

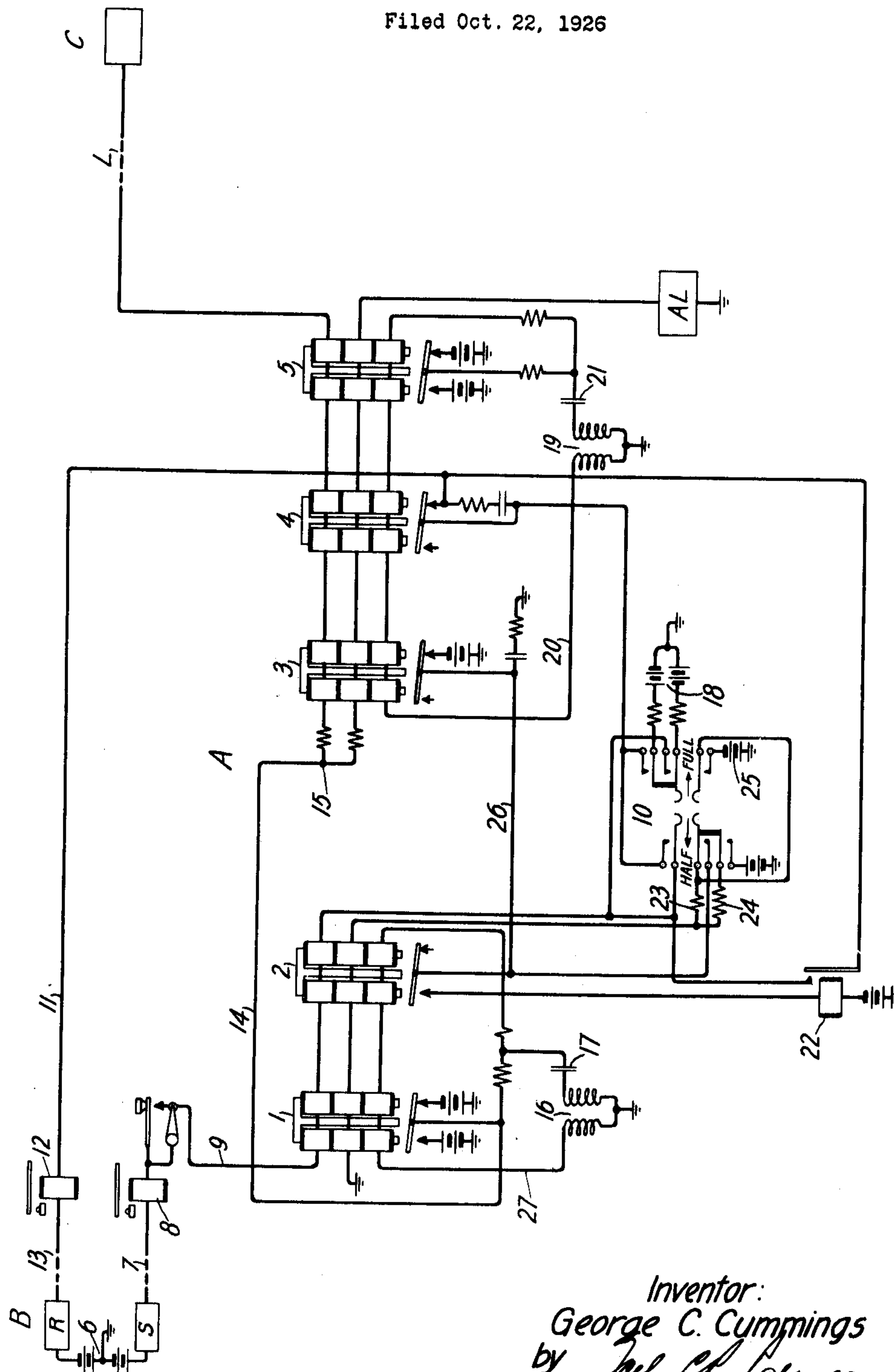
Feb. 5, 1929.

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1,701,100

HIGH SPEED TELEGRAPH REPEATER EMPLOYING VIBRATING RELAYS

Filed Oct. 22, 1926



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HIGH-SPEED TELEGRAPH REPEATER EMPLOYING VIBRATING RELAYS.

