Nov. 1, 1938. F. H. HANLEY 2,134,820

TELEGRAPH REPEATER

Filed July 9, 1937

FIG. 1

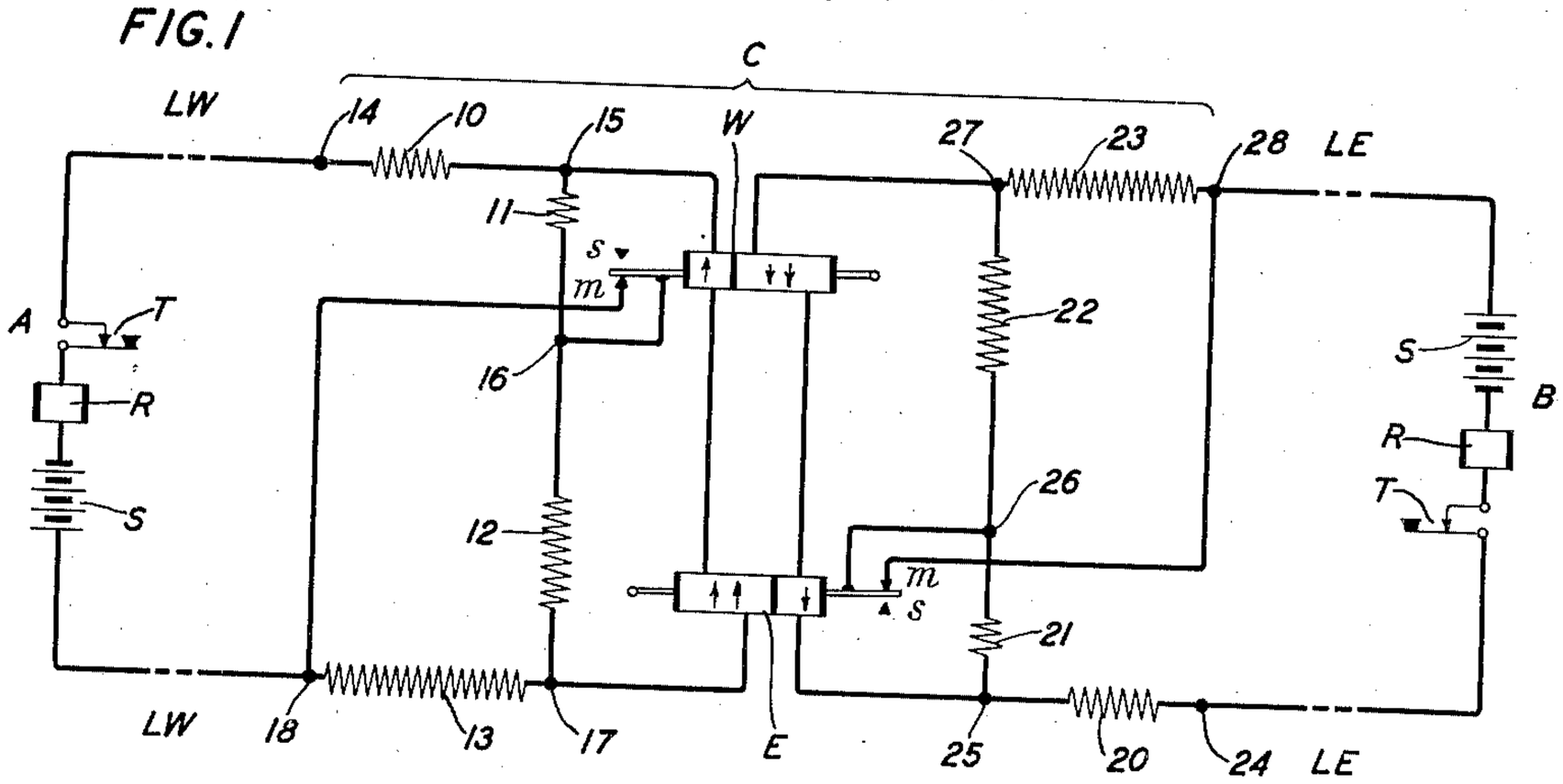


FIG. 2

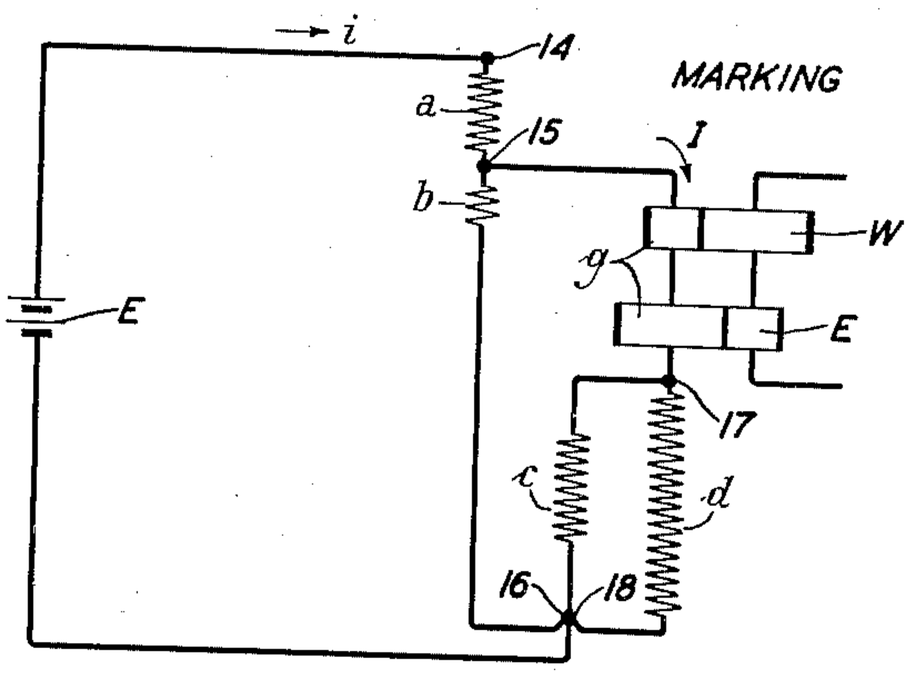
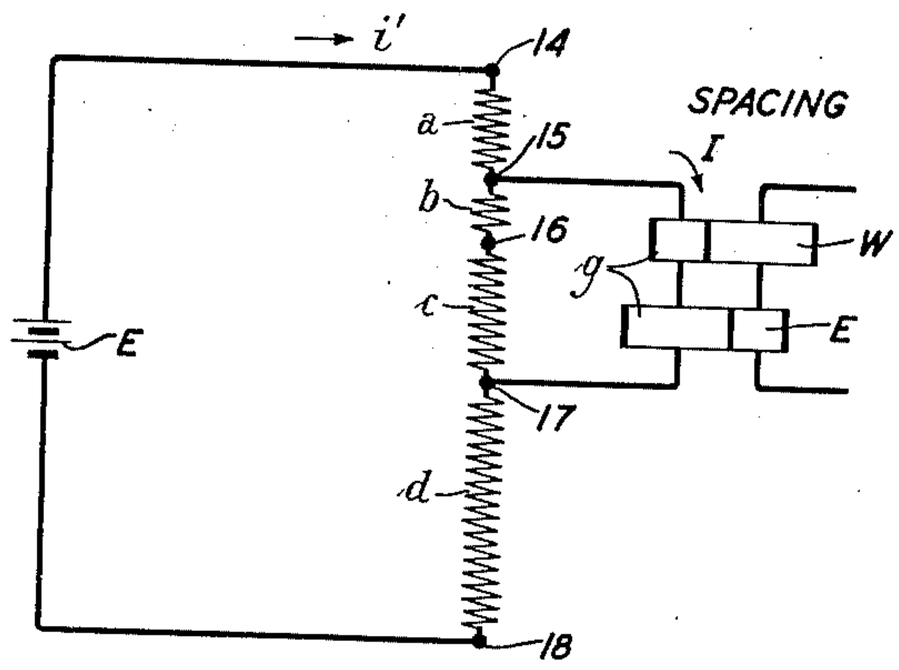


FIG. 3



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TELEGRAPH REPEATER

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19 Claims. (Cl. 178—71)

This invention relates to telegraph repeaters for transmission in both directions, one at a time, and more particularly to repeaters of this type which have no local current supply.

It is among the objects of this invention to provide a simple single line repeater which may be supplied with current over the two adjacent line sections and which will be efficient and accurate in operation.

It is a particular object of the invention to provide a repeater of this type in which the relays are at all times held definitely in either position by current over the line circuits without dependence upon the polarizing flux for this purpose.

