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REGENERATIVE TELEGRAPH REPEATER

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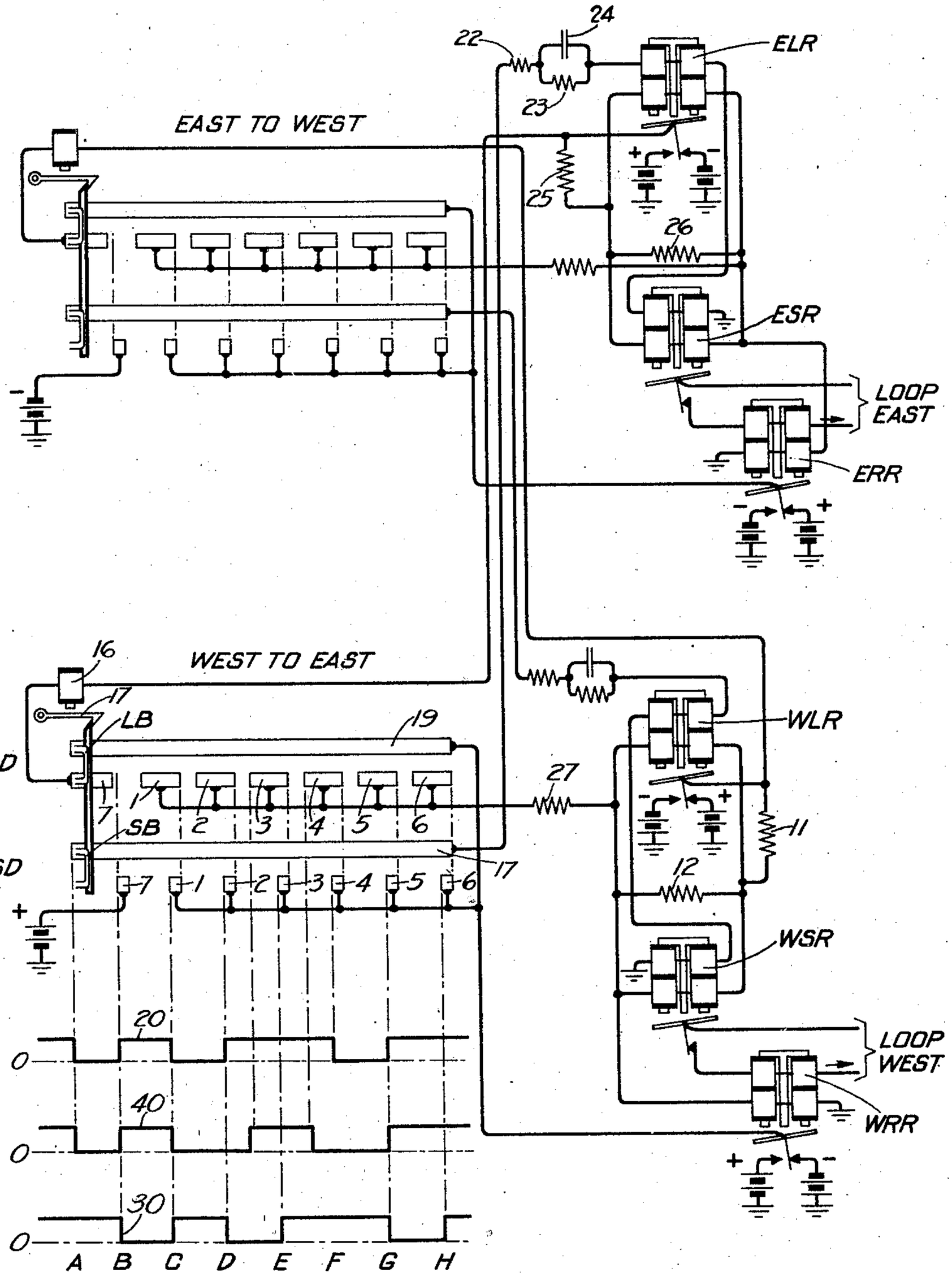


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# UNITED STATES PATENT OFFICE

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## REGENERATIVE TELEGRAPH REPEATER

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This invention relates to telegraph systems, and particularly to printing telegraph systems of the start-stop type.