Application filed October 22, 1926. Serial No. 143,335.

This invention relates to telegraph systems and more particularly to high speed telegraph repeaters employing vibrating relays.

5 An object of this invention is to give greater stability and higher speed to the operation of a telegraph repeater adapted for lines which do not possess high speed transmission characteristics, such as cables and grounded
10 open wire lines of considerable length.

A more specific object of the invention is to develop an accelerating circuit which will be positive in its operation and equally effective on a plurality of relays, particularly
15 when simultaneous operation of such relays is desired.

Heretofore in high speed telegraph systems various means have been used to overcome lag, which prevents the recording of
20 a signal impulse at a receiving station until some appreciable time after that signaling impulse has started from the transmitting station. Of these means, the ones most pertinent to the present invention are the re-
25 peaters comprising differential relays on which are arranged three windings each, namely, operating, opposing and accelerating. The operating winding of each relay is connected to the line and the incoming
30 signals are effective to control the relay, thereby connecting either the positive or negative pole of a current source, the polarity depending on the position of the relay armature, to both the outgoing line and the opposing winding. The current in the oppos-
ing winding is arranged to be considerably less than that in the operating winding and is in such a direction as to tend to move the
40 armature to its opposite contact. At the end of each incoming signal when the operating winding becomes momentarily deenergized, the current in the opposing winding assumes control of the relay and starts to move the
armature to its opposite contact, but as soon
45 as the armature leaves the contact to which it is engaged, the opposing current ceases to flow. In order to continue the movement of the armature to its opposite contact, thereby
anticipating the next incoming signal, the
50 vibrating circuit extending through the accelerating winding is used, in which certain devices are employed for storing energy before the armature leaves its engaged contact, and this energy is then utilized as the sole

means for completing the movement of the
armature to its opposite contact. The device
employed in some cases is a condenser in
which a stored charge produces a current flow
in the accelerating winding in such a direc-
tion as to complete the operation of the relay,
60 and in other cases a transformer is employed having its primary winding connected to the opposing winding and its secondary winding connected to the accelerated winding, so that
when the current in the opposing winding
65 ceases, a sudden rush of current is effected in the secondary winding to energize the accelerating winding and to thereby complete the operation of the relay. For disclosures
showing the above arrangements reference
70 may be had to Patents Nos. 1,160,097 and 1,464,088 granted to W. Finn on November 9, 1915, and G. C. Cummings on August 7, 1923, respectively.

According to the preferred embodiment of
75 the present invention, a repeater is equipped with differentially wound relays arranged in two groups for respectively receiving and sending signals which have been transmitted
from distant stations. These relays are each
80 equipped with windings known herein as the line, the biasing or the artificial line, and the vibrating windings, the corresponding windings in each group of relays being serially
connected in separate circuits so that a cur-
85 rent in each of these circuits will be equally and simultaneously effective on all of the relays of the group with which the circuit is associated. The line windings are connected
to line circuits and are arranged to be ener-
90 gized by signal impulses incoming from the line to which they are connected. The second mentioned windings are referred to herein as the biasing or the artificial line wind-
ings depending on whether the windings are
95 on the relays of the sending or the receiving group respectively. Of the relays in the sending group the windings, known, therefore, as the biasing windings, provide a path
100 for the biasing current which is about half the strength of the current in the line windings. The biasing current flows continuously in
such a direction as to oppose the magnetic
effect of the current in the line windings
and becomes controlling only when the line
105 circuit is open. The vibrating windings are connected in vibrating circuits each of which is arranged in two paths, one path extend-

