

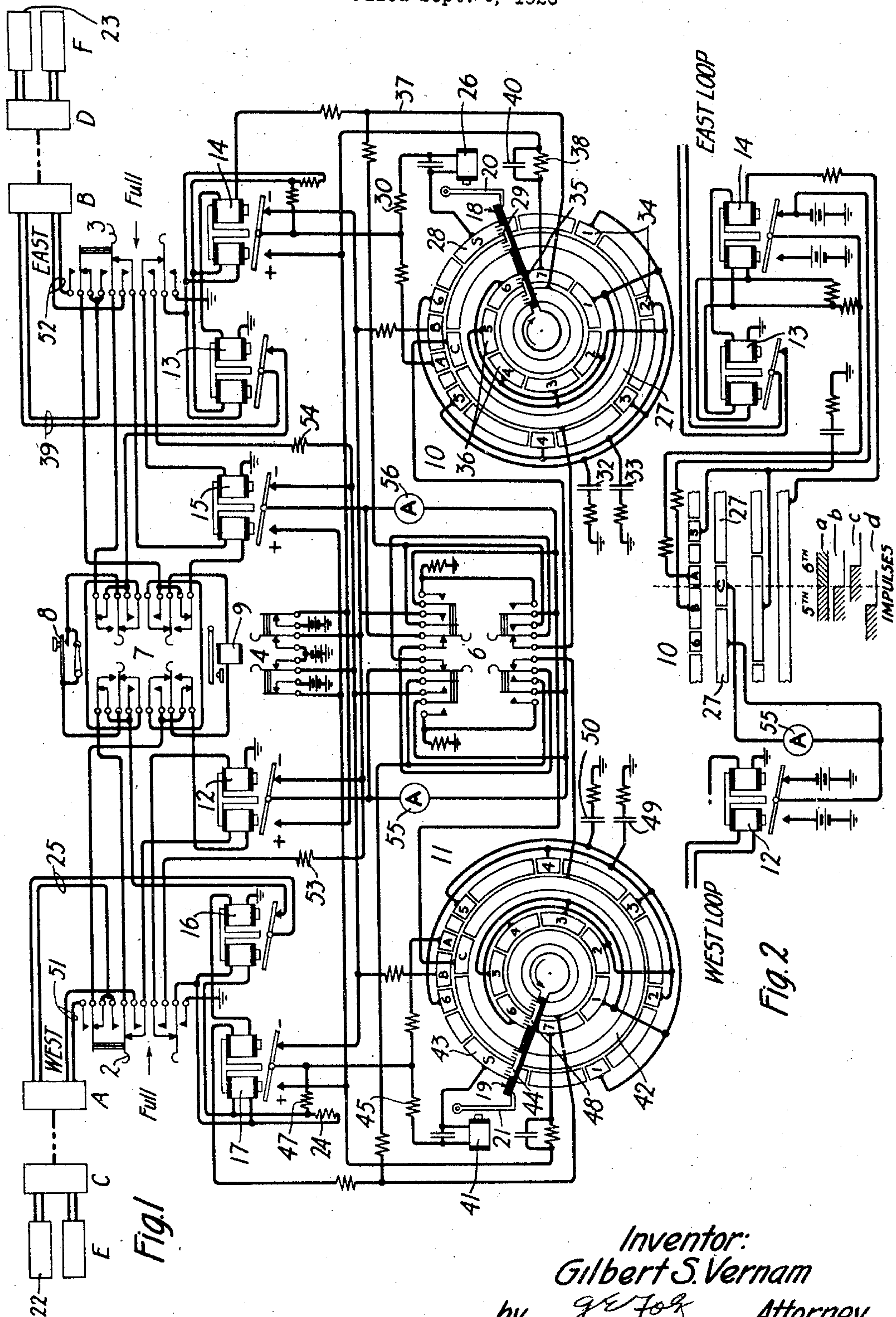
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G. S. VERNAM

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PRINTING TELEGRAPHY

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PRINTING TELEGRAPHY.

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This invention relates to transmission systems, and more particularly to telegraph systems adapted for start-stop printer service.

The object of this invention is to repeat and regenerate signaling current impulses free from all distortion at a point intermediate the ends of a long and complicated signaling line, so that the repeated signals will be as regular in form as those transmitted from the originating terminal.

