Oct. 8, 1929. W. A. KNOOP 1,730,614

SYNCHRONOUS VIBRATORY RELAY SYSTEM

Filed Oct. 26, 1927

FIG. 1

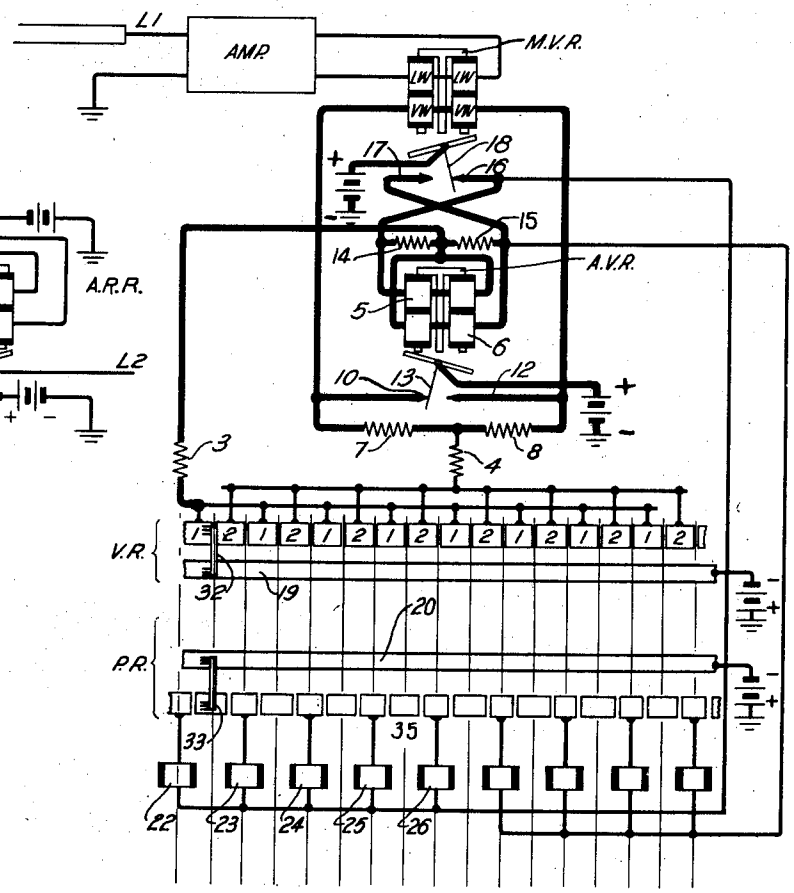


FIG. 3

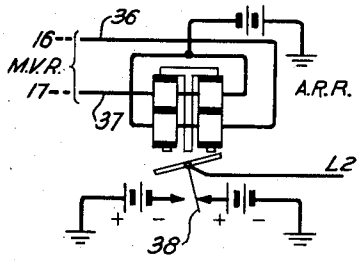
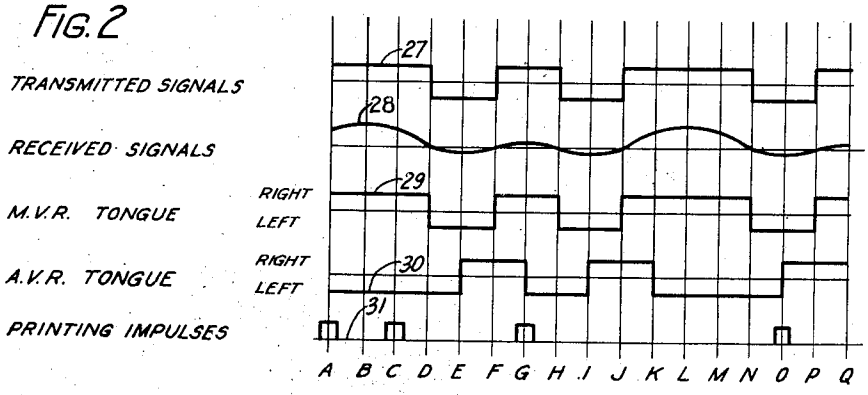


FIG. 2



INVENTOR
WILLIAM A. KNOOP
BY J. W. Schmied
ATTORNEY

Patented Oct. 8, 1929

1,730,614

UNITED STATES PATENT OFFICE

WILLIAM A. KNOOP, OF HEMPSTEAD, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SYNCHRONOUS VIBRATORY RELAY SYSTEM

Application filed October 26, 1927. Serial No. 228,706.

