

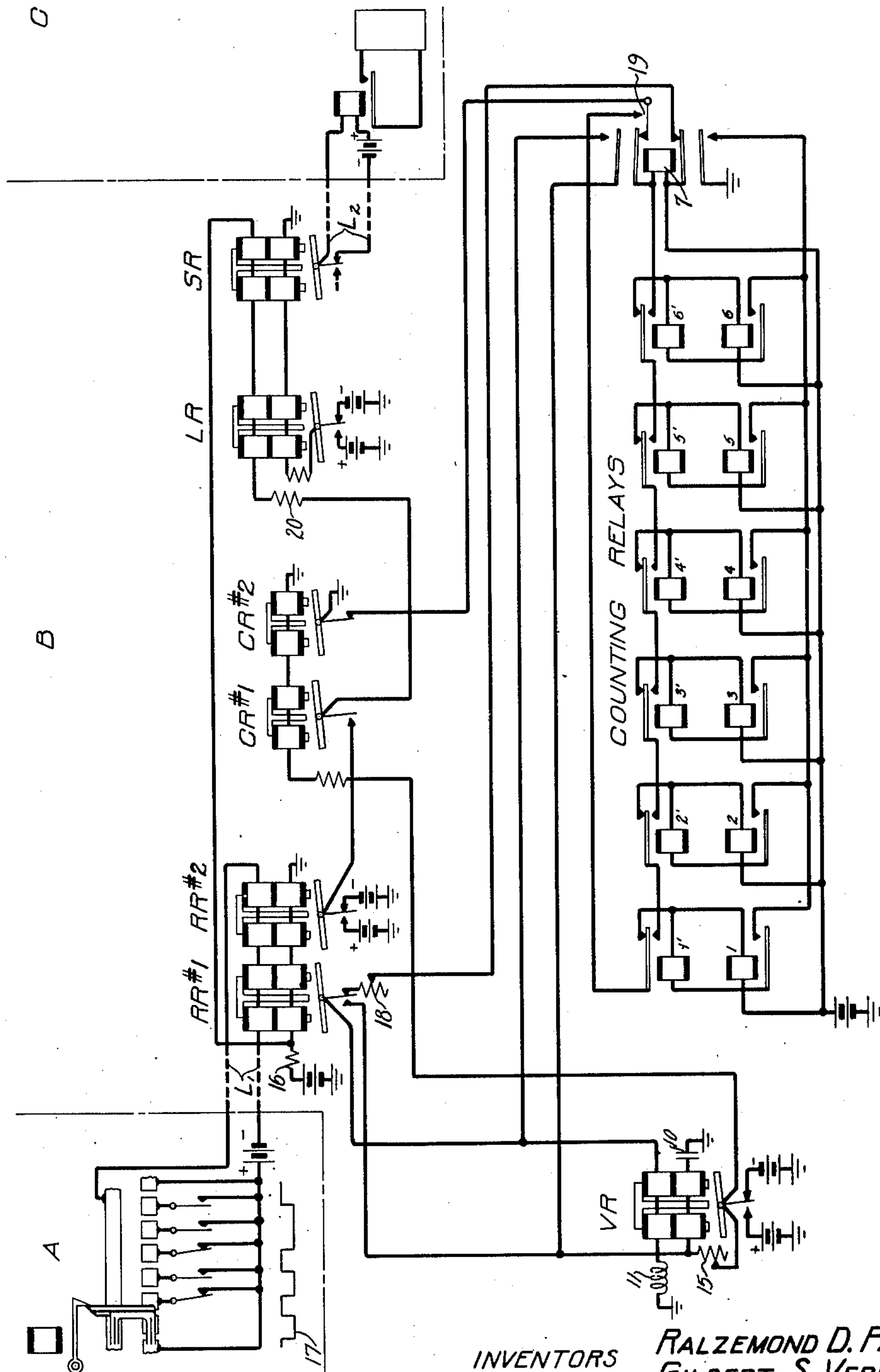
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REGENERATIVE TELEGRAPH REPEATER

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## REGENERATIVE TELEGRAPH REPEATER

Application filed June 9, 1928. Serial No. 284,241.