Ordinary telegraph repeaters repeat all or part of the distortion in the signals from one line section to the next, with the result that the magnitude of such distortion tends to increase as sections are added to the line, thereby limiting the speed of operating over long circuits and increasing the attention required in operating such circuits. A properly designed regenerative repeater will eliminate this distortion and improve the signals received at the terminals of the line. Suitable use of such repeaters makes possible a substantial increase in the operating speeds over long and complicated circuit layouts. Heretofore, the type of repeater used for repeating and regenerating signal impulses to an adjoining line section, employed a system of relays which were arranged to receive a portion of each of the incoming impulses and to prepare in response thereto for transmission over an adjoining line section impulses of practically the same quality as those transmitted from the originating station. In this way, any distortion in the received impulses was corrected before the corresponding impulses were repeated over the adjoining line section. For a disclosure of a system where relays are so employed, reference may be had to Patent No. 1,512,070, granted to G. S. Vernam on October 21, 1924. There is also disclosed in that patent a method heretofore employed, whereby the operator at a receiving station may "break in" and stop the transmitting apparatus at the transmitting station by means of the line relay at the latter station.

According to the present invention the signal impulses received for correction at a station intermediate the ends of a conducting line, are repeated and regenerated for transmission to the terminating station by means of a system of condensers. In attaining the object by this particular method there is also developed a circuit arrangement whereby the

transmitting apparatus at the originating station may be stopped from the terminating, or receiving station, and maintained inoperative therefrom, through the energization of a holding winding on a locking relay located at the intermediary, or regenerative repeater station. The locking relay is further arranged to hold an unbiased armature of a sending relay firmly in the position in which it happens to be set; to check the rotation of the distributor brushes at the intermediary station when a stop, or break, signal is sent from the receiving station; and to lock the armature of a receiving relay associated with the receiving station, but located at the intermediary station, during the time in which signals are outgoing from the latter to the former station, so that it will not be affected by such signals. Furthermore, another advantage of this invention, resides in the arrangement wherein a milliammeter is utilized for indicating to a monitor at the intermediary station any faulty operation of the line and repeating and regenerating means.

Referring to the drawing:

Figure 1 shows diagrammatically the circuit arrangement of a regenerative repeater arranged for either half duplex or full duplex service between two terminal repeater stations A and B in a long and complicated line having several other terminal repeater stations such as C and D, respectively, connected in series. There are also shown diagrammatically the sending and receiving equipment at subscriber's stations E and F which are connected to terminal stations C and D, respectively.

Fig. 2 shows a portion of the circuit arrangement of Fig. 1, for repeating in one direction only, and portions of several incoming signals, under four different conditions, for operating the milliammeter to indicate a faulty condition in the operation of the line or repeater.

In Fig. 1 there are shown two loop circuits extending to each of terminal repeater stations A and B, which are provided for associating the respective sending and receiving apparatus thereat with the regenerative repeater. The loop circuits extending to terminal station A are referred to herein as the west loops and those extending to terminal station B are the east loops. When the re-

generative repeater is set for full duplex operation, both loop circuits extending to each station are put into service, but when half duplex operation is desired, one loop at each station is disconnected from the repeater by means of keys provided for this purpose and the loops then remaining in service are each utilized for both sending and receiving. Unlike the loops which connect the regenerative repeater station with the terminal repeater stations A and B, the lines interconnecting the terminal repeater stations, such as A with C and B with D, consists of a single wire as shown, but the subscribers' lines which are connected to the terminal repeater stations are loops such as described above for the regenerative repeater station. Double loops are employed for connecting each subscriber's station with a terminal repeater station in order that the subscriber may be furnished with full duplex service, in which case the sending and the receiving equipments are each operated over a different loop.

The repeater shown has five switching keys. Keys 2 and 3 are provided for the purpose of changing the service for stations E and F, respectively, to either half or full duplex operation, the repeater being set for half duplex service when these keys are in their normal positions as shown, and for full duplex service when they are in their operated positions. Key 4 is for disconnecting the battery supply from the repeater circuits. Key 6 is provided for the purpose of connecting the repeater for regenerative or relay operation, or cutting the repeater out altogether so that signaling impulses will not pass through, and this key is referred to herein as the control key. Key 7 connects a Morse telegraph set, represented in the drawing by sending key 8 and sounder 9, to either the east or west loops, and may be used by the operator in monitoring messages passing through the repeater station.

