

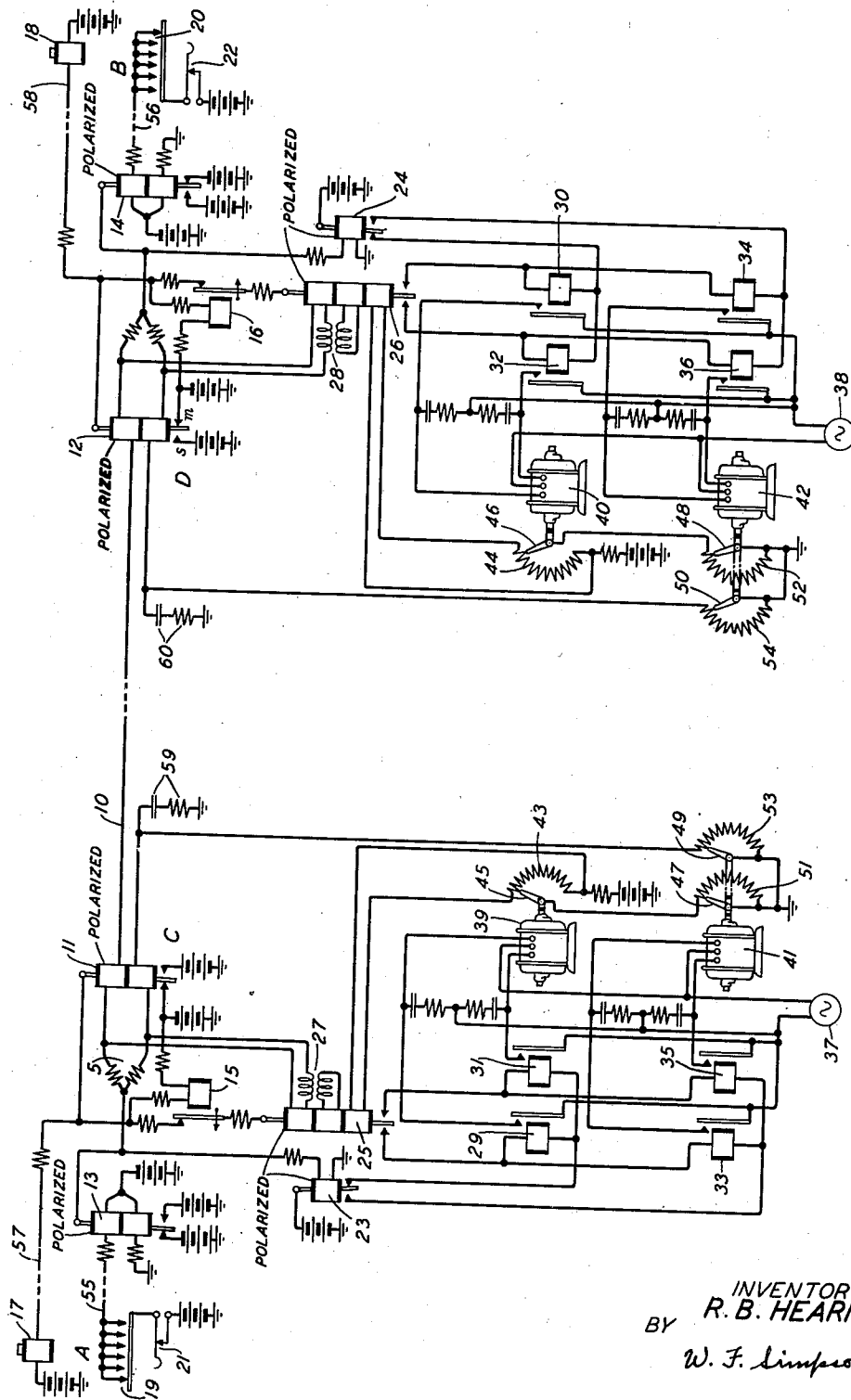
July 15, 1941.