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

5 An object of the invention is to produce less expensive regenerative repeaters.

A further 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 series of counting relays for stopping the vibrating relay at the end of each series of impulses comprising a signal character.

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 synchronous telegraph circuits at one or more intermediate points regenerative repeaters which receive and completely reconstruct for retransmission distorted signal impulses. Hitherto it has been the practice in start-stop telegraph systems 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 for instance as 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 signaling, however,

because no means has been provided for rapidly starting and stopping the vibrating reeds at the proper time.

In accordance with this invention a vibrating relay is used to time the signal impulses instead of a rotary distributor or a vibrating reed. 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.

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 means of a series of counting relays which operate in succession under the control of the vibrating relay and open its operating circuit when it has completed 7 cycles.

### General circuit description

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 only in a highly schematic form. Thus at station A only a sending distributor, transmitter contacts and a sending battery are shown, the common ring, and segments of the distributor and the transmitter contacts being connected in series with the battery to the line circuit L<sub>1</sub> extending to station B. Each time the distributor brush is released and moves over the segments it transmits to the line, in succession, a spacing or starting impulse, followed by signal impulses which may be either spacing or marking impulses depending on the positions of the transmitter contacts and finally, a closed or marking impulse which serves to stop the receiving distributor. The transmitting brush at station A is, as shown in the drawing, normally held



on the stop segment. With the transmitting contacts in the position shown a series of impulses corresponding to curve 17 will be transmitted to station B when the distributor brush is released and caused to move over the distributor 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.

At the repeating station B two repeating relays RR #1 and RR #2, each having an operating winding and a biasing winding, having their operating windings connected directly to the line circuit  $L_1$  extending from station A. Relay RR #1 serves to start a vibrating relay VR and relay RR #2 repeats incoming signals from station A through the armature and contact of a control relay CR #1 to the winding of a sending relay SR which repeats the signals into the line  $L_2$  extending to station C. Two control relays CR #1 and CR #2 are controlled by and operate in unison with the vibrating relay VR. Relay CR #1, as pointed out above, controls the operation of the sending relay SR and relay CR #2 co-operates with a series of counting relays Nos. 1 to 7 and 1' to 6', respectively, to stop the vibrating relay VR at the end of each signal character. A locking relay LR operates in unison with the sending relay SR and locks the sending relay firmly in the position to which it has

been moved under the control of the receiving relay RR #2.

The vibrating relay VR is a high speed polar relay which has its windings associated with an inductance element 11 and a condenser 10 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 system may be most effectively explained by considering first the actual regeneration of signals under the control of the vibrating relay and then the functioning of the receiving relay RR #1, the control relay CR #2 and the counting relays, in starting and stopping the vibrating relay VR at the beginning and end of each signal character.

#### *Function of vibrating relay*

During the actual repeating of a signal the operating windings of the vibrating relay VR are connected in multiple, either through the armature and left contact of the receiving relay RR #1 or through the upper armature and back contact of the counting relay #7 (which is released during the reception of a series of signal impulses) and are energized from current received over the contacts and armature of the relay VR through resistance 15. The currents in the two windings are so regulated by condenser 10 and inductance 11 that the relay VR vibrates at twice the dot frequency of the incoming signal. That is, the armature of VR completes one cycle of vibration in the period of time required for the brush at station A to pass over one segment.

The armature of the vibrating relay VR is connected to the windings of the control relays CR #1 and CR #2 so that the latter vibrate in unison with VR. The normal stop positions of the control relay armatures are against their right contacts.

Assume that an incoming open or spacing signal permits the normal biasing current, which may be about 30 milliamperes, through resistance 16 and the biasing windings of the receiving relays RR #1 and RR #2 to move the armatures of those relays against their left contacts. This has no immediate effect on the sending relay SR because the operating circuit of the latter is open at the armature of the control relay CR #1. The control relay armatures move in unison with the armature of the vibrating relay VR, however, and close on their left contacts just as the center of each unit impulse is received. When the armature of the control relay CR #1 closes on its left contact a circuit is closed from positive battery at the left contact and armature of the receiving relay RR #2 through the contact and armature of the con-



trol relay CR #1, resistance 20, the upper windings of the locking and sending relays LR and SR in series and back through the biasing windings of the receiving relays RR to ground. This current operates the sending and locking relays and the additional current through the biasing windings of the receiving relays locks the armatures of those relays firmly against their left contacts and keeps them from moving under the control of any distorting currents which might be received over the line  $L_1$  while the armature of CR #1 is closed on its left contact. The locking relay LR locks its own armature and that of the sending relay SR while the armature of the control relay CR #1 is on its open contact.

