for operation between two line sections comprising a repeating device having an input circuit in continuous operative association with both of said line sections for reception of signals, and having an output circuit, switching means in continuous operative association with both of said line sections for connecting said output circuit to either one of said line sections in response to the reception of a signal over the other line section.

6. A signal repeating system connected between an east line section and a west line section which comprises east and west duplex receiving relays each having marking and spacing contacts, a signal regenerator having an input side connected to said marking contacts and having an output side switching relay means connected to said spacing contacts and adapted to switch said output side alternately to the east and the west line sections.

7. A half-duplex repeater comprising a polar relay differentially connected to repeat signals from a west line section and to remain unaffected by signals outgoing to said west line section, a similar polar relay for an east line section, a signal regenerator having a receiving winding and retransmitting contacts, switching relay means having contacts for switching impulses from said retransmitting contacts to said east or west line sections through said differentially connected polar relays, said receiving winding being connected to contacts on both of said polar relays for regeneration of signals from either line section, and said switching means being connected to contacts on either of said polar relays in response to a break signal.

8. A half-duplex repeater in accordance with claim 7, in which said receiving winding is connected in series circuit to opposite potentials at the marking contacts of both of said polar relays.

9. A half-duplex repeater in accordance with claim 7, in which said polar relays for the west and east line sections have contacts for supplying opposite polarities in their marking positions to said receiving winding and in their spacing positions to said switching relay means for operation thereof.

10. A half-duplex repeater in accordance with claim 7, in which the contacts of said switching relay means connects said retransmitting contacts to the windings on either of said polar relays for differential transmission therethrough, and simultaneously connects line potential to the winding of the remaining polar relay.

11. A repeater direction switching system comprising west receiving relay means and east receiving relay means connected to receive signals incoming from east or west, respectively, and each having contacts for repeating said signals, switching relay means having contacts for directing repeater signals alternately to east and west, circuit means common to said receiving relay means for passing said received signals for retransmission to east or west in accordance with the direction determined by the contacts of said switching relay means, and separate circuit means from the contact of said receiving relay means for controlling said switching relay means in accordance with incoming signals.

12. A repeater direction switching system comprising west relay means and east relay means responsive to signals incoming from opposite directions to said system, repeater switching relay means, two position control relay means for operation of said switching relay means into two positions for transmission of outgoing signals in either direction, operating circuit means extending from said west and east relay means for operation thereby of said control relay means into one or the other, respectively, of the two positions, and locking circuit means extending to contacts of said control relay means for self-locking thereof in either of the two positions.

13. A repeater direction switching system in accordance with claim 12, in which said control relay means includes a polar relay with a single winding for operation thereof over said operating circuit by said west and east relay means.

14. A repeater direction switching system in accordance with claim 12, in which said control relay means includes a polar relay with a single winding for operation and locking thereof in the two positions.

15. A repeater direction switching system in accordance with claim 12, in which said control relay means includes a polar relay with a

single operating and locking winding and with a single armature for self-locking thereof and for the operation of said switching relay means.

16. A repeater direction switching system in accordance with claim 12, in which said west and east relay means have contact means connected to sources of positive and negative potential, respectively, for applying said potentials to said operating circuit means in one position of said contact means and for repeating in the other position signals incoming from the respective directions.

17. A repeater direction switching system comprising a switching relay for a repeating unit, a control relay for operating said switching relay into either of two positions, said control relay having a high resistance circuit for self-locking to positive potential in one position and to negative potential in the other position and an operating circuit to positive potential and another operating circuit to negative potential, a first relay responsive to signals incoming from one direction, and a second relay responsive to signals incoming from the other direction to said system, each for closing one of said operating circuits to operate said control relay into one or the other position, respectively.

18. The method of repeating signals accurately in each direction between two line sections by means of a one-way repeating device having a transmission relay, which consists in maintaining the receiving circuit of said repeating device in continuous operative association with both of said line sections for the reception of signals from either direction and switching the sending circuit of said repeating device in accordance with the direction of transmission to the proper one of said line sections, said switching operation being completed before the received signals which cause the switching operation to emerge from said repeating device.

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