ing through the vibrating windings and the primary winding of a transformer and the other through the secondary winding and a condenser. The current for the vibrating circuit of each group is derived from a source connected to the contacts of one of the relays, known herein as a master relay of the group, in such a manner that opposite polarities are alternately impressed on the circuit. The current in the vibrating circuit is never controlling. It is sufficient, however, to operate the relays if the line and biasing circuits are opened, in which event the operation of the relays is much the same as that of an ordinary buzzer. When the armatures of the relays in either group are against either of their respective contacts, a current energizes the transformer and the vibrating windings of the relays and charges the condenser. The current in the vibrating windings is in such a direction as to tend to move the relay armatures to their opposite contacts but this operation is prevented by the current in either the line or the biasing circuit. When the relays are operated by incoming signals the armatures of the relays move to their opposite contacts under the control of the current in either the line or the biasing circuit and the current source of the vibrating circuit is momentarily disconnected. The condenser discharges and the sudden cessation of current in the primary winding causes a momentary rush of current in the secondary winding of the transformer and these currents combine and flow through the vibrating windings of the relays in the same direction as the current received from the previously engaged contact at the master relay thereby forcefully driving the relay armatures against their opposite contacts. When the armature of the master relay reaches its opposite contact, a current of opposite polarity must first charge the condenser before building up in the vibrating windings and during the period that this capacity is charging and the current is building up in the primary winding of the transformer thereby inducing a corresponding current in the secondary winding, the combined currents are continuing through the vibrating windings to aid the current in either the line or the biasing circuit in securely holding the armatures at their opposite contacts. The armatures are held in this position as long as the line circuit remains unchanged because the relays are then under the control of the current in the line or the biasing circuit.

For a complete understanding of the invention reference is made to the following specification and appended claims together with the accompanying drawing.

Referring to the drawing repeater A is shown connected at one side to subscriber's station B at which S and R represent diagrammatically the sending and receiving ap-

paratus, respectively, and at the other side to a grounded open wire line L extending to another repeater station C which is similarly equipped with a repeater of the type shown in the drawing and adapted to send and receive electrical impulses of positive and negative polarities at a very high rate of speed. It is understood, of course, that the repeater is not limited to the representation shown but that it may be used for connecting several composited or non-composited lines for three or more way operation, and may also be used in connection with standard bridge polar duplex equipment or single line telegraph repeaters.

The repeater is of the differential duplex type and is arranged for either half duplex or full duplex service. It comprises five vibrating differential relays each having three windings, namely, line, biasing or artificial line and vibrating. The relays are arranged in two groups, relays 1 and 2 constituting a sending group and relays 3, 4 and 5 a receiving group, and the corresponding windings in each group are connected in series so that when a circuit extending through the corresponding windings of a group is energized, the relays constituting such group will be equally affected. The repeater may be set for either half or full duplex service by operating switch 10 to the left or right, respectively.

Assuming that the repeater is in normal position and is set for half duplex service, the armatures of relays 1 to 5 are resting against their respective marking, or right hand contacts, and the line circuits extending to subscriber's station B and repeater station C, respectively, are closed. The circuit extending to station B may be traced from the positive pole of battery 6 which has a mid-tap to ground, apparatus S, line 7, sounder 8, conductor 9, through the line, or upper, windings of relays 1 and 2 in series, upper left hand contact of switch 10, armature and marking contact of relay 4, conductor 11, sounder 12, line 13, apparatus R, to the negative pole of battery 6. The circuit extending to station C may be traced from the marking, or negative, contact of relay 1, conductor 14, to the apex 15 at which point the circuit divides into two parallel paths, one extending through the line, or upper, windings of relays 3, 4 and 5 in series, line L, to station C, and the other through the artificial line, or middle, windings of the same relays in series, to ground at the artificial line AL. Inasmuch as the repeater at station C is similar to that shown in the drawing, the negative polarity will be connected to each end of the line L when the repeaters are normal and therefore no current will be flowing at this time through the line windings of the relays 3, 4 and 5 and the current in the path including the artificial line

winding will be flowing in such a direction as to bias the relay armatures against their respective marking contacts.