The repeater distributor, which is of the same general start-stop type as that used at printer sets and disclosed in Patent No. 1,311,915, granted to P. M. Rainey on August 5, 1919, is provided with two distributing discs 10 and 11, the former being arranged to regenerate impulses incoming over the west loops and outgoing over the east loops, and the latter for regenerating impulses in the opposite direction. This type of distributor has receiving segments which can be oriented with respect to the incoming signals so that only the central portion of each received signal unit is used to control the character or polarity of the corresponding retransmitted signal units, the duration of the outgoing signals depending on the spacing of the sending segments and the speed of rotation of the distributor brushes. It is obvious that, unless the incoming signals are so badly distorted that the central portion of some signal

units are of the wrong polarity, and unless the repeater apparatus is faulty, the signals will be repeated in perfect form. The repeater distributor must operate in synchronism with signals from the printer sets associated with it. This means that it must be governed to run at the normal operating speed of the circuit and it must be controlled by received "start" impulses. It must be arranged also to send out a "start" and a "stop" impulse properly timed with relation to the usual five selecting impulses. Cooperating with distributor disc 10 in transmitting impulses from station E to station F are receiving relay 12, sending relay 13 and locking relay 14, and with distributor disc 11 in transmitting impulses from station F to station E, the corresponding relays 15, 16 and 17 are similarly employed. These relays are of the polarized type and their respective functions in the operation of the repeater will be fully explained hereinafter. In the normal, or idle, condition of the repeater, brush arms 18 and 19 of the distributor are held against their respective latches 20 and 21 and the armatures of all relays are held against their marking contacts, as shown. The armatures of receiving relays 12 and 15 are held to marking by currents normally flowing in circuits extending through the left hand relay windings, over a west loop to station A and over an east loop to station B, respectively. In the right hand windings of these relays there are flowing simultaneously with the currents in the left hand, or operating, windings, but in the opposite direction and of about one-half strength, biasing currents, which become effective only when the circuits extending through the operating windings are open.

When the repeater is set for half-duplex operation (the condition shown in the drawing) the biasing current in relay 12 also flows through the left hand, or locking, windings of the locking relay 17 and sending relay 16, which are connected in parallel, and these windings are shunted by a resistance 24, so that the current passing through the windings is of just sufficient strength to hold the armatures of relays 16 and 17 to marking. The right hand, or biasing winding, of receiving relay 12 is reversed with respect to the locking windings of the sending relay 16 and locking relay 17, as will hereinafter be explained.

When the repeater is set for full duplex operation the circuit for the biasing current flowing through the right hand winding of relay 12, extends to the negative pole of battery at the inner right contact of switch 4, over the next to the lowermost off-normal contact of switch 2; and the circuit for the locking current flowing through the left hand, or locking, windings of relays 16 and 17 extends from the negative pole of battery at

the inner left contact of switch 4, to ground at the lowermost off-normal contact of switch 2.

The circuits including the corresponding windings of receiving relay 15, sending relay 13 and locking relay 14 are completed for both half and full duplex operation, in a similar manner to those described for relays 12, 16 and 17, and, therefore, no further description is deemed necessary.

In order to indicate any faulty condition which may exist in the operation of the line or the repeater, milliammeters 55 and 56 are provided, the former being arranged to indicate trouble which may occur in the line or repeater while repeating signals from the west to the east loop and the latter, while signals are being repeated in the opposite direction. These milliammeters which are operated by the regular printer signals so that the special signals usually required for testing, are eliminated, serve to check bias in the circuit as well as the speed and orientation of the distributing discs 10 and 11 of the repeater. They are also arranged to indicate whether or not the loops are closed and the current received is of the correct polarity.

Assuming that the repeater is set by keys 2 and 3 for half duplex operation and that the operator at station E desires to send a message through the repeater to station F, the signals will be received over west loop 25 by receiving relay 12 and retransmitted by the armature of sending relay 13 over east loop 39. Loop 25 being normally closed, the first open impulse will permit the biasing current to move the armature of relay 12 to its spacing contact, thereby energizing the start magnet 26 in a circuit traceable from the positive pole of battery at the outer right contact of switch 4, left contact and armature of relay 12, inner left contact of the upper spring set and inner right contact of the lower spring set of switch 6, receiving ring segments 27 and 28 interconnected by brush 29 in its normal position at distributing disc 10, through the winding of magnet 26, resistance 30, armature and right contact of relay 14 to the negative pole of battery at the inner right contact of switch 4. Magnet 26 operates and releases brush arm 18, which then rotates over the distributor segments in unison with the incoming signals from station A.