This invention relates to high speed synchronous telegraph systems in which short signal impulses are excessively attenuated and must be rebuilt, or regenerated, at the receiving station, and its object is to simplify and increase the reliability of the equipment at the receiving station for rebuilding short signal impulses.

In a telegraph system it is customary to transmit current impulses of different length and polarity in various combinations to represent different signal characters. Due to the excessive attenuation of high frequency waves on long transmission lines, the short impulses are sometimes attenuated to a point where they cannot operate the receiving line relay although longer impulses are received with ample strength to control the relays.

To make possible signaling under such conditions, synchronous vibrating relay systems comprising relays, special rings on the synchronous receiving distributor, and sometimes auxiliary apparatus such as condensers, have been employed. These restore, at the receiving station, the short impulses that have been lost in transmission. The systems heretofore used have usually required either a multiplicity of polar relays or the use on the receiving distributor of several rings, or of two segmented rings with special insulating segments inserted between the live segments on one ring and in all cases it was customary to connect the opposite contacts of some of the polar relays to battery potential of opposite polarity, which necessitated the insertion of protective resistances in the battery leads to avoid danger of short-circuits from faulty adjustment of the relays. With protective resistances in the battery leads an extra relay was required to repeat the impulses to a printing distributor.

The present system eliminates the necessity of using, in a vibratory relay system, more than two polar relays and more than one plain and one segmented ring on the receiving distributor. Furthermore, in this system the necessity of connecting opposite contacts of a relay to sources of current of opposite polarity has been eliminated; therefore protective resistances are not required in the battery leads, and as a result no separate printing relay is required.

The invention, in preferred embodiments, will now be described and its operation explained in connection with the drawing in which:

Fig. 1 represents a complete system for the regeneration and printing of signal impulses received over a telegraph conductor;

Fig. 2 contains curves illustrating the operation of the apparatus in Fig. 1; and

Fig. 3 illustrates an alternative arrangement for repeating impulses to another line.

Referring to Fig. 1, the vibrating relay circuit proper comprises a main vibrating relay MVR and auxiliary vibrating relay AVR, vibrating rings VR, on a receiving distributor, and the circuit shown in heavy lines. Both MVR and AVR are high speed polar relays with two independent windings on each so disposed that an electron flow from left to right moves the associated relay tongue to the right and an electron flow from right to left moves the associated tongue to the left. The two windings on the main vibrating relay MVR function independently of each other, the upper winding LW being the line winding, which may be connected to the telegraph conductor L_1 through an amplifier as shown, and the lower winding VW forming a part of the vibrating circuit. It should be particularly noted that the operating current for the lower winding VW is limited by resistance 7 or resistance 8 to such a low value that the operation of the relay is controlled by the line winding LW, whenever a signal impulse of any substantial magnitude is received over the line conductor L_1.

Resistances 3 and 4 are for contact protection only and do not need to be considered in following the operation of the system. Likewise resistances 14 and 15 shunted across the windings of relay AVR are to improve the operating characteristics of that relay and may be disregarded.

An explanation of the operation of the circuit shown in Fig. 1, in connection with the curves of Fig. 2 will now be made. These curves represent conditions theoretically.