In accordance with the invention the repeater has certain windings in the west line sections and other windings in the east line sections supplied with current from the distant stations. The two sets of windings are normally opposed and the differential action serves to hold the contacts in marking position, thereby establishing a marking condition in both line sections.

Proper networks are provided in connection with each line section and are so arranged and proportioned that the current through a given set of windings will either be unaffected by the operation of the relay contacts in that section in response to signals in the other section, or will not be reduced sufficiently to cause "kick-off" of the relay contacts in the incoming section.

The invention will now be described as applied to a particular embodiment such as the repeating system shown in the accompanying drawing, in which

Figure 1 shows a two-way repeater connected between two remote stations, and

Figs. 2 and 3 are schematic diagrams of one-half of the repeater in marking and spacing positions, respectively, intended as an aid to the theoretical consideration of the system.

Referring more particularly to Fig. 1, repeater C comprises the relays W and E and is connected over the line section west LW to the station A and over the line section east LE to the station B. Stations A and B may be subscribers' stations or they may be other repeater stations, such as exchange stations. At the stations A and B there is provided a set of transmitting contacts T, which may be manually operated or may be operated by a relay for transmitting signals over repeater C to the other station. The stations A and B further comprise a receiving winding R for reception of signals incoming from the repeater station C, for recording or further transmission of the signals. Stations A and B also each include a source of current S. The stations A and B are serially included in the respective line circuits and contacts T are normally closed, thereby providing a normal line current in each section corresponding to the marking condition.

At the repeater station C the relay W is for transmission from east to west and it has its main operating winding serially included in the line LE; the contacts of relay W are included in the line west LW and are normally operated to marking position by the operating winding. Similarly, E has its main winding serially included in the line west LW and its contacts in the line east LE. Relay W furthermore, has a secondary winding included in line LW and under normal or marking conditions, the ampere turns of this winding are approximately one-half of those of the main operating winding and the direction of current therethrough is such that, under marking conditions, the windings are opposed in their effect upon the armature. Under spacing conditions, when the main or primary winding is currentless, the secondary or biasing winding will operate the armature to spacing. A similar secondary winding is provided for relay E.

A resistance network is furthermore included in the line LW comprising resistances 10, 11, 12, and 13. A similar network is included in the line LE and consists of the resistances 20, 21, 22, and 23.

The two relays of the repeater and their associated line circuits are substantially identical and operate in substantially identical manners for which reason the following discussion will be confined to transmission in one direction only, namely, from east to west. It will be assumed that the repeater is approximately midway between the two stations; in cases where this is not possible, it will be necessary to consider each direction of transmission separately in designing the associated networks.

The circuit is shown in normal or marking position in Fig. 1, that is with the transmitting contacts T and the relay contacts closed. The circuit from the source S at station A may now be traced as follows: from negative battery through receiving winding R, over transmitting contacts T, upper line conductor LW, resistance 10 to point 15, at which the current divides into different branches. A portion of the current passes through resistance 11 to point 16. Another portion passes through the secondary winding of relay W and primary winding of relay E to point 17, at which point this current divides, one portion going through resistance 13 to point 18, the other portion through resistance 12 to point 16 where it joins the current from resistance 11 and continues over the contacts of relay W to point 18, where it joins the current from resistance 13 and continues over lower conductor LW to the positive side of battery S.

The line current in this circuit is sufficient to hold the relay R in marking position. The current through the left-hand windings of relays W and E is, however, much smaller than the line

current and these relays will be assumed to be of a more sensitive type than the relays R.

As already stated, conditions similar to those just described exist in the right-hand portion of the circuit including the line LE so that a similar small current flows in the right-hand winding W and E as in the left-hand winding during the normal or marking condition.

The primary windings of relays W and E have approximately twice as may turns as the secondary windings so that their differential effect will be in the marking direction when the current in both sets of windings is the same. The primary winding of relay W will be twice as strong as the secondary winding and thus will hold the contacts safely in marking position. Similarly, the primary winding of relay E is twice as strong as the secondary winding and holds the contacts of this relay in marking position.

Assuming now that transmitting contacts T at station B are opened to send a spacing impulse, the current in the line LE and in the various branches of the resistance networks **20**, **21**, **22**, and **23**, as well as in the right-hand windings of relays W and E will reduce to zero. Relay E will remain unaffected in marking position, but relay W operates its armature to spacing by means of its secondary winding, which now exerts a force on the armature toward spacing approximately equal to that exerted by the previous differential effect of the two windings toward marking.

