

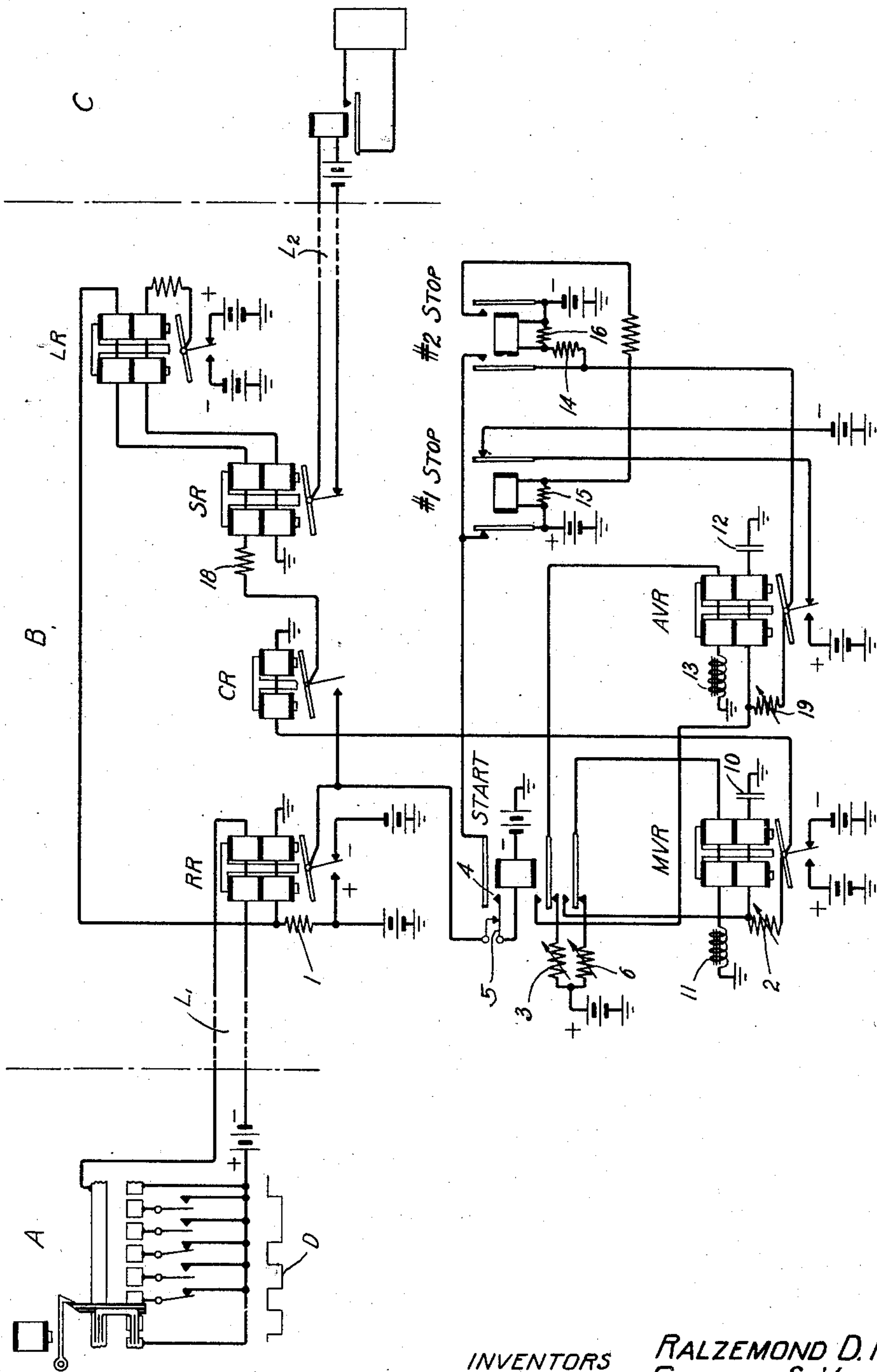
July 29, 1930.

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1,771,445

REGENERATIVE TELEGRAPH REPEATER

Filed June 9, 1928



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REGENERATIVE TELEGRAPH REPEATER

Application filed June 9, 1928. Serial No. 284,240.

This invention relates to start-stop printing telegraph systems and more particularly to regenerative repeaters for use in such systems.

5 The primary object of the invention is to reduce the expense of regenerative repeaters for use in start-stop printing telegraph systems. A more specific object is to regenerate and repeat start-stop telegraph signals without the use of the usual rotary distributor equipment.