R. B. HEARN

2,249,133

AUTOMATIC BALANCING SYSTEM

Filed June 30, 1939



UNITED STATES PATENT OFFICE

2,249,133

AUTOMATIC BALANCING SYSTEM

Richard B. Hearn, Hollis, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 30, 1939, Serial No. 282,013

6 Claims. (Cl. 178—69)

This invention relates to communication systems and more particularly to an automatic balancing arrangement for maintaining the impedance of the artificial line of a two-way communication circuit substantially equal to the impedance of the line.

More specifically the invention relates to a duplex telegraph system and provides means for automatically varying the impedance of the artificial line as the impedance of the main line varies due to changing weather conditions.

Systems disclosed in the prior art for reducing or eliminating the effects of varying weather conditions upon the transmission of signaling impulses such as usually employed for telegraph transmission, as shown in U. S. Patents 2,131,870, W. W. Cramer, October 4, 1938 and 2,133,380, R. W. Deardorff, October 18, 1938, for example, are effective only during the transmission in one direction at a time and do not compensate for variations in both the leakage resistance and conductor resistance. Other correcting arrangements such as shown in U. S. Patent 2,125,704, R. J. Wise, August 2, 1938, are operative only during the transmission of signaling impulses and properly compensate or correct only after transmission has been in progress for some period of time.

It is an object of this invention to provide an automatic compensating arrangement for full duplex telegraph systems in which signaling impulses are simultaneously transmitted in both directions over the system and which will automatically compensate for variations in both the leakage resistance of the main line due to wet weather and also for a variation in the line resistance due to changes in temperature.

Another object of this invention is to provide a system in which adjustment of some elements of the circuit is made during idle conditions during which no impulses are transmitted over the system.

A further object of this invention is to provide an automatic compensating arrangement which may be easily applied to any duplex telegraph or other similar signaling system without any changes or special adjustments. In other words this invention may be applied to telegraph lines having different characteristics and may be readily transferred from one telegraph line to another having different characteristics without alteration or any special adjustments.

Briefly, in accordance with this invention a relay or other current or potential measuring device is employed to measure or respond to the

difference in the current flowing in the main line and the artificial line under the signaling conditions transmitted from the station at which the measurements are made. This measuring device is rendered ineffective during the reception of one of the two signaling conditions from the distant end. When one of the signaling conditions is applied to the first end of the line and the proper signaling condition to the other end of the line the measuring device will control a motor which in turn varies the bias of the measuring device.

During the transmission of the second signaling condition from the first station the measuring device controls a second motor which in turn varies the resistance of the artificial line in such a direction as to tend to make its impedance substantially equal to the impedance of the main line.

The foregoing objects and other objects and features of this invention, the novel features of which are specifically pointed out in the claims appended hereto, may be more fully understood from the following description when read with reference to the attached drawing which illustrates the details of one specific embodiment of this invention.

As shown in the drawing, two stations A and B are connected together through two repeater stations C and D. The main line 10 extends between the repeater stations C and D and may include any type of signaling line or channel suitable for the transmission of low frequency or direct current signaling pulses or impulses. This line may include open wire telegraph lines, cable pairs, telegraph channels of composite telephone and telegraph lines including simplex channels or any combination of these various types of facilities. Furthermore it is to be understood that line 10 may include suitable composite coils, condensers and other filter elements and networks usually employed in the respective types of lines. Details of all of these features have not been shown in the drawing because they are well understood by those skilled in the art and because they would needlessly complicate the drawing and tend to obscure this invention.

The term "impulse" is used in this specification and also in the claims appended hereto to indicate the application of or the transmission of either signaling condition to or over the system for a unit interval of time of the telegraphic or signaling code or longer.

Line 10 as well as stations A and B are arranged for full duplex transmission, that is,

each station may transmit messages to the other station at the same time without interfering with each other. The receiving device or relay 17 at station A is connected to station C over line 57. The transmitting device comprising transmitting contacts 19 and break contacts 21 located at station A is connected to station C over line 55. Similarly the receiving device 18 at station B is connected to station D over line 58; and the transmitting device having transmitting contacts 20 and break contacts 22 connected to station D over line 56.