When the subscriber at station B desires to send signals to a subscriber's station (not shown) connected to station C, the subscriber's circuit is opened at apparatus S by either a manually operated key or some other form of transmitter. The upper windings of relays 1 and 2 are deenergized and the current in a continuously closed circuit extending through the biasing, or middle, windings of the relays 1 and 2 assumes control and moves the relay armatures to their respective opposite, or spacing, contacts. The current in the biasing windings has approximately one-half the strength of that in the line windings and flows in such a direction through the windings as to oppose the magnetic effect of the current in the line windings and therefore serves as a biasing current for the relays when the circuit of the line windings is opened at station B. The circuit for the biasing windings may be traced from ground, through the middle, windings of relays 1 and 2 in series, resistance 23 of a potentiometer, middle left contact of switch 10, conductor 26, to the negative pole of the battery connected to the marking contact of relay 3. At the time the subscriber's circuit was closed the third set of windings, known as the vibrating windings, on relays 1 and 2, were energized in a normally closed circuit and the current therein was flowing in a direction which opposed the current in the line windings in holding the relay armatures against their marking contacts. This circuit, known as the vibrating circuit because should the line and biasing circuits be open simultaneously, it would operate the relays much the same as an ordinary buzzer, includes transformer 16 and condenser 17 and may be traced in parallel paths, one from ground, left hand, or high resistance primary, winding of the transformer, conductor 27, through the lower, or vibrating, windings of relays 1 and 2 in series, to the armature and right, or negative, contact of relay 1, and the other, from ground, through the right hand, or low resistance secondary, winding of the transformer, condenser 17, to the armature and negative contact of relay 1. The condenser is charged and the current in the vibrating windings is considerably less than the current in the line windings, so that it is ineffective to operate the relays while the line windings are energized.

When the current in the biasing windings assumes control of relays 1 and 2 and moves the relay armatures away from their respective marking contacts, the vibrating circuit is opened permitting thereby the condenser to discharge and the transformer to deenergize. The sudden cessation of current in the transformer produces a rush of current in the

secondary winding in the same direction as the discharge of the condenser, which flows from the left side of condenser 17, secondary and primary windings of transformer 16 in series, through the vibrating windings of relays 1 and 2 in series, to the right side of the condenser. Although the armatures of relays 1 and 2 are now at their respective left, or spacing, contacts, the current in the vibrating windings continues for a moment to flow in the same direction as when the armatures were at their marking contacts and this continued current aids in holding the armatures securely against their spacing contacts. The engagement of the armature of relay 1 with its spacing contact closes a circuit path for charging the condenser with a current of opposite polarity and this current continues to flow in the condenser path until the condenser is fully charged and during the time that the current is building up in the primary winding of the transformer the induced current in the secondary winding aids in charging the condenser. As soon as the condenser is fully charged, the current from the spacing contact of relay 1 reverses in the vibrating windings of relays 1 and 2 and tends to move the relay armatures back to their marking contacts but is unable to do so at this time because the relays are controlled by the biasing current in the middle windings. When the subscriber at station B closes his key after sending an open signal the operating windings again assume control of the relay and move the relay armatures back to their marking contacts, and the current in the vibrating windings is now aiding in moving the armatures. As the armature of relay 1 leaves its spacing contact the condenser and transformer again discharge thereby continuing the current flow in the vibrating windings in such a direction as to hold the armatures against their marking contacts until the condenser is again fully charged with current of negative polarity. As stated above, when the condenser is fully charged the current in the vibrating windings again reverses in a direction which tends to move the armatures to their spacing contacts but fails to do so because the line windings are now energized. This operation is repeated for each signal and the current therefore flows through the vibrating windings in two directions for each signal interval, the duration of the current flow in one direction depending on the time required to fully charge the condenser.

When relay 1 operates in response to the operation of apparatus S at station B and spacing signals are transmitted over the line L, the line or upper windings of relays 3, 4 and 5 are energized because the positive pole of the battery of relay 1 is connected to line L which terminates, when the repeater at station C is in normal condition, in the negative pole of a battery at a relay corresponding to

relay 1. The direction of current in the line windings is such as to hold the armatures of relays 3, 4 and 5 against their marking contacts and the current in the artificial line, or middle, windings now reverses so as to tend to move the armatures to their spacing contacts. The current in the line winding is approximately double that in the artificial line windings and therefore prevents the operations of relays 3, 4 and 5. In this way the armatures of relays 3, 4 and 5 are held against their marking contacts during the transmission of signals from station B.