10 A feature of the invention is a start-stop regenerative repeater having, in lieu of a rotary distributor, a vibrating relay for timing individual signal impulses, and a second, slower speed vibrating relay for stopping the first vibrating relay at the end of each series of impulses comprising a signal character.

15 In telegraphing over long conductors, particularly conductors exposed to interference from such sources as induction from neighboring conductors, earth currents, etc., the signals become distorted from their original shape, the effect of the interference usually being to shorten spacing impulses and lengthen marking impulses, or vice versa. Ordinary repeating relays do not correct for such distortion but merely increase the amplitude of the distorted impulses. It therefore becomes necessary to insert in long telegraph lines, at one or more intermediate points, regenerative repeaters which receive and completely reconstruct distorted signal impulses for retransmission. Hitherto it has been the practice in start-stop telegraphy to use at the regenerating point a rotary distributor of the same general character as those used at the terminal stations. Vernam Patent 1,512,070, October 21, 1924, discloses such a system. Rotary distributors have the disadvantage that they are expensive to install and maintain. As a substitute for rotary distributors, vibrating reeds have been suggested for regenerating and repeating synchronous telegraph signals of a more or less

continuous nature, such as for instance the signals in multiplex systems. Rainey Patent 1,530,514, March 24, 1925, discloses such a system for repeating synchronous signals. Such systems do not appear to be adapted for start-stop signalling, however, because no means has been developed for rapidly starting and stopping the vibrating reeds at the proper time.

55 In accordance with this invention a vibrating relay is used, instead of a rotary distributor or a vibrating reed to time the signal impulses. A vibrating relay is suitable for use in start-stop telegraphy because its amplitude of vibration is fixed and its frequency is dependent chiefly on the electrical characteristics of the operating circuits. Hence it may commence vibrating at its normal frequency shortly after its operating circuit is closed.

60 Since in start-stop telegraphy each signal character comprises a start impulse followed by five signal impulses and a stop impulse, means must be provided for stopping the vibrating relay at the end of each series of 7 impulses. In the system herein disclosed this result is achieved by having a second, slow speed, vibrating relay, which completes one cycle while the first vibrating relay is completing 7 cycles, to open the operating circuit of the first relay at the end of the signal character.

General circuit description

80 Referring to the drawing, a start-stop telegraph system is shown comprising a transmitting station A, a repeating station B and a receiving station C. The apparatus at the terminal stations A and C has been shown in a simplified schematic form. Thus at station A are shown only the common ring and the segments of the sending face of a start-stop distributor, connected in series with the transmitter contacts and a source of current to the line L₁ extending to station 90

B. Each time the distributor brush is released and moves over the segments it transmits to the line a spacing or starting impulse, followed by five signal impulses which may be either spacing or marking impulses dependent on the positions of the transmitter contacts, and finally, a closed or marking impulse which serves to stop the receiving distributor. The transmitting brush is, as shown in the drawing, normally held on the stop segment. With the transmitter contacts in the positions shown, a series of impulses corresponding to curve D will be transmitted to station B when the distributor brush is released and moves over the segments.

The apparatus at station C would in practice be a start-stop receiver of conventional type, but since it is not a part of this invention it is shown merely as a source of current connected in series with a receiving relay to the line L_2 extending from station B.

The lines L_1 and L_2 are shown in the drawing as two-wire lines, or loops. It should be understood, however, that the invention is not limited to lines of this type. In practice the stations A and C would ordinarily be at a considerable distance from the repeater station B and the lines L_1 and L_2 would be of considerable length and might include intermediate repeaters and sections of circuit over which telegraph signals are transmitted by any of the well-known means, such as the polar duplex circuits, carrier current channels, or radio channels. The method of substituting any of these means for transmitting telegraph signals for the lines L_1 and L_2 is obvious to persons skilled in the telegraph art.

It should also be understood that, although the drawing shows means for transmitting signals in only one direction, by duplicating the apparatus shown, signals could readily be repeated in the opposite direction, i. e., signals starting from station C could be repeated and received at station A. In such cases, it is obviously necessary to equip lines L_1 and L_2 at station B with balanced circuits or other well-known means for preventing the outgoing signals from one side of the repeater from being repeated back through the other side of the repeater.