As brush 29 leaves segment 28, magnet 26 deenergizes and remains in this condition while the brush is passing over the short segments Nos. 1 to 6 of receiving ring 34 which may be oriented to pick up the central portion of each received signal unit. The receiving segments Nos. 1 to 6 of ring 34 are alternately connected to condensers 32 and 33 and as the brush crosses each segment in rotation, a charge is stored on the condenser to which the segment is connected, the polarity of the charge depending on which contact the ar-

mature of receiving relay 12 is on when the segment is crossed and the duration of a charge depending on the speed of brush arm 18 in rotating over the segments of a sending ring, hereinafter described. It is assumed herein that negative and positive charges correspond respectively to marking and spacing signals. The final closed "stop" impulse of each printer character moves the receiving relay armature to its marking contact, which connects the start magnet 26 to the negative pole of battery at the inner right contact of switch 4, and magnet 26 fails to reenergize when the brush arm 18 returns to its starting position because negative battery is connected to both ends of the magnet winding, thereby causing brush arm 18 to stop against its latch 20 until the next "open" or "start" impulse is received.

Simultaneously with the rotation of brush 29 over the receiving segments of ring 34 the transmitting brush 35 traverses the sending segments Nos. 1 to 7 of ring 36 to send out corresponding impulses, or signals, from the charged condensers 32 and 33, over conductor 37. The latter impulses are regenerated or retimed signals which, owing to the position of the various sending segments with respect to the receiving segments, are slightly delayed in passing through the repeater, so that each signal unit is sent out while the next following signal unit is being received. This delay, however, is of no consequence as regards the quality of the outgoing signals.

When brush 35 crosses segment No. 7 of ring 36, a circuit is completed from the positive pole of battery at the outer right contact of switch 4, through resistance 38, over conductor 37, through the right hand, or operating, windings of the locking relay 14 and sending relay 13 to ground. The current in these windings overcomes the locking current in the left hand windings, connected in parallel, of relays 14 and 13, as hereinbefore described in connection with the opposing currents in relays 16 and 17. This locking current is of the same strength as that in the locking windings of relays 16 and 17. The armatures of relays 14 and 13 are, therefore, moved to their spacing contacts and the operation of relay 14 causes a "start" impulse to be sent over loop 39 through terminal stations B and D in series to the receiving equipment 23 at station F. Condenser 40 shunted across the resistance 38 in the circuit of segment No. 7 of the sending ring 36, just traced, causes the current to build up rapidly in the windings of the relays, thereby increasing the speed of operation.

As the sending brush 35 crosses the remaining segments the storing condensers 32 and 33 will discharge alternately through the operating windings of relays 14 and 13. The direction of the current will depend on the

polarity of the charges on the condensers. It is evident that the character of each signal unit sent out will depend on the corresponding unit as received, but the duration of each unit sent will depend only on the speed of the brush and the spacing of the sending segments. Locking relay 14 and sending relay 13 operate together, the latter relay opening and closing the east loop to send the signals into loop 39 to station B. When the sending and locking relays change to spacing, loop 39 is open at the sending relay contacts, thereby checking the comparatively high current in the left hand, or operating, winding of receiving relay 15 and permitting the biasing current in the right hand winding which is now reversed by the moving of the armature of locking relay 14 to its spacing contact, to hold the armature of relay 15 on its marking contact. Therefore, signals sent out by the repeater will not affect the receiving relay armature, which will remain against its marking contact when the loop is opened or closed by the sending relay.

The No. 6 impulse in the printer code used herein is assumed to be marking, and in order to repeat "break" signals from station E to station F properly, it is necessary to control the outgoing sixth impulse from the incoming signals. If the No. 6 sending segment was connected permanently to marking battery the start magnet 26 would be operated, and a single marking impulse would be sent out over east loop 39 for every revolution of brush arm 18 as long as the west loop 25 is held open for the break signal.

In the case of a "break" signal being sent from station F over east loop 39, start magnet 41 at distributing disc 11 operates in a circuit traceable from the positive pole of battery at the outer left contact of switch 4, left contact and armature of receiving relay 15, inner right contact of the upper spring set and inner left contact of the lower spring set of switch 6, receiving segments 42 and 43 bridged by brush 44, through the winding of magnet 41, resistance 45, armature and right contact of relay 17, to the negative pole of battery at the inner left contact of switch 4. The operation of magnet 41 releases brush arm 19 which now rotates over the receiving and sending segments of distributing disc 11 in a manner similar to that described above in transmitting from station E to station F, to send spacing impulses through sending relay 16, thereby opening the west loop 25. The brush arm stops at the end of one revolution as both ends of the winding of start magnet 41 are connected to positive battery in a circuit which may be traced from the outer left contact of switch 4, left contact and armature of relay 17, resistance 45, through the winding of magnet 41, segments 43 and 42 bridged by brush 44, inner left contact of the lower spring set and inner right