Relay 13 at repeater or central station C responds to the impulses transmitted from station A over path 55 and repeats them to station D over line 19. Relay 12 at repeater or central station D responds to these impulses and repeats them over line 58 to the receiving device 18 at station B. Similarly, relay 14 at repeater station D responds to the impulses transmitted from station B and repeats them over line 10 to repeater or central station C. Relay 11 at station C responds to these impulses and repeats them over line 57 to device 17 at station A. In order for the receiving relay 11 at station C to accurately respond to the signals received over line 10 and be substantially unaffected by the signals repeated over line 10 by relay 13, it is necessary that the artificial line comprising network 59 and variable resistance 53 have substantially the same impedance as line 10 to the signaling currents.

In the past it has been customary to manually vary or adjust the impedance of the artificial line so that it will have substantially the same impedance as the main line. It is frequently necessary to make these adjustments as often as once a day and sometimes more frequently depending upon the changing weather conditions. In case the line is an open wire line or a channel of a system employing open wires it is subject to considerable variations in the leakage resistance which must be compensated by varying the adjustment of the artificial line. Furthermore in case line 10 comprises a wire of a cable pair or is a channel of a composite system employing cable conductors the wires are subject to considerable variation in resistance due to temperature changes.

The upper winding of relay 25 is connected across resistances 5 one of which is in series with the upper winding of relay 11 and main line 10 and the other of which is in series with the lower winding of relay 11 and the artificial line comprising variable resistance 53 and network 59. So long as currents flowing through these two resistances and hence through line 10 and the artificial line are substantially equal, substantially no current will flow through the upper winding of relay 25. Normally, however, with the transmitting relays 13 and 14 resting on the contacts shown, no current will flow through the main line 10 but current will flow through the artificial lines. This means that considerable current will flow through the upper winding of relay 25 and tend to operate it to one or the other of its contacts.

Assuming that relays 13 and 14 are resting on their marking contacts as shown, relay 15 at repeater station C and relay 16 at repeater station D will be short-circuited and thus in their released or non-operated condition. Under these conditions relay 25 will close one of its contacts, assume its right-hand contact, and thus complete a circuit for the operation of re-

lay 31 from negative battery through the left-hand contact and armature of relay 11 the contacts of relay 15, armature and right-hand contact of relay 25, winding of relay 31, to positive battery through the right-hand contact and armature of relay 23. Relay 31 in operating completes an obvious circuit from source of power 37 to motor 39. The source of power 37 has been shown as an alternating current source. It is to be understood, however, that any other suitable source may be provided.

The operation of relay 31 completes a circuit to motor 39 as described above and causes this motor to operate and move the arm 45 of variable resistance 43 in such a direction as to vary the biasing current flowing through the lower winding of relay 25 so that it will tend to produce an effect which will be substantially equal to the effect of the current flowing through the upper winding of this relay. These two currents flow through the windings of relay 25 in such a direction that they oppose each other so that when their effects become equal, relay 25 will release and its armature stand substantially midway between its contacts. This will interrupt the circuit of relay 31 and permit this relay to release, thus interrupting the operating circuit of motor 39 which will then come to rest and leave the potentiometer arm 45 in the position which maintains a bias current through the winding of relay 25 substantially equivalent in effect to the current flowing through the upper winding of this relay.

Similar circuits operate in substantially the same manner at repeater station D so that the current flowing through the lower winding of relay 26 produces substantially an equal and opposite effect to the current flowing through the upper winding of this relay. Consequently this relay will also be maintained with its armature standing between its contacts without resting against either one of them.

Assume now that a spacing impulse is transmitted from station A by the sending contacts 19. Relay 13 at repeater station C will respond to this spacing impulse and repeat it over line 10 to repeater station D. Relay 12 at repeater station D responds to this impulse and completes a circuit for the operation of relay 16 from negative battery connected to the marking contact of relay 12, winding of relay 16 to positive battery through the armature and spacing contact of relay 12. Relay 16 in operating interrupts the circuit through the armature of relay 26 and thus prevents the operation of motors 40 and 42 at this time. Relay 16 is made slow in releasing so that it will remain operated during the transmission of all but the longer signaling impulses. Consequently, no correction to the impedance of the artificial line can be made at repeater station D except during the transmission of the longer marking impulses from repeater station C.