With the contacts of relay W open the left-hand circuit may now be traced as follows:

From battery S, through winding R and contacts T at station A over the upper line LW to point **15**, where the current divides, one branch flowing through the left-hand windings of relays W and E to point **17** and the other branch flowing through resistance networks **11** and **12** to point **17**, the two currents joining at this point and flowing through resistance **13**, over the lower line of conductor LW to battery at station A. Thus a spacing condition is impressed upon the left-hand circuit, and the line current through station A is now reduced sufficiently to insure release of the relay R at station A for reception or retransmission of the spacing impulse. Under the same condition the current in the left-hand windings of relays W and E may be maintained at the same value as during the previously described marking condition, thereby insuring that the operating winding of relay E holds the contacts of relay E in marking position and thus preventing interference with the signals incoming over the line circuit LE. The current through the left-hand windings of relays W and E may, however, be reduced during spacing condition to about half the current flowing through these windings during marking condition, still with the desired effect of preventing "kick-off" of relay E, and still serving to safely lock the contacts of relay W in spacing position. The desired currents in the line circuit through station A and the desired currents through the left-hand windings of relays W and E during marking and spacing conditions, as imposed by station B, may be obtained by proper proportioning of the resistances **10**, **11**, **12**, and **13**. Similar current conditions may be established in the right-hand portion of the system by proper proportioning of the resistances **20**, **21**, **22**, and **23**.

The following procedure may be used in determining the value of these resistances and under the assumption that the relay current should remain substantially unaffected while the contacts in the associated line circuit transmits to the distant station.

Referring particularly to Fig. 2, this diagram shows in simplified form current paths associated with the line west LW during the transmission of a marking impulse from the repeater to the station A and conforms with the circuits which already have been traced. Fig. 3 similarly shows in diagrammatic form the same circuit under the condition of transmission of a spacing impulse from the repeater to station A, as already traced above.

Thus in Fig 3 the contacts of relay W are open and the resistances **10**, **11**, **12**, and **13** form a series circuit, whereas in Fig. 2 the contacts of relay W are closed, thereby bringing the points **16** and **18** together at the same potential.

In the following discussion the resistances **10**, **11**, **12**, and **13** will be assumed to have resistance values a, b, c, and d, respectively. The series resistance of the secondary winding of relay W and primary winding of relay E has the value g. E is the voltage of the source S at station A. Resistance a includes the line resistance and the resistance of the apparatus at station A, included in the line circuit. I is the current in the relay windings and is assumed to be the same both under spacing and marking conditions; i is the marking line current as it flows under the condition shown in Fig. 2, and i' is the spacing line current under the condition shown in Fig. 3.

From an inspection of the circuit in Fig. 2, we have

$$(i-I)\,b=E-ia \qquad (1)$$

$$I\left(g+\frac{cd}{c+d}\right)=E-ia \qquad (2)$$

From the circuit in Fig. 3, we have

$$(i'-I)\,(c+b)=Ig \qquad (3)$$

$$Ig=E-i'(a+b) \qquad (4)$$

In these formulas the following quantities are known and will be assumed to have the indicated values in a specific case, serving as an example:

E=267.5 volts
i=60 milliamperes
I=5 milliamperes
a=4000 ohms
g=167 ohms

From Formula 1 we have

$$b=\frac{E-ia}{i-I}=500 \text{ ohms} \qquad (5)$$

and from Formula 2 we have

$$\frac{cd}{c+d}=\frac{E-ia-Ig}{I}=5333 \text{ ohms} \qquad (6)$$

From Formulas 3 and 4 we obtain

$$c=\frac{Ig-(i'-I)b}{i'-I} \qquad (7)$$

$$d=\frac{E-i'a-Ig}{i'} \qquad (8)$$

By substituting these expression for c and d in the Formula 6 and solving with respect to i', we obtain

$$i'=I\frac{(E-ia-Ig)E+agiI}{(E-ia-Ig)E+agI^2}=5.128 \text{ milliamperes} \qquad (9)$$

Inserting this value of i' in the expressions (7) and (8) we obtain

c=6,000 ohms
d=48,000 ohms

Thus in the assumed specific example the sys-

tem will have a marking line current of 60 milliamperes and a spacing line current of 5.13 milliamperes; a constant current of 5 milliamperes will flow through the relay winding during both marking and spacing impulses in the outward side of the repeater. Of course, on that side of the system in which the transmitting contacts T are opened for transmission of a spacing impulse, the line current as well as the relay current will become zero.