The operation of the receiving, locking and sending relays 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 windings of the receiving relays opposes the normal biasing current received through resistance 16. Resistance 20 is lower in value than resistance 16, however, and permits about 60 milliamperes to flow in the locking circuit, thus leaving an effective locking current of about 30 milliamperes in the biasing windings of RR #1 and RR #2 which insures that their armatures will remain fast against their right contacts despite distortion in the received signal, as long as the armature of CR #1 is 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 armature of the control relay CR #1 closes on its left contact. If this closure occurs at the time when the center of a received signal impulse should arrive, 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. To insure the closure of the armature of CR #1 on its left contact at the time when the center of each incoming signal arrives it is necessary that the vibrating relay VR which drives the control relays CR #1 and CR #2 operate at a uniform speed at twice the incoming signal frequency and in the proper phase relation thereto. The speed or frequency of the vibrating relay and its phase with respect to receiving signals may be regulated by adjusting resistances 15 and 18 as will be described later.

#### *Starting the vibrating relay*

When no signals are being transmitted

from station A the relays are all in the positions shown in the drawing. The vibrating relay VR has its armature held on its right contact by current through its upper or inductive winding. The circuit over which this current is supplied extends from ground through inductance element 11, upper winding of the relay, the armature and right contact of the receiving relay RR #1, resistance 18, the contact and inside lower armature of counting relay 7 (which is normally operated) to positive battery.

At this time 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 circuit to the operating windings of the receiving relays RR #1 and RR #2. If it is assumed that a current in a winding of any relay, as they are shown in the drawing, tends to move the armature of the relay in the direction of the electron flow, it will be seen that the normal line current tends to hold the armatures of the receiving relays against their right contacts. At this time, as pointed out above, a current of approximately 30 milliamperes is flowing through resistance 16 and the biasing windings of the receiving relays RR #1 and RR #2 to ground, the direction of this current being such as to tend to move the armatures to the left. The 60 milliampere line current is stronger and controls the relay. 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 relays and the 30 milliampere current in their biasing windings moves the relay armatures to the left. This opens the circuit extending from positive battery to the inductive winding of the vibrating relay VR at the right contact of receiving relay RR #1 and connects the two windings of relay VR together through the armature and the left contact of relay RR #1. Since the armature of the vibrating relay VR is permanently connected through resistance 15 to the left contact of relay RR #1, a circuit is closed from negative battery at the right contact of relay VR through the armature of the relay, through resistance 15, the left contact and armature of relay RR #1, through the upper winding of VR and the inductance element 11 to ground. This applies a potential tending to cause an electron flow to the left through the upper winding of relay VR, but the armature of the relay does not start to vibrate immediately because the inductance 11 opposes any change in the current through the relay winding and thus delays the movement of the armature. This delay at the starting of the vibrating relay usually amounts to about one-half cycle, depending on the value of the resistance 18. This delay is desirable since it closes the armature of the control relay CR #1 (operating in unison with re-



lay VR) on its left contact at the time when the center of the starting impulse is received.

The time required for the armature of relay VR to complete its first half-cycle may be controlled to a certain extent by varying resistance element 18, which is accordingly termed an "orienting" resistance. The period of the relay after it has once been set vibrating may be controlled by resistance element 15, which may be considered analogous to the governor in a rotary distributor system.