If the subscriber at the receiving station, (not shown) wishes to send a break signal the transmitting apparatus at the distant subscriber's station is opened thereby connecting the positive pole of the battery at the relay at station C, which corresponds to relay 1 at station A, and the current in the line windings of relays 3, 4 and 5 is reduced to approximately zero so that the armatures of relays 3, 4 and 5 move to their spacing contacts under the control of the current in the artificial line windings. The moving of the armature of relay 4 to its spacing contact opens the subscriber's circuit for station B, thereby preventing the energization of the line windings of relays 1 and 2 when the next closed signal is sent from station B. However, the deenergization of the line windings of the relays 1 and 2 does not permit at this time the current in the biasing windings to move the relay armatures to their spacing contacts because the biasing current is also reversed by the operation of relay 3 which moves the armature thereof away from its negative contact and permits a current from the positive side of the battery at the lower left contact of switch 10 to hold the armatures of relays 1 and 2 against their marking contacts while the positive polarity is connected to the line L at station C. The subscriber at station B is therefore unable to operate relay 1 to transmit signals to the receiving station.

When the subscriber at the distant station transmits signals through the repeater at station A for transmission to station B, spacing signals incoming from line L are received and the line windings of relays 3, 4 and 5 are effective to move the relay armatures to their spacing contacts although the current in the artificial line windings tends to hold the relay armatures against their marking contacts. The current in the artificial line windings assumes control only when the line windings are deenergized by negative battery being connected to the distant end of line L for the transmission of a marking signal. The vibrating, or lower windings of relays 3, 4 and 5 are connected in series in the vibrating circuit of the receiving group of relays and this circuit which is alternately connected to the opposite poles of the battery

at relay 5 is equally effective upon relays 3, 4 and 5. The circuit functions in the same manner as that of the sending group of relays and may be traced in two parallel paths, one from ground, through the high resistance primary winding of transformer 19, conductor 20, through the vibrating windings of relays 3, 4 and 5 in series and the armature of relay 5, to battery, and the other from ground, through the low resistance secondary winding of the transformer, condenser 21, to the armature of relay 5 and battery.

Should two subscribers at each end of the line operate their transmitting apparatus simultaneously, the armatures of the relays in both the sending and the receiving group will move to their spacing contacts causing thereby the operation of restoring relay 22 in a circuit which may be traced from negative battery, through the winding of relay 22, spacing contact and armature of relay 2, middle left contact of switch 10, resistances 23 and 24 of a potentiometer, to the positive pole of the battery connected to the lower left contact of switch 10. The operation of relay 22 closes at the relay armature a circuit which short-circuits the marking contact of relay 4 which opened the subscriber's loop circuit including the apparatus S and R. This circuit gives control of the line or the circuits to the subscriber connected with the repeater at which the restoring relay operated.

If it is now assumed that the repeater is set for full duplex service, switch 10 is moved to its right hand position thereby closing connections for providing separate circuits for the sending and the receiving apparatus at station B so that receiving and transmitting through the repeater are entirely independent of each other. The sending circuit may be traced from a positive pole of battery 6, line 7, sounder 8, conductor 9, through the line windings of relays 1 and 2 in series, middle right contact of switch 10, to the negative pole of battery 18; and the receiving circuit may be traced from the negative pole of battery 6, apparatus R, line 13, sounder 12, conductor 11, right contact and armature of relay 4, upper right contact of switch 10, to the positive pole of battery 18. At the lower right contact of switch 10 is connected the negative pole of battery 25 for furnishing the continuous biasing current for the biasing windings of relays 1 and 2. The operation of the repeater when arranged for full duplex service is practically the same as that described above for half duplex service, except that both the S and R apparatus at station B are available for use simultaneously.

What is claimed is:

1. In a transmission system, incoming and outgoing circuits, relaying means for repeating current impulses from one circuit to the

other, and a circuit comprising a transformer and a condenser the effect of each being to accelerate said relaying means.

2. In a signaling system, an incoming and an outgoing line, a relay for repeating signals from one line to the other, biasing means for controlling said relay when said incoming line is open, and other means arranged to both aid and oppose during each signal interval said biasing means in assuming control of said relay, said other means when opposing being insufficient to overcome the control of said biasing means over said relay while said incoming line is open.

3. In a signaling system, means for transmitting signals, an incoming and an outgoing line, a relay for repeating signals from one line to the other, an armature and contacts on said relay, a vibrating circuit for said relay, a source of current connected to the contacts of said relay for alternately impressing currents of opposite polarities on said circuit to thereby cause said armature to vibrate between its contacts, other means independent of said circuit for vibrating said armature, and energy storing means in said circuit for continuing the current therein after said other means has effected an engagement between said armature and its opposite contact to produce a current in said circuit in the opposite direction, the current in the opposite direction becoming effective when said storing means has fully discharged its energy and been recharged with energy of the opposite polarity.