The reduction of the line current from 60 to 5.13 milliamperes is sufficient to surely release relay R at the distant station. By permitting a continuous line current to flow, even during the spacing impulses in the output circuit of the repeater, a definite holding force will be provided for the inactive relay while the other relay is operating, thereby preventing "kick-off" and interference with the signals incoming to the repeater, without reliance upon the natural attraction of the armature by the polarizing flux. This continuous line current also serves to provide a definite locking force for the armature in spacing position of the active relay until the next marking impulse arrives.

What is claimed is:

1. A two-way telegraph repeating system comprising two line circuits, repeating contacts in each line circuit for varying the respective line currents in repeating of signals, winding means connected to said line circuits for operating said contacts in opposite directions as signals are incoming over one or the other of said line circuits, said winding means remaining connected to said line circuits irrespective of the operation of said contacts.

2. A two-way telegraph repeating system comprising two line circuits, repeating contacts in each line circuit for varying the respective line currents in repeating of signals, winding means connected to both line circuits for operating each of said contacts in opposite directions in response to signals incoming over either of said line circuits, the current in said winding means remaining substantially unaffected by the operations of said repeating contacts.

3. A two-way telegraph repeating system comprising two line circuits, repeating contacts in one of said line circuits for varying the line current in repeating of signals, winding means connected in multiple relation to said contacts for operating them in one direction and other winding means for operating said contacts in the opposite direction in response to signals in the other of said line circuits.

4. A telegraph signaling system comprising an east line circuit, a west line circuit, repeating relay means having active contacts in said west line circuit and inactive contacts in said east line circuit, having an operating winding and a biasing winding connected in said west line circuit to operate said contacts in one direction and having winding means in said east line circuit to operate said contacts in the opposite direction, resistance means interconnecting said active contacts, said operating and biasing windings and said west line circuit to maintain sufficient current in said operating winding during the operation of said active contacts to prevent kick-off of said inactive contacts.

5. A telegraph signaling system comprising an east line circuit, a west line circuit, west repeating relay means having active contacts in said west line circuit, having an operating winding connected in said east line circuit and a biasing winding in said west line circuit to operate said contacts in opposite directions, east repeating relay means having inactive contacts in said east line circuit and having a winding connected in said west line circuit for operation of said inactive contacts, and resistance means interconnecting said active contacts, said windings in the west line circuit and said west line circuit to continuously maintain sufficient current in said winding of the east repeating relay means during the operations of said active contacts to prevent pick-off of said inactive contacts.

6. A two-way telegraph repeating system comprising an east line circuit including an east current source and a west line circuit including a west current source, repeating relay means having active contacts and inactive contacts and having west windings energized by signal current from said west source for operation of said contacts in one direction, and having east windings opposed to said west windings and energized by signal current from said east source for operation of said contacts in the opposite direction, resistance sections connected between said west line circuits, west windings and active contacts to maintain sufficient current in said west windings when said active contacts are opened by signals in said east line circuit to maintain said inactive contacts inactive.

7. A two-way telegraph repeating system comprising a west line circuit, an east line circuit, west repeating contacts and west circuit means in said west line circuit, east repeating contacts and east circuit means in said east line circuit, winding means connected to both of said line circuits to operate said contacts in opposite directions in response to signals incoming over one or the other of said line circuits, said west circuit means being connected to said west contacts to vary the current in said west line circuit for repeating of signals therein and to maintain substantially constant the current in the windings connected in said west line circuit as said west contacts are operated in opposite directions.

8. A two-way telegraph repeating system comprising an east line circuit, a west line circuit, a source of current in each line circuit, repeating relay means having contacts in each line circuit and having windings in each line circuit energized by said sources to operate said contacts in opposite directions as one or the other line circuit is opened and closed, resistance means connected in one of said line circuits to be varied by operation of the contacts associated therewith to vary the current in said one line for transmission of signals and to maintain sufficient current in the associated windings to prevent operation of the contacts in the other line circuit as said other line circuit is opened and closed.