Relay 13 at repeater station C in responding to the spacing impulse transmitted from station A moves its armature to its right-hand position and thereby connects positive battery to the upper winding terminal of relay 23, causing the armature of this relay to move to its left-hand position where it prepares a circuit for the operation of relays 33 and 35.

If the artificial line comprising resistance 53 and network 59 has substantially the same impedance as line 10, substantially the same voltage will appear across resistances 5 and thus across

the upper winding of relay 25 as appears across these resistances during transmission of the marking condition. Consequently, the armature of relay 25 will remain in its center position where it makes contact with neither its right-hand nor its left-hand contact. If the artificial line does not have substantially the same impedance as the artificial line, a different voltage will appear across resistances 5 during the transmission of a spacing impulse than appears across these resistances during the transmission of a marking impulse. Consequently, a different voltage is applied to the upper winding of relay 25, causing this relay to close one or the other of its contacts. Assume, for example, that during the transmission of a spacing impulse from station A, as described above, relay 25 will close its left-hand contact. This completes a circuit from negative battery through the left-hand contact and armature of relay 11, contacts of relay 15, armature and left-hand contact of relay 25, winding of relay 33 to positive battery through the left-hand contact and armature of relay 23. Relay 33 operates due to current flowing through this circuit and completes an obvious circuit from source 37 to motor 41 for the operation of this motor. Motor 41 varies the impedance of the artificial line and also the bias current flowing through the lower winding of relay 25.

Then, during the transmission of the next marking signal from station A, relay 23 will be operated to its right-hand position and relay 25 operated to either its right-hand or left-hand position for completing a circuit through the windings of either relay 31 or 29 to further regulate the bias current flowing through the lower winding of relay 25. The above-described operations will be repeated until the armature of relay 25 remains in its neutral or center position during the transmission of both marking and spacing impulses from station A at which time the impedance of the artificial line will be substantially equal to the impedance of the main line.

If the impedance of line 10 now changes, so that it no longer is substantially the same as the impedance of the artificial line, relay 25 will again be operated so as to close either its right-hand or left-hand contact and the above-described operations will be repeated until the armature of relay 25 again remains in its neutral position when the impedance of the artificial line will again be substantially equal to the impedance of line 10.

The operation of the automatic balancing equipment at station D is similar to that described with reference to repeater or central station C. It should also be noted that in case signaling impulses are simultaneously transmitted from stations A and B, both relays 15 at station C and 16 at station D will be operated and disconnect the correcting apparatus. These relays, as pointed out above, are made slow in releasing so that they will not immediately release but provide sufficient time for relays 25 and 26 to operate to close the proper contacts before relays 15 and 16 release. It is also within the scope of this invention to make relays 15 and 16 sufficiently slow in releasing to prevent any correction to the artificial line during any but the longer signaling impulses transmitted over the system from the distant station.

It should be noted that transformer 27 is connected to the windings of relay 25 and transformer 28 is connected to the windings of relay 26. These transformers serve to make these re-

lays insensitive to alternating current as well as to other stray potentials introduced into the system. They also serve to retard the operation of relays 25 and 26 so relays 11 and 12 respectively will operate first on the reception of a spacing impulse from the distant station and thus interrupt the circuit through the armature and contacts of relays 25 and 26, respectively before these relays operate at this time to improperly adjust the circuit elements.

It is also within the scope of this invention to connect relays 25 and 26 or relays similar to them directly in the line and artificial line circuits similar to the differential duplex relays instead of as a bridged polar relay, as shown in the drawing.

It should be noted that during the transmission of one of the signaling conditions from the transmitting station, the bias of the testing or measuring relay 25 is varied or controlled and during the transmission of the other signaling condition the impedance of the artificial line is varied. Thus some measurements and adjustments are made during idle conditions as well as during signaling conditions.