Of the apparatus at the repeating station B a receiving relay RR, having an operating winding and a biasing winding, has its operating winding connected directly to the line circuit L_1 extending from station A. It serves to repeat incoming signals from station A through the armature and contact of a control relay CR to the operating winding of a sending relay SR which repeats the signals into the line L_2 extending to station C. A start relay "Start" has a winding normally connected between a source of negative current and the armature of the receiving relay

RR and is energized on the first operation of the receiving relay to start a main vibrating relay MVR and an auxiliary vibrating relay AVR into operation. The stopping of these vibrating relays is controlled by two stop relays, "#1 stop" and "#2 stop." A locking relay LR operates in unison with the sending relay SR and serves to lock the sending relay firmly in the position to which it has been moved under the control of the receiving relay.

The vibrating relays MVR and AVR are high speed polar relays each of which has associated therewith a condenser and an inductance element whereby it vibrates continuously, in response to current received from sources of current of opposite polarities connected to its contacts, at a frequency determined by the capacity and inductance of its operating circuits. The operation of the polar relays in the system may be easily followed by bearing in mind that the relays have been shown in the drawing in such a manner that an electron flow from left to right in a winding of any polar relay tends to move the armature to the right, and vice versa when the electron flow is in the opposite direction.

The operation of the system may be most effectively explained by considering first the actual regeneration of signals under the control of the main vibrating relay and then the functioning of the starting, stopping, and auxiliary vibrating relays in starting and stopping the main vibrating relay at the beginning and end of each signal character.

Function of main vibrating relay

During the actual repeating of a signal the two operating windings of the main vibrating relay MVR are connected in multiple through the lower armature and front contact of the start relay (which is energized) and are energized by current received over the contacts and armature of the relay MVR through resistance 2. This current is so regulated by condenser 10 and inductance 11 that the relay MVR vibrates at twice the dot frequency of the incoming signal. That is, the armature completes one cycle of operation during the time required for the sending brush at station A to pass over one segment. The armature of relay MVR is also connected to the winding of the control relay CR so that the latter vibrates in unison with MVR. When the armature of MVR lies against its right contact, current flows from negative battery through the contact and armature of MVR through the winding of the control relay CR to ground. This results in an electron flow to the right through the winding of CR which holds the armature against its right or open contact. This is the normal stop position of the control relay. When the armature of MVR lies against its left contact, current flows through the winding of

CR in the opposite direction and moves the armature to the left.

Assume that an incoming open or spacing signal, operates the armature of the receiving relay RR to its positive contact. This has no immediate effect on the sending relay SR because the operating circuit of the latter is open at the contact of the control relay CR. The control relay armature operates in unison with the main vibrating relay MVR, however, and approximately a half cycle later makes contact with its right contact in synchronism with the incoming signals and about at the center of the impulse. By adjusting orienting resistance 6 the best phase relation may be chosen as will be explained below. While the armature of the control relay CR is against its left contact, a circuit is closed from positive battery at the left contact and armature of the receiving relay RR, through the contact and armature of the control relay CR, resistance 18, the operating windings of the sending and locking relays SR and LR in series and back through the biasing winding of the receiving relay RR to ground. Resistance 18 has such a value as to limit the current to about 60 milliamperes. This not only operates the sending and locking relays but the additional current through the biasing winding of the receiving relay RR locks the armature of that relay firmly against its left contact and keeps it from moving under the control of any distorting currents which might be received over the line circuit while the armature of the control relay CR remains on its closed contact. The locking relay LR locks its own armature and that of the sending relay SR and prevents any further movement of the armatures of those relays while the armature of the control relay CR is on its open contact. The sending relay SR repeats signals into line L_2 by opening and closing the line at its armature and contact.

The operation of the relays RR, SR and LR is the converse of that outlined above when a closed or marking impulse is received from station A. In the latter case the locking current in the biasing winding of the receiving relay RR opposes the normal biasing current received through resistance 1. Resistance 18, in the locking circuit, is lower in value than resistance 1 and permits a larger current to flow so that a resultant locking current flows in the biasing winding of RR in such a direction as to insure that the armature of the relay will be held fast against its right contact, despite distortion in the received signal, as long as the armature of the control relay CR remains against its left contact.

It will be seen from the above description that in order to obtain signals of the correct polarity and length from the sending relay it is only necessary that the receiving relay armature be on the proper contact when the control relay armature closes on its contact,

and that if the control relay armature closes on its left contact at the time when the center of an incoming signal impulse arrives, the signals transmitted by the sending relay will be entirely free from distortion so long as the signals incoming to the receiving relay have their centers intact, in other words, so long as the line distortion does not cut off more than half of the signal impulses on either end. In order that the control relay CR shall close on its contact when the center of each signal impulse is being received, it is only necessary that the main vibrating relay MVR operate at a uniform speed at twice the incoming signal frequency and in the proper phase relation thereto.