Curve 27 represents the form of the wave transmitted from a distant station on conductor L_1, while curve 28 represents the form of the received current after it is amplified and applied to the line winding LW of the main vibrating relay. Curves 27 and 28 would actually be displaced relatively by an amount equal to the line time but this displacement has not been shown in the curves. It will be noted that where impulses of greater than unit length occur such as from (*a*) to (*d*) and from (*j*) to (*n*), appreciable current is received, but on the short or unit impulses of alternately opposite polarity, such as occur between (*d*) and (*f*), (*f*) and (*h*), and (*h*) and (*j*), a very small current is received. Curves 29 and 30 represent the positions of the relay tongues on the main vibrating relay MVR and the auxiliary vibrating relayAVR, respectively, at any instant of time, plus values indicating that the tongue lies against its right contact and minus values indicating that the tongue lies against its left contact. The curve 31 indicates the impulses applied to the printing magnets 22 to 26 inclusive.

Assume at instant of time (A) that a long positive impulse has been transmitted over the line conductor L_1, and is holding the main vibrating relay MVR against its right contact as shown in Fig. 1. At this time brush 32 makes contact with segment 1 and applies negative current from the common ring 19 through resistance 3, through upper winding 5 of the auxiliary vibrating relay AVR, through contact 16 and relay tongue 18 of MVR to positive battery. This results in an electron flow from right to left through the upper winding of AVR and the tongue 13 is held against left contact 10 as indicated at curve 30. No current flows through tongue 13 and the vibrating winding VW of MVR at this time, but at time (B) brush 32 closes a circuit from segment 2 through resistance 4, resistance 8, winding VW and contact 10 to tongue 13 and positive battery. This results in an electron flow to the left through winding VW of MVR, but the relay does not operate because as shown by curve 28, the line current in the line winding LW still controls the relay.

At time (C) conditions are the same as they were at time (A) and a circuit is again closed causing an electron flow to the left through the upper winding of auxiliary vibrating relay AVR which of course tends to hold the tongue in the position it is already in.

At time (D) brush 32 again makes contact on a segment 2 and applies negative current through segment 2, resistance 4, resistance 8, winding VW of the main vibrating relay, contact 10 and tongue 13 of the auxiliary vibrating relay to positive battery. This results in an electron flow from right to left and moves tongue 18 to the left, since, as shown at curve 28, the current in the line winding has become zero.

At time (E) brush 32 again closes on a segment 1, applying negative potential to the midpoint of the auxiliary vibrating relay AVR and, since tongue 18 of MVR is closed on contact 17, causes a flow of electrons from left to right through the lower winding 6 of AVR, which moves the relay tongue 13 to the right against contact 12 as shown in curve 30.

At time (F) when brush 32 again makes contact on a segment 2, negative current is applied through resistances 4 and 7, winding VW of MVR, conductor 12 and tongue 13 of the auxiliary vibrating relay to positive battery. This electron flow to the right through winding VW of MVR moves the tongue 18 to the right against contact 16, since as shown by curves 27 and 28 a unit impulse of negative polarity transmitted from the distant transmitter causes insufficient current to be received in the line winding LW of MVR to control its operation.

At time (G) the brush 32 again applies negative current to a segment 1, current flows to the left through the upper winding of auxiliary vibrating relay AVR and contact 16 of the main vibrating relay MVR causing tongue 13 to move to the left as shown by curve 30. It will be seen that as long as unit impulses of alternately opposite polarity are transmitted from the distant station, no current of controlling strength will be received in the line winding LW of the main vibrating relay MVR and the relay system will automatically vibrate to rebuild the unit impulses. The operation already followed through is repeated periodically until time (L), at which time, as shown by curve 28, an impulse greater than unit length has been transmitted from the distant station and a current of controlling strength is flowing in the line winding LW of the main vibrating relay MVR. Therefore, when brush 32 applies negative current through a segment 2, resistance 8, winding VW of MVR, contact 10 and tongue 13 of the auxiliary vibrating relay, tongue 18 of the main vibrating relay does not move to the left as it did at time (D), because of the controlling action of the current in the line winding LW. Therefore, at time (M) negative current is still flowing from right to left through the upper winding of the auxiliary vibrating relay AVR and the armature thereof holds its position against its left contact 10.