contact of the upper spring set of switch 6, armature and left contact of relay 15, to the starting point at switch 4. However, the loop 25 remains open due to the fact that the locking relay 17 is locked to spacing, thereby holding the sending relay 16 to spacing. The locking circuit may be traced from the positive pole of battery at the outer left contact of switch 4, left contact and armature of relay 17, resistance 47, through the left hand windings, in parallel, of relays 17 and 16, lower normal contact of duplex key 2, through the right hand winding of relay 12 to ground. An "open" or spacing, signal is thus sent out over loop 25 to indicate a "break" to the operator at station E, and as long as sending relay 16 is held open no signaling impulses can be sent from station E. When east loop 39 is closed at the end of the "break" signal, magnet 41 again operates and releases the brush arm 19 for one more revolution, the east loop 25 being closed when the sending brush 48 crosses sending segment No. 1. The circuit for reenergizing magnet 41 may be traced from the negative pole of battery at the inner left contact of switch 4, right contact and armature of relay 15, inner right contact of upper spring set and inner left contact of lower spring set of switch 6, segments 42 and 43 interconnected by brush 44, through the winding of magnet 41, armature and left contact of relay 17 to the positive pole of battery at the outer left contact of switch 4.

The use of the locking relay in the repeater circuit may be summarized as follows:

1. It controls the polarity of the weak holding, or locking, current through its own left hand winding and that of the sending relay. This current holds the armature of the sending relay firmly in either of its two positions during the intervals between the condenser discharges and this function is particularly important in this invention inasmuch as the sending relay employed herein has an unbiased armature.
2. It controls the polarity of the current applied to one side of the start magnet circuit. If the start magnet was connected directly to negative battery instead of being connected to the armature of the locking relay, the brush arm would rotate continuously during a break signal and in the event that the loop circuit should close at the termination of the "break" signal at a time after the brush had crossed the No. 6 receiving segment and before the brush arm had reached the "start" latch, the brush arm would stop and the loop on the outgoing side would be left open even though the incoming loop is closed. This is because of the fact that the condenser receives a positive charge when the brush crosses the No. 6 segment if the outgoing loop is open at this time, and the condenser discharge will operate the sending re-

lay to the spacing side. With the start magnet connected to the locking relay, the brush arm makes one revolution at the beginning and another at the end of the break signal, and therefore avoids the continuous rotation during the interval of the "break" signal.

3. When the repeater is arranged for half-duplex service, the locking relay also controls the biasing current which flows in the right hand winding of the receiving relay. When the locking relay armature is against its marking, or right hand, contact, the biasing current in the receiving relay opposes the loop, or operating, current and the receiving relay will operate in response to incoming signals; but when the locking relay armature is against its spacing, or left hand, contact, the biasing current is reversed in the receiving relay to hold the armature against its marking contact even though the loop circuit is open at the contact of the sending relay.

In repeating signals from station F to station E the action is similar to that described above, except that the signals are repeated by receiving relay 15, through the distributing disc 11, storing condensers 49 and 50, sending relay 16 and locking relay 17.

If it is desired to set the repeater for full duplex operation, the keys 2 and 3 are moved to their alternate positions, and the operating windings of the receiving relays 12 and 15 are thereby connected to the receiving loops 51 and 52, respectively, and the contacts of the sending relays 16 and 13 are connected to their respective sending loops 25 and 39. At the same time the biasing windings of the receiving relays are connected directly to battery through resistances 53 and 54, respectively, and the locking windings of each pair of sending and locking relays are connected to ground so that the receiving and sending relays on each side of the repeater can act independently. The two sides of the repeater can then operate entirely independently of each other to repeat signals in both directions at the same time.

As hereinbefore stated, the control key 6 is designed to perform three operations, namely, to connect the repeater for regenerative or relay operation, or to cut the repeater out altogether. When the key is in its normal position, as shown, the repeater is connected as a regenerative repeater. In its "down" position the key connects the repeater for relay operation and the receiving relay on one side directly operates the locking and sending relays on the opposite side of the repeater so that signals are repeated without being regenerated by the distributor and storing condensers, thereby permitting the repeater to be used for repeating Morse signals or printer signals without regeneration. In its "up" position the key performs the operation of cutting the repeater so that no signals can be

sent through it, inasmuch as the circuits including the armatures of the receiving relays are opened and the marking battery is connected through the windings of the sending and locking relays to hold their armatures on their marking contacts. This last operation is provided so that circuits on either side of the repeater can be lined up independently without disconnecting the repeater and any loop or line troubles may be more readily traced.