The vibrating circuit of relay VR through the left contact and armature of relay RR #1 is opened whenever the armature of that relay moves to the right in response to a marking impulse from station A, but when the armature of relay VR moves to its left contact in its first cycle of operation the control relay CR #2, which operates in unison with the vibrating relay VR, opens the operating circuit of the #7 counting relay which thereupon releases and closes an additional operating circuit for relay VR through its outside upper armature and back contact. The circuit from positive battery to resistance 18 is also opened at the inside lower armature of the #7 counting relay so that relay RR #1 can have no further effect on the vibrating relay as long as relay #7 remains deenergized. The #7 counting relay is normally energized by current flowing from positive battery through its winding, inside upper armature and contact, through the right contact and armature of control relay CR #2 to ground. After it is once released, counting relay #7 can only be re-operated through the inside contact and armature of the #6' counting relay.

#### Stopping the vibrating relay

As outlined above, the first impulse of the signal character starts the vibrating relay VR vibrating and before this relay has completed a cycle of vibration its operating circuit is closed through the outside upper armature and back contact of counting relay #7, the operating circuit of which is thereafter under the control of the #6' counting relay. The vibrating relay VR will therefore continue to vibrate until such time as the #6' counting relay is operated. The latter relay is operated at the end of a signal character as a result of the operation of the preceding counting relays, as follows:

When the vibrating relay VR and the control relays CR #1 and CR #2 have completed their first cycle of operation and their armatures lie against their right contacts, a circuit is completed from positive battery through the winding of the #1 counting relay, through the back contact and armature of the #1' counting relay, through contacts 19 on the #7 counting relay to ground over

the right contact and armature of control relay CR #2. Counting relay #1 thereupon operates and closes a circuit for the operation of counting relay #1' through the armature and contact of counting relay #1, through the back contact and lower armature of counting relay #7 to ground. Counting relay #1' does not operate at this time, however, because its winding is shunted by the path to ground through the right contact and armature of control relay CR #2. When the vibrating relay VR and the control relays CR #1 and CR #2 complete their next half-cycle and move their armatures to the left, the control relay CR #1 opens the shunt path around the winding of the #1' counting relay, which thereupon operates over the circuit traced above.

At the end of the first cycle and a half of operation of the vibrating relay VR, therefore, the counting relays #1 and #1' are left locked up over the armature and contact of counting relay #1 and the lower back contact and armature of counting relay #7. This gives the control relay CR #2 control of the #2 counting relay over the armature and front contact of the #1' counting relay, and when the vibrating relay VR completes its second cycle of vibration, the #2 counting relay operates in the same way as was outlined for the #1 relay and at the end of another half-cycle the #2' counting relay operates.

The counting relays are thus operated in succession under control of the vibrating relay VR through the control relay CR #2. At the end of the sixth cycle, counting relay #6 is operated and one-half cycle later counting relay #6' operates. This completes a circuit from positive battery through the winding of counting relay #7 through the inside contacts and armatures of the upper row of counting relays #6' to #1', inclusive, in series, through contacts 19 of counting relay #7 to the right contact of control relay CR #2. Therefore, when the vibrating relay VR and the control relay CR #2 move their armatures to the right at the end of the seventh cycle, counting relay #7 operates. This opens the vibrating circuit of relay VR at the outside upper armature and back contact of counting relay #7 and stops the vibrations of relay VR. Relay #7 also closes the normal circuit from the inductive winding of relay VR through the armature and right contact of receiving relay RR #1 and resistance 18 to positive battery over the contact and inside lower armature of counting relay #7. Counting relays Nos. 1 to 6 and 1' to 6' are released by the opening of their locking circuit at the back contact and outside lower armature of relay #7 and the latter relay is locked over its inside upper armature and contact to ground at the armature of control relay CR #2.



This leaves the system in its normal condition ready to receive, regenerate and repeat another series of impulses representing the next signal character.

### Summary

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

10 The repeating relay RR #2 responds to received signal impulses and repeats them through a sending relay SR to an outgoing line.

15 The control relay CR #1 vibrates in synchronism with received impulses and locks the armature of the receiving relay RR #2 at the center of each received impulse to insure the retransmission of perfect signals, despite distortion in the received signals.

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

25 The locking relay LR moves in unison with the sending relay SR and provides a holding or locking current to lock the sending relay armature firmly in its proper position when it is not under control of the receiving relay RR #2.

30 The vibrating relay VR 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 actuates the control relays CR #1 and CR #2 which have functions analogous to those of the distributor brushes and associated segments on a rotary distributor.