At time (N) the received current in line LW of MVR has again been reduced to zero and the negative current applied through a segment 2, resistance 8 and vibrating winding VW, contact 10 and tongue 13 of the auxiliary vibrating relay moves tongue 18 against its left contact and again starts the automatic periodic vibration of the armatures.

Heretofore no description has been given of the actual recording of the received and regenerated signals. In Fig. 1 printing rings PR are represented on the receiving distributor comprising the common ring 20 and a segmental ring 35 each segment of which is connected to a printer magnet. In the system shown, the Baudot code comprising five unit pulses is used, and five printer magnets 22 to 26 inclusive have been shown as representing the equipment for one channel. It is expected that a system of the type described may comprise a number of channels but the printer equipment for each channel would be similar to that shown. Printer magnets or relays 22 to 26 are of the conventional type, each having a normal and an operated position, the normal position corresponding to a negative signal impulse and the operated position to a positive signal impulse. When operated, the relays lock up until brush 33 has passed over all five segments in a channel and the recorded code character is printed, after which the locked up relays are automatically restored to normal position. The common return from printing magnets 22 to 26 in the first channel is connected to contact 16 of relay MVR, and the common printing ring 20 is connected to negative battery. Brush 33 moves synchronously with brush 32 and as shown by the curves in Fig. 2 the tongue of the main vibrating relay MVR moves in synchronism with the transmitted signals shown in curve 27. Therefore, whenever positive impulses are transmitted from the distant station, the tongue of the main vibrating relay lies to the right and as brush 33 closes on a printing segment there is a flow of current from negative battery over ring 20, brush 33, through the printing magnet to contact 16 and positive battery connected to tongue 18. Therefore, at time (A) when a positive impulse is transmitted, tongue 18 will apply an operating impulse to printer magnet 22. At time (C), a positive impulse is still being transmitted from the distant station and an impulse is applied to printer magnet 23. At time (E) a negative impulse is transmitted from the distant station and since the tongue 18 of the main vibrating relay lies to the left, a circuit is not closed for the operation of printer magnet 24 and it remains in normal position. Again, at time (G), a positive impulse is transmitted from the distant station and an impulse is applied by tongue 18 of the main vibrating relay to printer magnet 25. At time (I), a negative impulse is transmitted from the distant station, tongue 18 lies against its left contact and printer magnet 26 remains in normal position.

It will be noted that the common return conductor from the printing magnets (only four of which are shown) of the second channel is connected to contact 17 instead of contact 16 on relay MVR. With more than two channels the common return conductor from alternate channels would be connected together. The result of connecting the common return conductor from channel two, (and all even numbered channels) to contact 17 of relay MVR is to invert the impulses applied to the printing relays in those channels. This is done to correct for corresponding inversions or reversals of polarity at the transmitting station, known as "channel reversals", which are customarily made in order that synchronizing impulses may be transmitted when no signals are being sent.

The system described above eliminates the necessity of using a special printing relay between the main vibrating relay and the printing rings of the distributor, but such a relay may be inserted if desired, or, a repeating relay may be inserted to retransmit the regenerated signal impulses to another line. In Fig. 3 ARR represents an auxiliary repeating relay which is a double winding, polar relay similar to auxiliary vibrating relay AVR. These two windings are connected in series aiding relation and the midpoint connected to negative battery while the two terminals 36 and 37 are connected to contacts 16 and 17 respectively of the main vibrating relay MVR. Since the tongue 18 of main vibrating relay MVR is connected to positive battery, there will be an electron flow from right to left through the upper winding of ARR, when tongue 18 of MVR lies against its left contact 17, and it will move tongue 38 of ARR against its left contact. On the other hand, when tongue 18 of the main vibrating relay lies against its right contact 16, there will be an electron flow from left to right through the lower winding of ARR which will move tongue 38 to the right. Thus the tongue of relay ARR follows the movements of the tongue of the main vibrating relay. If the opposite contacts of the auxiliary printing relay ARR are connected to negative and positive battery respectively, as shown in Fig. 3, and the tongue 38 connected to a second line L_2, impulses received over line L_1 will be regenerated by the vibrating relay system and retransmitted over L_2.