4. In a signaling system, means for transmitting signals, an incoming and an outgoing line, a relay for repeating signals from one line to the other, an armature and contacts on said relay, a vibrating circuit for said relay, a source of current connected to the contacts of said relay for alternately impressing currents of opposite polarities on said circuit to thereby cause said armature to vibrate between its contacts, other means independent of said circuit for vibrating said armature, a transformer and a condenser in said circuit for continuing the current therein after said other means has effected an engagement between said armature and its opposite contact to produce a current in said circuit in the opposite direction, the current in the opposite direction becoming effective when said condenser has fully discharged its energy and has been recharged with energy of the opposite polarity.

5. In a signaling system, an incoming and an outgoing line, a relay for repeating signals from one line to the other, biasing means for controlling said relay when said incoming line is open, and a vibrating circuit comprising a transformer and a condenser connected in series for accelerating the operation of said relay in repeating signals.

6. In a signaling system, an incoming and

an outgoing line, a repeater comprising a relay having electromagnetic means connected to said incoming line for controlling said relay in repeating signals from one line to the other, other electromagnetic means on said relay normally opposing said first means and adapted to control said relay when said first means is deenergized and a third electromagnetic means on said relay for both aiding and opposing during a signal interval the first mentioned means when energized and the second mentioned means when said first mentioned means is deenergized.

7. In a signaling system, an incoming and an outgoing line, a repeater comprising a relay for relaying signals from one line to the other, windings on said relay connected to said incoming line for controlling said relay, other windings on said relay for normally opposing said first mentioned windings and adapted to control said relay when said first mentioned windings are deenergized, and a third set of windings on said relay for both aiding and opposing during a signal interval, said first mentioned windings when energized and said second mentioned windings when the first mentioned windings are deenergized.

8. In a signaling system, incoming and outgoing lines, a repeater comprising a relay for relaying signals over said lines, electromagnetic means on said relay connected to said incoming line and arranged to receive signals therefrom, a continuously closed circuit, other electromagnetic means on said relay arranged in said circuit for ineffectively opposing the magnetic effect of the first mentioned means, and a third electromagnetic means on said relay for both aiding and opposing during a signal interval the second mentioned means when the first mentioned means is deenergized and the first mentioned means when the incoming line is closed.

9. In a signaling system, an incoming and an outgoing line, a repeater comprising a relay for relaying signals over said lines, an armature on said relay, electromagnetic means on said relay connected to said incoming line and arranged to receive signals therefrom, a continuously closed circuit, other electromagnetic means on said relay arranged in said circuit for operating said relay when said first mentioned means is deenergized, a third electromagnetic means on said relay for aiding said second mentioned means in moving said armature to its opposite position when said first mentioned means is deenergized, a source of current arranged to reverse the current in said third means when said armature is in its opposite position, and means connected to said third means for preventing said reversal of current for a predetermined interval after said armature assumes its opposite positions.

10. In a signaling system, an incoming and

an outgoing line, a repeater comprising a relay for relaying signals over said lines, an armature on said relay, electromagnetic means on said relay connected to said incoming line and arranged to receive signals therefrom, a continuously closed circuit, other electromagnetic means on said relay arranged in said circuit for operating said relay when said first mentioned means is deenergized, a third electromagnetic means on said relay for aiding said second means in moving said armature to its opposite position when said first mentioned means is deenergized, and a source of current arranged to reverse the current in said third means when said armature is in its opposite position, and a transformer and a condenser connected to said third means for preventing said reversal of current for a predetermined interval after said armature assumes its opposite position.

11. In a signaling system, an incoming and an outgoing line, a repeater comprising a plurality of circuits, a receiving relay for disabling said incoming line in response to a signal from said outgoing line, a sending relay and a break relay connected in series in one of said circuits, said sending relay being adapted to relay signals between said lines and said break relay being adapted to effect the restoration of said incoming line to normal when signals are received from both of said lines simultaneously, and means in said circuit effective during each signal period to accelerate the simultaneous operation of said sending and break relays, hold said sending and break relays in their operated positions for a predetermined interval, and tend to restore said sending and break relays to their previous positions at the end of said predetermined interval.