An object of the invention is to regenerate into substantially their original form signals which have been so badly distorted that further distortion would change their identity.

A feature of the invention is a rotary distributor, start-stop repeater theoretically capable of regenerating signals which have suffered distortion up to 50% of their normal length on either end.

Ordinary telegraph repeaters comprise one or more electromagnetic relays which, although they increase the amplitude of the signals, repeat uncorrected any distortion which may have occurred in the signal impulses before their arrival at the repeating point. Regenerative repeaters have been developed for repeating printing telegraph signals which, in addition to increasing the amplitude, correct for a certain amount of distortion in the signals. In general, these systems utilize a signal absorbing device (commonly a condenser or a relay) which is connected to the line through a distributor device for a short period at a time when the center of a signal is being received. The usual effect of line distortion is to cut off or eliminate the ends of signal impulses and therefore the middle portions of the signals are least affected. Since distortion may affect either end of a signal impulse, the greatest possible freedom from the effects of distortion would be obtained in systems of the above type if an infinitely short receiving segment were used which would select only the very center of each signal impulse. Such a system is not possible in practice because a segment of appreciable length is required to pass sufficient current to actuate the signal responsive device.

In accordance with this invention, signal impulses are applied directly to one winding of a receiving relay without the use of a receiving segment, but the receiving relay is locked in whatever position it happens to be when the center of the signal should occur by means of a separate locking winding energized through locking segments on the distributor. Since the receiving relay repeats impulses of characteristics dependent only on its position at the time the locking brush makes contact with an associated segment, the degree of signal distortion permissible is not dependent on the minimum allowable width of the segment but only on the position of the edge of the segment, and may approach the maximum theoretical value, that is, 50% on either end.

### *General description of apparatus*

A regenerative repeater system in accordance with this invention for repeating signals in either direction between two line sections, one of which is, for convenience, called loop east and the other loop west, is illustrated in the drawing.

As shown in the drawing the apparatus comprises two distributor faces, one for repeating from west to east and the other for repeating from east to west. Each face comprises locking rings LD and sending rings SD, associated with which are brushes LB and SB, adapted to be moved over the distributor face in synchronism with received signals by a motor, which is not shown. In practice the rings are circular and the brushes sweep over the seven segments in one revolution when the catch 17 is released by start magnet 16. Associated with each distributor are a locking relay, a sending relay, and a receiving relay, the relays associated with the loop west being identified as WLR, WSR and WRR, respectively, and those with the loop east ELR, ESR, and ERR, respectively. The function of these relays will be made clear by a detailed description of the operation of the

system in repeating signals from the loop west into the loop east.

*Detailed description of operation*

In systems of the type described the line circuit, or loop as it is termed, is normally closed through a source of current. Thus, referring to the drawing, the loop west is normally closed through a source of current at the distant end, the upper winding of the west receiving relay WRR and the armature and contact of the west sending relay WSR. For purpose of explanation it is assumed that an electron flow from left to right through any relay winding urges the relay armature from left to right, and vice versa when the electron flow is in the opposite direction. The direction of the electron flow from the source at the distant end of the loop west is always from left to right through the relay WRR as indicated by the arrow. Thus the armature of this relay is held on its right contact by a loop current, which may conveniently be made approximately 60 milliamperes. An opposing current of approximately 30 milliamperes flows through the lower winding, which will hereinafter be termed the biasing winding. The circuit for the 30 milliampere current extends from positive battery through the contact and armature of the west locking relay WLR, through resistance 11, through the paralleled lower windings of the west locking relay WLR and the west sending relay WSR, which are shunted by a resistance 12, and through the biasing winding of the receiving relay to ground. This locking current of 30 milliamperes holds the west locking and sending relays on their right contacts and tends to move the receiving relay armature to the left. The effective current in the windings of the locking and sending relays is small compared with that in the lower winding of the receiving relay because of the shunting effect of resistance 12.