Starting the main vibrating relay

When no signals are being transmitted, the sending brush at station A is held on its stop segment so that a current of approximately 60 milliamperes is applied over the line L_1 to the operating winding of the receiving relay RR. Since it has been assumed that a current in a winding of any relay, as shown in the drawing, tends to move the armature in the direction of the electron flow, it will be seen that the normal line current tends to urge the armature of the receiving relay against its right or marking contact. At the same time a current of approximately 30 milliamperes is flowing from positive battery through resistance 1 and the biasing winding of the receiving relay to ground, the direction of this current being such as to tend to move the armature to the left. The biasing current is insufficient to overcome the effect upon the armature of the line current. However, as soon as the brush at station A is released and moves on to the first or starting segment, it opens the operating winding of the receiving relay RR and the 30 milliampere current in the biasing winding moves the relay armature to the left. Current from positive battery thereupon flows over the left contact and armature of the receiving relay through the contact 5 on the "start" relay and through the winding of start relay to negative battery. The start relay thereupon operates and locks up over a circuit extending from negative battery through its operating winding, contact 4, and upper armature to positive battery over the back contact and armature of the #1 stop relay. This makes the start relay independent of the receiving relay RR while the remaining impulses of the incoming signal are received.

Before the start relay operated, positive battery was connected through resistances 3 and 6, back contacts and lower armatures of the start relay, through the upper windings of each vibrating relay and through relays on their right or negative contacts.

When the start relay operated, the vibrating circuits of the relays MVR and AVR were closed through the lower armatures and front contacts of the start relay but the vibrating relays did not start immediately. The inductances 11 and 13 in series with a winding of each relay are effective in delaying changes in the currents through the relay windings and thus in delaying the movements of the relay armatures. This delay in the starting of the vibrating relay MVR usually amounts to about $\frac{1}{2}$ cycle depending on the adjustment of the resistance 6. In the case of the main vibrating relay the delay is desirable, since it causes the control relay CR (operating in unison with MVR) to close its armature on its left contact at the time when the center of the starting impulse is received. The time interval before the armatures of MVR and AVR make their first swings may be controlled to a certain extent by varying the resistance elements 3 and 6 which accordingly are termed "orienting resistances." The period of the relay MVR, after it has once been set vibrating, may be controlled by resistance element 2 which therefore may be considered analogous to the governor in a rotary distributor system. The period of relay AVR may likewise be controlled by adjustable resistance element 19.

Stopping the main vibrating relay

As outlined above, the first or starting impulse operated the start relay and locked it up under the control of the stop relay "#1 stop." The start relay, in addition to starting the main vibrating relay MVR as outlined above, also started the auxiliary vibrating relay AVR, which operates in the same general way as MVR. The values of capacity 12 and inductance 13 are so chosen, however, that AVR only vibrates once while MVR vibrates seven times. Hence, when MVR has completed seven vibrations and controlled the regeneration and retransmission of a complete series of start-stop impulses representing a signal character, the armature of AVR must be leaving its left or positive contact which, as will be explained, releases the start relay and stops the main vibrating relay.

The auxiliary vibrating relay AVR performs the stopping operation in two steps. When its armature moves to the left contact current flows from positive battery over its left contact and armature, through resistance 14 and the winding of the #2 stop relay to negative battery. The #2 stop relay thereupon operates and in closing its contacts operates the #1 stop relay and transfers the positive battery connection for the start relay from the armature of the #1 stop relay to the armature of the auxiliary vibrating relay AVR through the contact and left

armature of the #2 stop relay. This places the release of the start relay directly under the control of the auxiliary vibrating relay AVR and when the armature of the latter relay leaves its left contact, the start relay is released. This opens the vibrating circuits of both vibrating relays and applies positive battery to the inductance branches of the vibrating relay circuits. The stopping relays "#1 stop" and "#2 stop" release slightly later than the start relay as they are sluggish due to the resistances 15 and 16 shunted across their respective windings. Since the #1 stop relay is operated through the inside contact and right armature of the #2 stop relay, it releases later than the #2 stop relay. This delayed release of the #1 stop relay is necessary in order to insure that the start relay is released before the positive battery is reconnected to its upper armature through the left contact of the #1 stop relay. The auxiliary vibrating relay armature therefore stops against its right contact and is locked there by the current from positive battery through the resistance 3, back contact and inside lower armature of the start relay through its upper or inductive winding. With the completion of the above operation, the whole repeater circuit is in its idle or normal position and is ready to receive the next series of signal impulses.