The monitoring key 7 is arranged to connect the Morse telegraph set to either the west or east loop circuits for communication purposes and for monitoring signals passing through the repeater. This key connects the sounder 9 in series with the receiving relay winding and the telegraph key 8 in series with the sending relay contacts on that side of the repeater to which the key is thrown. When the repeater is operating half duplex, throwing the monitoring key to its right or left position will connect the key and sounder in series with the east or west sending loop, respectively. When the repeater is operating full duplex, the monitoring key will connect the telegraph key in the sending loop and the sounder in the receiving loop, so that the sounder will respond to incoming but not outgoing signals. The monitoring key contacts are so arranged that its operation does not even momentarily open the loop circuits or interfere with signals passing through the repeater. In the normal position of the monitoring key, the telegraph key and sounder are disconnected.

Inasmuch as the keys do not form any part of the invention, a detailed description of their operation and the circuits affected thereby is not deemed necessary.

The milliammeters 55 and 56 which are provided for the purpose of indicating bias in the line and faulty operation of the repeater distributor, are so connected that when the control key 6 is in its normal or regenerative position, as shown in the drawing, they are each connected on one side to segment C of their respectively associated distributing discs 10 and 11 and on the other side to the receiving relays 12 and 15 respectively.

In Fig. 2 there is shown that portion of the repeater circuit which is arranged for repeating signals from the west to the east loop, and also portions of several incoming signals in their positions relative to the distributor segments when the orientation is properly set. Milliammeter 55 is shown connected on one side to the armature of receiving relay 12 and on the other side to segment C of the receiving rings of disc 10. The receiving and sending rings of disc 10 are shown in this figure as developed for the purpose of showing the relation of the segments to the portions of the several incoming signals selected for illustration. The signals selected show

only the fifth and sixth impulses and these are shown under four different conditions, namely "a", "b", "c" and "d", in order to give a full explanation of the operation of the milliammeter 55.

Under condition "a" the fifth impulse is shown as "marking" and inasmuch as the sixth impulse, as hereinbefore assumed is always marking except during a "break signal", the meter 55 will not indicate because the armatures of the receiving relay 12 and locking relay 14 will both be against their marking contact during the time the brush 29 is passing over segments A, B and C and the meter will have both of its terminals connected to negative battery. However, in about half of the received printer signals the fifth impulse is "spacing" and when it is, the meter needle will deflect to one side or the other if there is distortion in the signals or improper adjustment of the repeater as will be explained below.

In condition "b" is shown a perfect signal with the fifth impulse as "spacing". For the duration of the fifth impulse the armatures of the receiving relay 12 and locking relay 14 are on their spacing contacts. Segment A and meter 55 are connected to positive battery and while the brush is crossing segment A there will be no current flow through the meter and therefore no indication. Segment B has negative battery connected to it permanently, and since the condition is assumed to represent a perfect signal the armature of receiving relay 12 moves to its negative, or marking, contact just as the brush meets segment B, the edge of which is arranged to be exactly half way between the fifth and sixth receiving segments. The meter then has both of its terminals connected to negative battery and therefore there is no indication of current.

If there is marking bias in the signals the sixth impulse is lengthened as shown in condition "c". In such a case the armature of receiving relay 12 will be moved to its marking contact while the brush is still on segment A. Segment A will be connected to positive battery while the meter is connected to negative and the current will flow through the meter while the brush is crossing segment A. The direction of this current is such that it will deflect the meter needle to its marking or right hand side. The duration of the current and, therefore, the amount of the deflection will be approximately proportional to the amount of distortion. As soon as the brush comes in contact with segment B the meter needle will return to zero as both terminals of the meter are connected to negative battery.

In condition "d" the signals are shown as having spacing bias and in this case the fifth impulse is lengthened to such an extent that the armature of receiving relay 12 is moved

to connect positive battery to the meter while the brush is starting over segment B. Current now flows in the meter circuit thereby causing the needle to deflect to the left indicating a spacing bias.

When the repeater and its circuits are operating in their normal condition the meters will frequently deflect slightly to the right and the left about equally often in each direction, as the result of distortion in the signals. But if the meter deflection is more frequently to one side than to the other, it may indicate trouble as follows:

To the left: The line circuit is biased to spacing, or the sending station distributor speed is slow, or the repeater distributor speed is fast, or the distributor disc is oriented too far in the direction contrary to brush rotation.

To the right: The line circuit is biased to marking, or the sending station distributor speed is fast, or the repeater distributor speed is slow, or the distributor disc is oriented too far in the direction of brush rotation.