When the relays are all in their idle condition (on their right contacts) the start magnet circuit for the west to east distributor is short-circuited. This circuit extends from negative battery through the right contact and armature of the west receiving relay WRR, through the common ring 19, locking brush LB, start segment 7 of the locking distributor rings LD, through the start magnet 16 and back to negative battery through the armature and right contact of the east locking relay ELR.

*Repeating signals from west to east*

In start-stop telegraphy seven impulses are transmitted for each signal character. These comprise a first or starting impulse, which is commonly a spacing impulse, followed by five impulses which may be either marking or spacing and represent the signal character to be transmitted. These are followed by a seventh or last marking impulse which stops the distributor and is termed the stop impulse. For purposes of explanation it will be assumed that an "F" signal is to be repeated from the loop west into the loop east. The seven impulses of an "F" signal are the start, which is spacing, #1 marking, #2 spacing, #3 and #4 marking, #5 spacing and #6, the stop impulse, which is always a closed or marking impulse. Such a series of impulses is graphically represented at 20, the marking impulses being represented by values above the zero line and the spacing impulses as zero values of current. Thus the loop is normally closed but changes to open or spacing condition at time A when the start impulse is transmitted.

This start or open impulse removes the 60 milliampere current from the upper winding of the west receiving relay WRR and permits the 30 milliampere biasing current in the lower winding to move the armature to the left contact. This applies positive battery to the start magnet circuit which was previously traced and current flows from positive battery at the left contact of the west receiving relay through the contact and armature of the relay, through the common ring 19, locking brush LB and start segment 7 of the locking distributor rings LD, through the start magnet 16 to negative battery at the right contact of the east locking relay ELR. Start magnet 16 thereupon operates to raise the stop latch 17 and release the brush arm carrying the locking and sending brushes LB and SB.

Almost immediately after the locking brush leaves the start segment, the sending brush SB contacts with sending segment 7 which applies positive battery from segment 7, over sending brush SB, common ring 17, through resistances 22 and 23, the upper winding of the east locking relay ELR and the upper winding of the east sending relay ESR to ground. An electron flow from right to left therefore occurs through the upper windings of these two relays, overcomes the weak locking current and moves their armatures to their left contacts and opens the east loop at the east sending relay contacts. A condenser 24 is shunted around resistance 23 to improve the wave shape of the current transmitted therethrough and cause the relay to operate more quickly. These relays are now locked on their left contacts by current through the armature of the east locking relay ELR, through resistance 25, the paralleled lower or locking windings of the relays ELR and ESR, which are shunted by a resistance 26, through the biasing winding of the east receiving relay ERR to ground. As in the case of the west locking and sending relays, resistance 26 may have such a value as to limit the current in the lower windings of ELR and ESR to about 11 mil-

liamperes. It may be noted at this point that the current in the lower or biasing winding of the east receiving relay ERR is now in such a direction as to hold the armature on the right contact although the loop east circuit is open at the contacts of the east sending relay. At this time the start magnet is deenergized, as its circuit has been opened by the locking brush LB passing off the segment 7.