40 The receiving relay RR #1 is to start the synchronous timing apparatus, which in this case comprises vibrating relay VR and the control relays CR #1 and #2, at the beginning of each series of impulses.

45 The counting relays #1 to #6 and #1' to #6' count the vibrations of the vibrating relay VR and stop this relay at the end of each series of impulses representing a signal character, through the agency of counting relay #7.

50 This specification is for an improvement upon copending application Serial No. 284,240 which was filed on June 9, 1928 by the same inventors, and which contains claims generic to both applications. The copending application discloses a regenerative telegraph repeater having a vibrating relay and an arrangement, which was replaced by the counting relays of the present application, for stopping the vibrating relay.

What is claimed is:

65 1. In a start-stop printing telegraph system, a regenerative repeater comprising cyclic timing means normally inactive and adapted to be started by one of a series of impulses to

be repeated, and thereafter to make periodic changes in approximate synchronism with said impulses and to be stopped at the end of said series, in combination with means responsive to said one impulse of said series for starting said timing means, and other means responsive to the cyclic changes of said timing means for counting said changes and for stopping said timing means when it has completed a number of changes corresponding to the number of impulses of said series.

2. In a start-stop printing telegraph system, a regenerative repeater comprising an oscillatory timing device capable of operating at a frequency independent of that of received line signals 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 controlling the character (as distinguished from the duration) of the repeated impulses, and means for stopping said oscillatory timing device after a definite number of oscillations independent of the frequency of oscillation of said timing device.

3. In a start-stop synchronous telegraph system, a source of signal impulses, a vibratory frequency control means comprising a relay and associated impedance elements, characterized in this, that it vibrates at a frequency determined primarily by the electrical constants of its circuits, means responsive to a start impulse of predetermined nature from said source for starting said frequency control means at the beginning of each signal character, signal regenerating means producing signals of polarity dependent on signals received from said source but of length dependent on said frequency control means, and means comprising a series of counting relays adapted to be started by said start impulse and to count thereafter each vibration of said vibratory control means corresponding to the signal impulses in the start-stop code and to stop said frequency control means at the end of a signal character.

4. A regenerative repeater for start-stop telegraphy comprising receiving relays having line windings and locking windings, control relays, vibratory timing means for operating the control relays, a sending relay and a locking relay, means for locking said sending relays when said control relays are in one position, means for locking said sending and locking relays when the control relays are in the other position, means comprising the receiving relays and control relays for determining the position in which the said sending and locking relays shall be locked, means comprising said receiving relays responsive to a start impulse for starting the timing means, and a plurality of counting relays corresponding in number to the number of impulses in each series of the start-stop



code for counting the movements of said timing means corresponding to received impulses and stopping the timing means at the end of a series of impulses.

5 5. In a start-stop printing telegraph system, a regenerative repeater comprising cyclic timing means normally inactive but adapted to make periodic changes in approximate synchronism with received impulses and to  
10 return to its initial position at the end of each periodic change, in combination with means responsive to one of a series of received impulses for starting said timing means, and  
15 other means responsive to the periodic changes of said timing means for counting said changes and for stopping said timing means when it has completed a predetermined number of periodic changes, independent of  
20 the frequency of periodic changes of said timing means.

6. In a start-stop printing telegraph system, a regenerative repeater adapted to receive series of impulses from one line and transmit corresponding series over another  
25 line, comprising an oscillatory timing device for controlling the instant at which each impulse is to be transmitted, means responsive to the received impulses and to said timing device for controlling the character of the  
30 transmitted impulses, means responsive to one impulse of a series for starting said timing means and means responsive to another impulse of the same series for subsequently stopping said timing means.

35 7. In a start-stop telegraph system, a regenerative repeater comprising timing means adapted to be started from an initial condition and to make alternate changes in approximate synchronism with incoming im-  
40 pulses to be repeated, said timing means including a tuned circuit, in combination with means responsive to an impulse of a series of impulses to be repeated for starting said timing means, and other means responsive to  
45 a series of said alternate changes corresponding to said series of impulses to stop said timing device at the end of the series of impulses.

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

RALZEMOND D. PARKER.  
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