As stated above, the meters may indicate bias in the signals, incorrect speed, or faulty adjustment of the orientation. It is obvious, however, that in order to have the meters indicate one trouble it must be known that the others are not present. For instance, if the repeater is connected in a local circuit with a monitoring printer, not shown, and if the repeater and printer speeds have been set exactly the same, and if all the relays have been properly adjusted so that there is no appreciable bias, the meter will indicate improper adjustment of the orientation. The repeater is then checked and adjusted for orientation in a manner well known in the art and returned to its operating circuit. With all sending station speeds checked accurately any deflection of the meter needle will indicate bias which may be present in the circuit. If the line is checked and found to be without bias and the orientation of the repeater is set correctly, incorrect speed of the repeater distributor or sending station distributor will now be indicated.

When control key 6 is operated up or down, cutting the repeater or connecting the repeater as a relay repeater, each meter is connected from the corresponding receiving relay armature through the outer upper contacts of key 6 to ground. In this position the meter will follow the signals received by the receiving relay.

To determine whether the loops are closed and the current therein of the correct polarity, control key 6 should be operated to its "up" position thus cutting the repeater and separating the loops. When the loops are closed and poled correctly the meters will deflect to the right. If one meter deflects to the left the loop associated with that meter is either reversed or is open. In this case the moni-

toring key 7 may be operated to connect the sounder 9 in series with the reverse or open loop. If the sounder operates, the loop is reversed; if not, the loop is open. When the
 5 repeater is set for full duplex operation, the meters and sounder will test the condition of the receiving loops, and when set for half duplex service they will test the sending loops.

10 In case of line failure, control key 6 would be operated to its "up" position to cut the repeater from the line and the meter associated with the line section in which the failure occurred, would then indicate the di-
 15 rection of the trouble.

It will be seen, therefore, from the foregoing description that the use of condensers in conjunction with the receiving and the sending segments on the repeater distributor, for
 20 the purpose of repeating and regenerating signal impulses to a distant station furnishes an economical as well as a novel arrangement. This arrangement is such that it may be readily adapted for use with carrier chan-
 25 nels or even as a link in radio transmission. Furthermore, the arrangement permits the use of milliammeters for checking the bias in the incoming signals as well as the speed of the distributor brushes and the orientation of
 30 the distributor discs.

What is claimed is:

1. In a telegraph system adapted for transmission alternately in each direction, two line sections, an intermittently operated timing
 25 device, means for operating said device under the direct control of both sections to receive, regenerate, and repeat signal impulses from one section to the other section when the other section is in a receptive condition and for
 40 retaining said device in normal position when the said other section is not in a receptive condition.

2. In a start-stop telegraph system, a regenerative repeater and two telegraph loops
 45 connected thereto, said loops being normally closed when receiving impulses and adapted to be alternately opened and closed to transmit signal impulses and to be opened for a long period to transmit a break signal, said
 50 repeater comprising intermittently operated timing devices for receiving and repeating signal impulses from one loop to the other, and means responsive to a break signal from either loop for maintaining said devices in
 55 normal condition and opening the other loop.

3. In a signaling system, a signaling line divided into sections, relaying apparatus in-
 60 terposed between adjacent sections comprising an intermittently operated timing device, electrostatic means for storing impulses transmitted over one of said line sections through
 65 said timing device, means on said intermittently operating timing device for transmitting the stored impulses over an adjoining line section, and means controlled from both

of said lines sections for maintaining said timing device in its normal position.

4. In a signaling system, a signaling line divided into sections, relaying apparatus in-
 70 terposed between adjacent sections comprising a source of energy, means for producing impulses from said source corresponding to those incoming over one of said line sections, an intermittently rotating distributor for
 75 receiving said corresponding impulses, a plurality of capacity elements connected to said distributor and each arranged to receive certain of said impulses, means at said distributor for discharging said elements to
 80 effect the regeneration of said corresponding impulses for transmission over an adjoining line section and means operated from the receiving section of said signaling line for
 85 stopping the operation of said repeating and regenerating apparatus and maintaining said apparatus in normal condition.

5. In a signaling system, a signaling line divided into sections, a relaying apparatus
 90 interposed between adjacent sections comprising receiving and transmitting distributing mechanisms, a plurality of electromagnets for each of said mechanisms, and means associated with said electromagnets and operated
 95 from one of said adjacent line sections for controlling the operation of said mechanisms while one of said mechanisms is under the control of the other of said adjacent line sections.

6. In a telegraph system, a signaling line divided into sections, relaying apparatus in-
 100 terposed between adjacent sections comprising receiving and transmitting distributing mechanisms, a group of relays for each of said mechanisms, and means in each of said groups controlled from either of said line sections for
 105 maintaining said mechanisms in their normal positions.