Summary

The functions of the different elements of the repeater system may be briefly summarized as follows:

The repeating relay RR responds to incoming signal impulses and repeats them through a sending relay SR to an outgoing line.

The control relay CR vibrates in synchronism with the received impulses and locks the armature of the receiving relay RR at the center of each received impulse to insure the retransmission of perfect signals despite distortion in the received signals.

The sending relay SR repeats regenerated impulses to the outgoing line.

The locking relay LR moves in unison with the sending relay SR and provides a holding current to lock the sending relay armature firmly in its proper position when it is not under the control of the receiving relay RR.

The main vibrating relay MVR vibrates at a natural frequency determined by the capacity of the condenser 10 and the inductance of the inductance element 11 connected in series with its operating windings during the transmission of a series of signal impulses. It is analogous to and takes the place of the constant speed motor in a rotary distributor system and drives the control relay CR which has a function analogous to that of the dis-

tributor brush and associated segments on a rotary distributor.

The start relay is, as its name implies, to start the synchronous timing apparatus, which in this case comprises the vibrating relays MVR and AVR, at the beginning of each series of impulses.

The auxiliary vibrating relay AVR regulates the time during which the main vibrating relay MVR shall operate.

The stop relays "#1 stop" and "#2 stop" perform the actual operations necessary to stop the vibrating relays at the end of a series of signaling impulses. They operate under the control of the auxiliary vibrating relay AVR.

What is claimed is:

1. In a start-stop telegraph system, a regenerative repeater comprising an oscillatory timing device normally inactive and adapted to be started from rest at the beginning of a series of impulses representing a signal character and to be stopped at the end of said series, in combination with means responsive to the first impulse of said series for starting said timing device, and other means also responsive to the first impulse of said series of impulses for measuring the time consumed in the transmission of said series of impulses and for stopping said timing device at the end thereof.

2. In a start-stop telegraph system, a source of signal impulses, vibratory frequency control means comprising a relay and associated impedance elements, characterized in this that said relay vibrates at a frequency determined primarily by the electrical constants of its circuits, means responsive to an impulse of predetermined character from said source for starting said frequency control means at the beginning of each signal character, and signal regenerating means for producing signals of polarity dependent on signals received from said source but of length dependent on said frequency control means.

3. In a regenerative telegraph repeater for repeating over an outgoing line groups of character signals received over an incoming line, a receiving relay, a sending relay, oscillatory timing means for controlling the frequency of the regenerated signals transmitted by said sending relay, said timing means being at rest between successive groups of signals, and means responsive to starting impulses received between groups of signals for setting said timing means oscillating during the reception of signals.

4. In a regenerative telegraph repeater for repeating over an outgoing line groups of character signals received over an incoming line, a receiving relay, a sending relay, oscillatory timing means for controlling the frequency of the regenerated signals transmitted by said sending relay, said timing means be-

ing at rest between successive groups of signals, means responsive to starting impulses received between groups of signals for setting said timing means oscillating during the reception of signals, and means for varying the time required for said timing means to complete its first oscillation independently of succeeding oscillations.

5. In a regenerative telegraph repeater for repeating over an outgoing line groups of character signals received over an incoming line, a receiving relay, a sending relay, oscillatory timing means for controlling the frequency of the regenerated signals transmitted by said sending relay, said timing means being at rest between successive groups of signals, means responsive to starting impulses received between groups of signals for setting said timing means oscillating during the reception of signals, means for varying the time required for said timing means to complete its first oscillation independent of succeeding oscillations, and separate means for varying the period of all the oscillations.

6. In a regenerative telegraph repeater for repeating over an outgoing line groups of character signals received over an incoming line, a receiving relay, a sending relay operable in alternate directions by said receiving relay in accordance with the alternate character of the received signals, start-stop vibratory timing means for determining the time of operation of said sending relay, said timing means being at rest between successive signal groups and including an oscillatory circuit and a start relay responsive to an initial impulse of a signal group for establishing the oscillatory circuit for said timing means.

7. In a telegraph repeater system for repeating groups of signal impulses, a receiving relay, a sending relay, oscillatory timing means for controlling the phase relation between the operation of said sending relay and the incoming signal impulses, said timing means having a natural frequency corresponding to the frequency of the incoming impulses of said groups, and means for stopping the oscillation of said timing means between periods of reception of said groups of signal impulses.