The brushes traverse the segments in approximate synchronism with the signal impulses from the loop west so by the time the locking brush LB reaches the #1 segment of the locking ring LD, the first impulse of the "F" signal, as shown at 20, has been received, and the west receiving relay armature is now on its right contact. When the locking brush makes contact with #1 segment of the locking ring LD, it completes a circuit from negative battery at the right contact and armature of the west receiving relay WRR, through the common ring 19, brush LB and segment 1 of the locking distributor LD, through a resistance 27 and thence to the left end of the lower or biasing winding of the west receiving relay WRR. The potential thus applied through resistance 27 to the left end of the biasing winding of WRR is opposite in polarity and of higher potential than the potential previously applied to this point from positive battery through the right contact and armature of the west locking relay WLR, resistance 11, the lower windings of WLR and WSR and resistance 12 in parallel. This change in potential causes a current of about 30 milliamperes to flow in the reverse direction through the biasing winding of the west receiving relay WRR which firmly locks the armature of the relay against its right contact. Regardless now of the electrical condition of the loop west due to distortion in the received signal, the receiving relay armature will remain on its marking contact as long as the locking brush is on segment #1 and while the locking brush LB is still on segment #1 the sending brush SB traverses its #1 segment. This completes a circuit from the west receiving relay armature through contact #1, brush SB and common ring 17 of the sending distributor rings SD, through resistances 22 and 23 and the upper windings of the east locking relay ELR and east sending relay ESR which moves the armatures of these relays to their right or marking positions and sends a marking impulse into the loop east as shown at "C" in curve 30. It will be seen that an impulse of the correct polarity must be sent from the west receiving relay WRR, through the east locking and sending relays ELR and ESR because the receiving relay armature is locked on its contact during the time the sending brush SB is contacting with sending segment 1 of the sending distributor SD.

The next impulse of the "F" signal, the #2 impulse, is an open or spacing impulse. Both the locking brush LB and the sending brush SB leave their #1 segments at the same time, although it would be permissible to so position the sending segments that SD leaves its segment ahead of SB. While the locking brush LB was on its #1 segment, the #2 (open) impulse of the "F" signal was received over the west loop as shown at "C" in curve 20. However, due to the fact that the receiving relay armature was locked while the locking brush LB was on its #1 segment, as explained above, the receiving relay armature could not leave its right or marking contact. Since this locking circuit is opened when the locking brush LB leaves segment #1, the west receiving relay WRR is thereafter under the control of the normal biasing current flowing from positive battery at the right contact of the west locking relay WLR through resistance 11 and the lower windings of the relays WLR and WSR and the resistance 12 in parallel. Since there is no current in the line winding at this time, the receiving relay armature is moved to its left contact by the normal 30 milliampere current from the above source in its lower or biasing winding. The east locking and sending relays ELR and ESR remain on their right contacts, however, as they are held by the 11 milliampere current in their locking windings, their operating windings being opened at this time at the segments of the sending distributor SD.

When the locking brush LB contacts with its #2 segment it once again completes the locking circuit from the armature of the west receiving relay WRR to the left end of its biasing winding, and since the armature of relay WRR is now in its left or spacing position and therefore connected to positive battery, the current applied through resistance 27 has the same polarity as that applied through the armature of the west locking relay WLR through resistance 11. The normal current of 30 milliamperes through the biasing winding of WRR is therefore increased to approximately 90 milliamperes, which holds the armature of the relay firmly against its left contact. If the loop west should close due to distortion while the locking brush LB is on the #2 segment, 60 milliamperes will flow in the operating winding of the west receiving relay tending to move its armature to its right contact. The armature will remain against its left contact, however, due to the 90 milliamperes in the biasing winding.

In the same way as was previously described, the sending brush SB crosses the sending segment #2 while the locking brush LB is still on the #2 locking segment. The correct impulse, (in this case a spacing impulse) is therefore sent from the west receiving relay armature through the #2 segment

and brush SB of the sending distributor SD to the operating windings of the east sending and locking relays, overcoming the 11 milliampere holding current in the windings of those relays and moving their armatures to the left or spacing contacts. The #2 impulse is thus repeated into the loop east at the armature and contact of the east sending relay ESR as shown at "D" in curve 30.