9. A two-way telegraph repeating system comprising an east line circuit, a west line circuit, a repeater station between said line circuits, a source of signaling current in each line circuit at points remote from said repeater station, said repeater station including contact means in each line circuit, windings in each line circuit and energized by said two sources of current respectively to operate one or the other of said contact means in opposite directions as one or the other of said line circuits is opened and closed, and resistance means connected in one of said line circuits to be varied by operations of the contact means associated therewith to vary the current in said one line for transmission of signals and to maintain sufficient current in the associated windings to

prevent operation of the contact means in the other line circuit as said other line circuit is opened and closed.

10. A telegraph repeater station connected between two line sections comprising repeating contacts in each line section, winding means energized over one line section for operating said contacts in one direction and other winding means energized over the other line section for operating said contacts in the opposite direction as one or the other line circuit is opened, and resistance means connected in said line circuits to be varied by operation of said contact means for retransmission of signals without interruption of the current in said winding means.

11. A half-duplex telegraph repeater connected between two line circuits and comprising retransmitting relay means having sending contacts in both line circuits and having operating and biasing windings in both line circuits, sources of current in both line circuits, and resistance networks in both line circuits connecting said windings and contacts to said line circuits to make said windings substantially unaffected by the operations of said contacts.

12. A half-duplex telegraph repeater comprising two line circuits, sending contact means in each line circuit, windings permanently connected in both line circuits for operating each of said contact means, and a resistance network in each line circuit connecting the associated windings and contact means to their line circuit to make all of said windings substantially unaffected by the operations of said contact means.

13. A telegraph repeater in accordance with claim 12 in which each of said resistance networks comprises a high resistance section alternately connected in multiple and series relation to said associated windings by the operations of said associated contact means.

14. A telegraph repeater in accordance with claim 12 in which each of said resistance networks comprises a low resistance section permanently connected in multiple relation to said associated windings, a high resistance section permanently connected in series relation to said associated windings and a third resistance section alternately connected in multiple and series relation to said associated windings by the operations of said associated contact means.

15. A telegraph repeater in accordance with claim 12 in which each of said resistance networks comprises a low resistance section permanently connected in multiple relation to said associated windings, a high resistance section permanently connected in series relation to said associated windings and a third resistance section alternately connected in multiple and series relation to said associated windings by the operations of said associated contact means, the proportion of the said third resistance to the said low resistance being substantially equal to the proportion of said high resistance to the total resistance included in the associated line circuit.

16. A telegraph signaling system comprising an east line circuit, a west line circuit, a plurality of retransmitting relay means having sending contacts in said west line circuit and having an operating and a biasing winding connected in said west line circuit and winding means in said east line circuit for operating said contacts, and resistance means interconnecting said contacts, said operating and biasing windings and said west line circuit, to maintain a substantially constant current in said operating and biasing windings during the operation of said contacts in response to signals incoming over said east line circuit.

17. A telegraph signaling system comprising an east line circuit, a west line circuit, retransmitting relay means having sending contacts in said west line circuit and having a west winding connected to said west line circuit and an east winding connected to said east line circuit for operating said contacts in opposite directions in response to signals incoming over said east line circuit, and resistance means interconnecting said contacts, said west winding and said west line circuit to maintain a substantially constant current in said west winding during the operations of said contacts.

18. A signal repeating system comprising an east line circuit including a current source, a west line circuit including a current source, east-to-west repeating relay means having an operating winding in said east line circuit and having a biasing winding and contact means in said west line circuit, a resistance network included in said west line circuit and having points connected to said contact means to provide a large current in said west line circuit in marking position and a small current in said west line circuit in spacing position of said contact means, the current from said west line circuit through said biasing winding being substantially the same in the marking and spacing positions of said contact means.

19. A signal repeating system comprising an east line circuit including a current source, a west line circuit including a current source, east-to-west repeating relay means having contacts connected in said west line circuit, west-to-east repeating relay means having contacts connected in said east line circuit, said repeating relay means each having windings in said west and east line circuits for operation of their respective contacts in opposite directions in response to incoming signal impulses, a network including a plurality of joined resistances connected to said west line circuit and having connections to the said windings in said west line circuit, said contacts of said east-to-west relay means having connections to joining points of said resistances to maintain a substantially constant current in the said windings in said west line circuit during operation of the said contacts of the east-west relay means in response to signals incoming over said east line circuit, thereby preventing interference with said incoming signals by the contacts connected in said east line circuit.

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