12. In a signaling system, an incoming and an outgoing line, a repeater comprising a plurality of circuits, a receiving relay for disabling said incoming line in response to a signal from said outgoing line, a sending and a break relay connected in series in one of said circuits, said sending relay being adapted to relay signals between said lines, and said break relay being adapted to effect the restoration of said incoming line to normal should signals be received from both of said lines simultaneously, and a transformer and a condenser in said circuit effective during each signal period to accelerate the simultaneous operation of said sending and break relays, hold said sending and break relays in their operated positions for a predetermined interval and tend to restore said sending and break relay to their previous positions at the end of said predetermined interval.

13. In a signaling system, an incoming and an outgoing line, a plurality of relays, one of said relays being arranged to repeat signals from one line to the other, biasing means on each of said relays connected in series for

controlling said relays when said incoming line is open, and other means arranged to both aid and oppose during each signal interval said biasing means in assuming control of said relays, said other means when opposing being insufficient to overcome the control of said biasing means over said relays while said incoming line is open.

14. In a signaling system, means for transmitting signals, an incoming and an outgoing line, a plurality of relays, one of said relays being arranged to repeat signals from one line to the other, armature and contacts on each of said relays, a vibrating circuit connecting said relays in series, a source of current connected to the contacts of one of said relays for alternatively impressing currents of opposite polarities on said circuit to thereby cause said armatures to vibrate between their respective contacts, other means independent of said circuit for vibrating said armatures, and energy storing means in said circuit for continuing a current therein after said other means has effected an engagement between said armatures and their respective opposite contacts to produce a current in said circuit in the opposite direction, the current in the opposite direction becoming effective when said storing means has fully discharged its energy and then has been recharged with energy of the opposite polarity.

15. In a signaling system, an incoming and an outgoing line, a plurality of relays, one of said relays being arranged to repeat signals from one line to the other, biasing means on said relays connected in series for controlling said relays when said incoming line is open, and a vibrating circuit comprising a transformer and a condenser connected in series for accelerating the operation of said relay in repeating signals.

16. In a signaling system, an incoming and an outgoing line, a repeater comprising a plurality of relays, one of said relays being arranged to relay signals from one line to the other, windings on said relays connected in series to said incoming line for controlling said relays, other windings connected in series on said relay for normally opposing said first mentioned windings and adapted to control said relays when said first mentioned windings are deenergized, and a third set of windings connected in series on said relays for both aiding and opposing during a signal interval said first mentioned windings when energized and said second mentioned windings when the first mentioned windings are deenergized.

17. In a signaling system, incoming and outgoing lines, a repeater comprising a plurality of relays, one of said relays being arranged to relay signals over said lines, electromagnetic means on said relays connected to said incoming line and arranged to receive signals therefrom, a continuously closed

- circuit, electromagnetic means on said relays arranged in said circuit for ineffectively opposing the magnetic effect of the first mentioned means, and a third electromagnetic means on said relays for both aiding and opposing during a signal interval the second mentioned means when the first mentioned means is deenergized and the first mentioned means when the incoming line is closed.
- 10 18. In a signaling system, an incoming and an outgoing line, a repeater comprising a plurality of relays, one of said relays being arranged to repeat signals from one line to the other, armatures on said relays, electromagnetic means on said relays connected to said incoming line and arranged to receive signals therefrom, a continuously closed circuit, other electromagnetic means on said relays arranged in said circuit for operating said relays when said first mentioned means is deenergized, a 20 third electromagnetic means on said relay for aiding said second mentioned means in moving said armatures to their respective opposite positions when said first mentioned means is deenergized, a source of current arranged 25 to have its current flow reversed in said third means when said armatures are in their opposite positions, and means connected to said third means in said circuit for preventing said reversal of current for a predetermined 30 interval after said armatures assumed their opposite positions.
- In witness whereof, I hereunto subscribe my name this 20th day of October, A. D. 1926.
- GEORGE C. CUMMINGS.