It has been assumed heretofore that the impulses were received undistorted substantially as they were transmitted, as shown in curve 20. Let its be assumed for purposes of illustration that the #3 and #4 impulses are distorted as they are received over the loop west. For instance, referring to curve 40, assume that nearly 50% of the first part of the #3 impulse has been wiped out and that nearly 50% of the latter part of #4 impulse has also been eliminated, possibly by some fortuitous interference on the lines. Thus, instead of a marking impulse extending from time "D" to time "F" as shown in curve 20, we would have a much shorter marking impulse as shown in curve 40 which begins a little less than half way between times "D" and "E" and ends only a little more than half way between times "E" and "F". It will be remembered that the distributor face is oriented with respect to the incoming signals so that the locking brushes LB just contact with the edge of a segment on the locking distributor LD as the exact center of an undistorted incoming impulse is being received. Thus referring to curve 20, it will be seen that the front edge of the #1 segment on the locking distributor LD is on a line with the center of the impulse received between times "B" and "C". Therefore, the west receiving relay armature will be moved to its marking contact by the incoming distorted #3 impulse just before the locking brush LB contacts with the #3 segment of the distributor LD. In contrast to this, it will be remembered that the #2 impulse had arrived in the receiving relay operating winding while the locking brush LB was still passing over the #1 locking segment. Due to the assumption of nearly 50% distortion in the #3 signal impulse, however, this impulse does not appear in the receiving relay operating winding until the locking brush leaves #2 segment and is about to contact with #3 segment.

Since the #3 impulse had moved the west receiving relay armature to the right or marking contact before the locking brush LB completed the locking circuit through the biasing winding of the relay, current of the correct polarity is applied to the operated windings of the east locking and sending relays ELR and ESR and the #3 impulse is correctly repeated into loop east.

While the locking brush is still on locking segment #3 the #4 impulse (which is also marking as shown in curve 20) is received in the operating winding of the receiving relay WRR. As stated above, it has been assumed that nearly 50% of the latter part of the #4 impulse has been cut off by fortuitous distortion but the locking brush LB makes contact with #4 locking segment just before the current in the loop west goes to zero, due to the latter half of the fourth impulse being eliminated as shown in curve 40. The receiving relay armature, therefore, remains on its marking contact in spite of the distortion as the locking circuit to the biasing winding of the receiving relay was completed by the locking brush LB closing on segment #4 before the receiving relay armature could move from its marking contact. Therefore, current of the correct polarity is applied to the operating windings of the east locking and sending relays ELR and ESR when the sending brush SB makes contact with #4 sending segment.

The #5 and #6 impulses are assumed to be perfect signals and they will be repeated in a normal way as were the #1 and #2 impulses.

The #6 impulse is always a marking impulse and is used to stop the brushes and set the relays in their normal position in preparation for the repeating of the next signal. The armature of the west receiving relay WRR is moved to its right or marking contact and the sending brushes connect the marking current to the operating windings of the east locking and sending relays, thus closing the loop east and connecting negative battery to the start magnet 16 at the armature and marking contact of the east locking relay ELR. The other end of the start magnet winding 16 is also connected to negative battery at the right or marking contact of the west receiving relay WRR through the locking brush LB and start segment 7 of the locking distributor LD. Therefore, the magnet does not operate until the next start impulse is received.

*Reversing direction of transmission*

Heretofore it has been assumed that the loop east was closed at the distant station through a source of current applying about 60 milliamperes through the loop to the operating winding of the east receiving relay ERR. This is the normal condition at the distant station while it is receiving. If while receiving, the distant operator wishes to signal the sending station, he opens the loop east. This opens the upper winding of the east receiving relay ERR, leaving the latter under the control of its biasing winding. The normal biasing current of 30 milliamperes from the right contact of the east locking relay ELR, through resistance 25 and the lower windings of relay ELR and ESR and resistance 26 in parallel thereupon moves the armature of the east receiving relay ERR to its left contact. This completes a circuit from