While in the specific embodiment of the invention shown in the drawing the artificial line is adjusted during the transmission of the spacing condition it is to be understood that it may be made during the transmission of the marking condition. Other changes of this nature and of other natures will occur to those skilled in the art which are within the scope of this invention.

Since measurements are made during the transmission of both signaling conditions the system shown in the drawing is capable of compensating for variations in both the leakage resistance of line 10 and also variations in the conductor resistance of line 10 due to temperature changes.

What is claimed is:

1. A duplex telegraph system comprising a telegraph line, transmitting and receiving apparatus connected to said line, an artificial line connected to said receiving apparatus, a variable resistance connected to said artificial line, a single measuring device responsive to differences in current flowing in the main line and the artificial line, a local circuit for said measuring device for adjusting the limits of response of said device, and means responsive to one set of signaling conditions applied to said system for varying the potential applied to said local circuit under control of said measuring device and means responsive to another set of signaling conditions applied to said system for varying the resistance of said artificial line under control of said measuring device.

2. A duplex telegraph system comprising a telegraph line, transmitting and receiving apparatus connected to said line, an artificial line connected to said receiving apparatus, a variable resistance connected to said artificial line, a measuring device responsive to differences in impedance of said main line and said artificial line, a local circuit connected to said measuring device the current of which adjusts said measuring device, and means responsive to one set of signaling conditions transmitted over said system from said transmitting apparatus for varying the current flowing through said local circuit under control of said measuring device and means responsive solely to another set of signaling conditions transmitted over said system by said transmitting apparatus for varying the

resistance of said artificial line under control of said measuring device.

3. In a telegraph system comprising a telegraph line, transmitting apparatus connected to said line for normally applying one signaling condition to said line, means for causing said transmitting apparatus to apply a second signaling condition to said line, receiving apparatus also connected to said line and an artificial line connected to said receiving apparatus, means for automatically maintaining a balance between the impedances of said telegraph line and said artificial line comprising a device for indicating unbalances between said lines, means for supplying a biasing current to said indicating device and means controlled by said indicating device for varying the biasing current during the time said first signaling condition is applied to the line and means for varying said artificial line under control of said indicating device only during the time said second signaling condition is applied to said line.

4. A telegraph system comprising a metallic telegraph path, impulse transmitting apparatus connected to each end of said path for normally applying a first signaling condition thereto, independent means for causing each of said transmitting apparatus to apply a second signaling condition to said path, receiving apparatus connected to each end of said path, an artificial line connected to each of said receiving apparatus, a measuring device responsive to the differences in currents flowing in said telegraph path and in said artificial lines at each end of said path, local circuits controlled by said measuring device, a bias circuit for said measuring device, and means responsive to said measuring device for varying current flowing in said biasing circuit during the time said first transmitting condition is applied to both ends of said telegraph path, means for interrupting said local circuits at either end of said path when said second signaling condition is applied thereto at the opposite

end, and means for varying the resistance of said artificial line under control of said measuring device during the time said second transmitting condition is applied to said path at said first end of said path.

5. A duplex telegraph system comprising a telegraph line, transmitting apparatus for applying at least two different signaling conditions to said line, receiving apparatus connected to said line, an artificial line connected to said receiving apparatus, a variable resistance connected in said artificial line, a measuring device responsive to differences in current flowing in the main line and the artificial line, a bias circuit for said measuring device, a variable resistance connected in said bias circuit, means responsive solely to one signaling condition for varying one of said variable resistances under control of said measuring device, and means responsive to said other signaling condition for varying said other variable resistance under control of said measuring device.

6. In a telegraph system comprising a telegraph line, transmitting apparatus connected to said line for normally applying one signaling condition to said line, means for causing said transmitting apparatus to apply a second signaling condition to said line, receiving apparatus also connected to said line, and an artificial line connected to said receiving apparatus, means for automatically maintaining a balance between the impedances of said telegraph line and said artificial line comprising a device for indicating unbalances between said lines, a biasing circuit for said indicating device, and means controlled by said indicating device for varying said biasing circuit during the time said second signaling condition is applied to said line, and means for varying the impedance of said artificial line only during the time said first signaling condition is applied to said line.

RICHARD B. HEARN.