8. In a telegraph repeater system for repeating groups of signal impulses, a receiving relay, a sending relay, oscillatory timing means for controlling the phase relation between the operation of said sending relay and the incoming signal impulses, said timing means having a natural frequency corresponding to the frequency of the incoming impulses of said groups, a second oscillatory timing means for measuring the time of transmission of each group of signal impulses, and means controlled thereby for stopping said first oscillatory means at the end of each group of impulses.

9. In a telegraph repeating system as de-

defined in claim 8, means for varying the period of oscillation of said second timing means.

10. In a telegraph repeater system for repeating groups of signal impulses, a receiving relay, a sending relay, an oscillatory circuit including a vibrating relay for controlling the operation of said sending relay, said circuit having a natural frequency corresponding to the frequency of the incoming impulses of said groups, and synchronizing means for controlling the phase relation between the vibrations of said vibrating relay and said incoming impulses including a slow acting relay for preventing said vibrating relay from vibrating during the period between reception of groups of signals, said slow acting relay having a period of operation corresponding to the period of reception of a group of signals.

11. In a start-stop telegraph system, a regenerative repeater comprising an oscillatory timing device the frequency of which is determined by the inductance, capacity and resistance of its circuits, means for supplying current through an adjustable resistance element to said frequency determining circuit when no signals are received, said means being responsive to the first of a series of received signal impulses to interrupt said current through said first variable resistance element and supply current through a second adjustable resistance element to said frequency determining circuit, whereby the period of the first oscillation may be varied by adjusting the first adjustable resistance element and the periods of succeeding oscillations by adjusting said second adjustable resistance element, and other means also responsive to the first of said series of received impulses for measuring the time consumed in the transmission of said series of impulses and for stopping said timing device at the end thereof.

12. A telegraph system as defined in claim 11, characterized in this, that said other means comprises a frequency determining circuit containing resistance, inductance and capacity, and that said means responsive to the first of a series of received impulses supplies current to the frequency determining circuit of said other means through an adjustable resistance element before being actuated by said first impulse and through a second adjustable resistance element after being actuated by said first impulse.

13. In a telegraph repeating system for repeating groups of signal impulses, a receiving relay, a sending relay, vibrating timing means for controlling the time of operation of said sending relay, having a natural frequency corresponding to the frequency of said signal impulses, and a second timing means for determining the number of vibrations of said vibratory timing means and having a period of operation corresponding to

the period of reception of a group of signal impulses.

14. In a start-stop telegraph system, a source of signal impulses, a vibratory frequency control means comprising a relay and associated impedance elements, characterized in this, that said relay vibrates at a frequency determined primarily by the electrical constants of its circuits, relay means responsive to an impulse of predetermined nature from said source for starting said frequency control means at the beginning of each signal character, signal regenerating means for producing signals of polarity dependent on signals received from said source but of length dependent on said frequency control means, and timing means also responsive to said impulse of predetermined nature for stopping said frequency control means at the end of a signal character.

15. A regenerative repeater for start-stop telegraphy comprising a receiving relay, a sending relay, a vibratory timing means for timing the operation of said sending relay, which is capable of being started and stopped at the beginning and end of each signal character, a start relay responsive to a start impulse from the receiving relay for starting said timing means, a second vibratory timing means adapted to vibrate at a slower speed than said first timing means which is also adapted to be started by said start relay, and a pair of stopping relays responsive to an impulse from said second timing means for stopping both timing means at the end of a series of impulses representing a signal character.

16. In a start-stop printing telegraph system, a regenerative repeater for repeating signals received from a line, comprising an oscillatory timing device for controlling the duration of individual repeated impulses, means under the control of received line signals for starting said timing device, other means responsive to received signals for controlling the character (as distinguished from the duration) of the repeated impulses, and means for stopping said timing device after a definite period of time.

17. In a telegraph system, a repeater as defined in claim 16, which further comprises means for varying the frequency of oscillation of said timing device.

18. A telegraph system, a repeater as defined in claim 16, which further comprises means for controlling the interval between the starting and stopping of said timing device.

19. In a start-stop printing telegraph system, a regenerative repeater comprising an oscillatory timing device for controlling the duration of individual repeated impulses, means for starting said timing device under the control of received line signals, means responsive to received signals for control-

ling the character (as distinguished from the duration) of the repeated impulses, and relay means for stopping said oscillatory timing device after a definite number of oscillations.

5 In testimony whereof, we have signed our names to this specification this 8th day of June, 1928.

10 RALZEMOND D. PARKER.
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