7. In combination, a signaling line divided into sections, repeating and regenerating ap-
 110 paratus interposed between adjacent sections comprising receiving and transmitting mechanisms, a group of relays for each of said mechanisms, a pair of condensers connected to each of said mechanisms, each condenser of
 115 said pair being arranged to be alternately charged in response to impulses repeated from one line section and alternately discharged through its associated distributing mechanism to effect the regeneration of the repeated im-
 120 pulses over an adjoining line section, and means in each of said relay groups operated from the receiving section of said signaling line for stopping the operation of said re-
 125 peating and regenerating apparatus and maintaining said apparatus in normal condition.

8. In a telegraph system, a signaling line divided into sections and adapted for either
 130 half or full duplex operation, repeating and regenerating apparatus interposed between

adjacent sections comprising a pair of distributing mechanisms, each adapted to receive and transmit impulses and both arranged to operate either singularly or simultaneously, a group of relays for each of said mechanisms, a pair of condensers connected to each of said mechanisms, each condenser of each of said pairs being arranged to be alternately charged in response to impulses received for repeating from one line section and alternately discharged through its associated distributing mechanisms to effect a regeneration of the repeated impulses for an adjoining line section, and means in said relay groups operated from the receiving section of said signaling line for stopping the operation of said repeating and regenerating apparatus and for maintaining said apparatus in their normal positions.

9. In a signaling system, a signaling line divided into sections, relaying apparatus interposed between adjacent sections, and common means associated with said relaying apparatus for indicating bias in the polarity of incoming signals and faulty operation of said apparatus.

10. In a signaling system, a signaling line divided into sections, a sending and a receiving subscriber's station, relaying apparatus comprising a rotary distributor interposed between adjacent sections and arranged to interconnect said subscriber's stations, a rotary distributor at each of said stations, and means forming a part of said relaying apparatus and comprising a meter for indicating a difference in the speeds of the sending and the relaying distributor.

11. In a signaling system, a signaling line divided into sections, relaying apparatus interposed between adjacent sections, and means in said apparatus comprising a meter for indicating bias in the polarity of incoming signals and failure of the incoming line section.

12. In a signaling system, a signaling line divided into sections, relaying apparatus interposed between adjacent sections, a rotary distributor forming a part of said apparatus and comprising a disc and an adjusting member attached to said disc, and means comprising a meter for indicating improper adjustment of the orientation of said disc and adjusting member.

13. In a telegraph system, a signaling line divided into sections, a sending and a receiving subscriber's station, a rotary distributor at each of said stations, repeating and regenerating apparatus interposed between adjacent sections, comprising a rotary distributor, and means associated with said apparatus comprising a meter for indicating bias

in the polarity of the incoming signals, a difference in speeds of the distributors at said sending station and in said apparatus, a failure in the incoming line section, and faulty adjustment of the orientation of the distributor associated with said apparatus.

14. In a telegraph system, a signaling line divided into sections and adapted for either half or full duplex operation, repeating and regenerating apparatus interposed between adjacent sections comprising a pair of distributor mechanisms each adapted to receive and transmit impulses and both arranged to operate either singly or simultaneously, and means associated with each of said mechanisms comprising a meter for indicating bias in the polarity of the signals received in its associated mechanism, a difference of speeds between incoming and outgoing signals, a failure in the incoming line section, and the faulty adjustment of the orientation of its associated mechanism.

15. In a telegraph system, a signaling line divided into sections, a sending and a receiving subscriber's station, a rotary distributor at each of said stations, repeating and regenerating apparatus interposed between adjacent sections, comprising a rotary distributor, and means associated with said apparatus comprising a meter, responsive to the regular printer signals, for indicating bias in the polarity of the incoming signals, a difference in speeds of the distributors at said sending station and in said apparatus, a failure in the incoming line section, and faulty adjustment of the orientation of the distributor associated with said apparatus.

16. In a signaling system a signaling line divided into sections, repeater stations interconnecting adjacent sections, regenerative apparatus located at a point in said line intermediate said repeater stations said apparatus comprising two groups of relays and a rotary distributor for regenerating and repeating signals over said line, a locking, a sending, and a receiving relay in each of said groups, and means comprising said locking relay arranged to hold said sending relay firmly in the position in which it happens to be set to check the rotation of said distributor when a break signal is sent from the receiving end of said line, and to lock said receiving relay when said sending relay is transmitting signals to the receiving end of said line.

In testimony whereof, I have signed my name to this specification this 3rd day of September, 1926.

GILBERT S. VERNAM.