the left contact and armature of the east receiving relay ERR, through the common ring, locking brush, start segment and start magnet of the east to west distributor to positive battery at the armature and right contact of the west locking relay WLR and operates the start magnet on the east to west distributor in the same fashion outlined in detail above for the west to east distributor. The east to west distributor brush will thereupon move over its associated segments, and, since the loop cast is open, repeats only spacing impulses to the west sending relay WSR which operates and holds the armature of the latter relay in its left position and opens the loop west. After completing one revolution, the east to west brushes remain stopped because each end of the start magnet is connected to negative battery, at the left contacts of WLR and ERR, respectively. When the west operator notes that the loop west is opened, he knows that the east operator wishes to transmit to him and he closes the loop west through his receiving apparatus. Transmission of signals from the loop east to the loop west through the east to west distributor can then take place in the same manner as outlined in detail above in connection with transmission through the west to east distributor.

It should be noted that the armatures of the west receiving relay WRR and west locking relay WLR normally rest against contacts connected to battery of polarities opposite those of the contacts against which the armatures of the east receiving relay ERR and east locking relay ELR normally lie. This makes possible the transmission through the repeater of a break signal from the receiving station as just described and prevents the distributor brushes from revolving continuously when a break signal is transmitted.

*Summary*

The function of the different elements of the system may be briefly set forth as follows:

Each receiving relay responds to line signals received from its associated loop and repeats them through the sending segments of the associated distributor to the sending relay associated with the opposite loop.

The function of the sending relays is self-evident.

Each locking relay moves in unison with the associated sending relay and supplies current of the requisite polarity to lock the sending relay firmly on one contact or the other when the operating winding of the sending relay is not energized. It also controls the polarity of the potential applied to the return side of the start magnet circuit and prevents the brush arm from revolving continuously during a break or open signal from the associated loop. A third function is to control the polarity of the biasing current in the receiving relay and hold the armature against its right or marking contact when an open or "spacing" signal is transmitted from the corresponding sending relay.

The function of each pair of locking distributor rings is to furnish a path for the start impulse from the armature of the associated receiving relay to the start magnet, and thereafter, during the repeating of signals, to lock the receiving relay at the center of each received signal impulse to prevent distortion in the incoming signals from being retransmitted.

The function of each pair of sending distributor rings is to permit each receiving relay to control the opposite sending relay only while the receiving relay is locked in position by the locking distributor.

It is to be particularly noted that a locking brush should always be in contact with a locking segment while the associated sending brush is passing over a sending segment. In the system described it was found convenient to so orient the locking and sending segments that the locking and sending brushes left their segments substantially simultaneously. There would be no objection to moving the sending segments slightly to the left with respect to the locking segments but they should not be moved any farther to the right.

Where, in the claims, it is specified that the sending brush leaves its associated segment before the locking brush, it is to be understood that the difference may be so slight that the brushes leave their segments substantially simultaneously.

What is claimed is:

1. In a telegraph system, a source of signal impulses, distributing means, a receiving relay and a regenerating relay, said receiving relay having an armature movable between two contacts connected to sources of current of opposite polarity, and having an operating winding connected to said source of signal impulses and a locking winding connected through periodically closed contacts on said distributing means to the armature of said receiving relay, a winding on said regenerating relay connected through a different set of periodically closed contacts on said distributor to the armature of said receiving relay, said second contacts being adapted to close later than said first contacts but to open before the opening of said first contacts, whereby said receiving relay armature is locked in position during the time its armature is connected to the winding of the regenerating relay.

2. A system as defined in claim 1, characterized in this, that said distributor means comprises a rotary distributor in which the first named contacts comprise a common ring and a segmented ring and the second named contacts comprise a common ring and a segmented ring with segments shorter than those

of the first named segmented ring, with brushes associating each common ring with a segmented ring.

3. A system as defined in claim 1, in which said regenerating relay has an additional locking winding and has an additional locking relay having an armature operable between two contacts connected to sources of current of opposite polarity and an operating winding and a locking winding, the operating winding being connected in circuit with the operating winding of said regenerating relay and the locking winding being connected in circuit with the locking winding on the regenerating relay, the armature of the locking relay and the sources of current connected to the contacts of the locking relay.

4. In a start-stop telegraph system in which a start impulse of fixed characteristic followed by a plurality of impulses of varying characteristics are transmitted, a regenerative repeater comprising a receiving relay having a line winding and a locking winding, an armature operable to a spacing position and a marking position and contacting in each position with one of two contacts connected to sources of potential of opposite polarity, a rotary distributor having a brush adapted to pass over a plurality of segments in succession, the first of said segments being connected to a source of current of opposite polarity to that of the marking contact of said receiving relay and the remaining segments being connected to the armature of said relay, means for restraining said brush, and current responsive means connected between the armature of the receiving relay and the other pole of said source of current connected to the spacing contact of said relay for releasing said brush restraining means, a repeating relay having an operating winding connected between said brush and the other terminals of said sources of potential, a second brush on said distributor adapted to move in synchronism with the first brush and contact with a plurality of segments which are wider than said first segments, said second brush being connected to the armature of the receiving relay and the segments associated therewith being connected through the locking winding of said relay to the other terminals of said sources of potential, said second brush and associated segments being so oriented with respect to received impulses that the brush makes contact with each segment at the time when the center of an undistorted signal is received, and said first brush and associated segments being so oriented with respect to the second brush and segments that contact is made with each segment later than the time of initial contact between the second brush and a segment associated therewith but during the time of contact closure of the second brush.

5. In a half duplex, start-stop telegraph system, a regenerative repeater comprising two groups of relays and two rotary distributors for repeating signals in each direction, a locking, a sending and a receiving relay in each of said groups and locking and sending segmented rings on each distributor, means comprising the locking and sending relay in each group for locking the receiving relay in that group when signals are being transmitted to the associated line section, means comprising the locking segments on one of said distributors for locking the receiving relay momentarily at the center of each received signal when signals are being received from the associated line section, means comprising the sending segments on said distributor whereby said receiving relay controls the opposite sending relay during a portion of its locked period and means comprising the receiving and locking relay in each group for transmitting a break signal from the receiving section of the line to the transmitting section during transmission.

6. In a telegraph system, a source of signal impulses of unit length, a receiving circuit for reception and storing of incoming signal impulses and including a winding of a receiving relay, distributing means included in said circuit having a series of long segments, locking means included in said circuit adapted to cooperate with said long segments to fix successive conditions in said circuit determined by the signal character at the respective middle points of the unit length signals, an operating circuit including a regenerating relay having locking means, and other distributing means having a series of short segments and adapted to cause the operation of said regenerating relay in accordance with one of said fixed circuit conditions, said distributing means having contacting means for their respective segments whereby the operating circuit will be closed and again opened at each of said short segments entirely within the time during which the receiving circuits is completed over a corresponding long segment.

7. A method of regenerating telegraph signals comprising storing incoming signals in accordance with the character of each signal at a moment during its greatest stability, then initiating regenerated impulses and then separately storing said impulses in accordance with the character of said stored signals, the storing of an incoming signal being maintained until the storing of the corresponding regenerated impulse has been fully accomplished.

8. A method of repeating telegraph signals which comprises receiving an incoming signal of unit length, then storing said incoming signal in accordance with its character at some selected instant at about its mid-point, thereafter initiating and then

separately storing a regenerated impulse for retransmission of a character corresponding to the character of said stored signal, then discontinuing the storing of said stored signal, discontinuing the storing of said regenerated impulse when the next regenerated impulse is initiated, and transmitting said regenerated impulse of unit length.

In testimony whereof, I have signed my name to this specification this 8th day of June, 1928.

GILBERT S. VERNAM.