What is claimed is:

1. In a synchronous vibrating relay system, two polar relays, an operating source connected to the movable contacts of said relays, and means whereby each of said relays functions to operate the other as a result of its own operation.

2. A system in accordance with claim 1 having a circuit operatively connected to one of said relays to control its operation under the influence of electrical waves supplied by an external source which circuit when properly energized prevents one of said relays from operating the other.

3. A synchronous vibrating relay system comprising polar relays and a rotary dis-

tributor, a single segmented distributor ring and a source of current which in conjunction with incoming signal impulses constitute, with their connecting circuits, the entire control means for controlling the vibration of said relays.

4. In a synchronous normally vibrating relay system comprising two polar relays, two operating windings for each of said relays, a segmented ring for controlling said relays, and means for applying an electromotive force of the same polarity to each segment of said ring in succession.

5. In a synchronous vibrating relay system comprising a polar relay, having an energizing winding, the method of vibrating said relay with successive current impulses of like polarity, which comprises applying said successive impulses of like polarity through different portions of the energizing winding, and in opposite directions.

6. In a synchronous telegraph system two polar relays, each having an energizing winding, a movable armature and two opposing contacts cooperating therewith, a synchronous distributor having a vibrating ring with similar, equally spaced segments, traversed by a synchronously driven brush, characterized in this, that the armatures of both relays are connected to one terminal of a source of current, the other terminal of which is connected to the vibrating ring distributor brush, and that the energizing circuit for each relay winding comprises a distributor segment and the armature and a contact of the other relay.

7. In a synchronous vibrating relay system, a main relay and an auxiliary relay, each having a movable armature bearing a contact and opposing contacts therefore, and an operating winding on each relay connected between the opposing contacts of the other relay, a circuit for energizing each winding comprising a source of electrical energy, and synchronous switching means, connected in series between the movable contact of each relay and the operating winding of the other relay, a line winding on said main relay and printing means operated in response to current supplied through the movable contact of the main relay.

8. In a telegraph receiving system, a receiving relay having a fixed contact and a contact movable in response to received signals whereby it makes electrical connection with the fixed contact, an operating circuit for said relay extending through a distributor and a winding of said relay, printing magnets, and means for periodically connecting each printing magnet in rotation in a series circuit comprising a source of electric current, the fixed contact, and the movable contact of said relay.

9. In a synchronous telegraph receiving system, a polar relay operating in response to received signals having an armature movable between two fixed contacts, said armature being connected to one terminal of a source of electrical energy, a group of printing magnets each having two operating terminals, one of which is connected to one of said fixed contacts, and means for periodically connecting the other terminal of each printing magnet to the opposite terminal of said source of electrical energy in synchronism with received signals.

10. In a telegraph receiving system a synchronous distributor having a common ring and a segmented ring, alternate segments of which are connected together, a main relay and an auxiliary relay, each of said relays having a vibrating winding connected to the fixed contacts of the other relay, a third confixed contacts of the other relay, a third connection from the effective mid-point of the vibrating winding of one of said relays to one of said connected group of alternate distributor segments, an a connection from the effective midpoint of the vibrating winding on the other relay to the second group of alternate distributor segments, a source of potential connected between said common distributor ring and the movable contacts of said relays, a line winding on said main vibrating relay, printing rings on said distributor comprising a segmented ring with printer magnets connected between the segments of said ring and a fixed contact of one of said relays, a common printing ring connected to a source of potential of the same polarity as that impressed upon the common vibrating ring, a synchronously moving brush bridging the common vibrating ring to the segmented vibrating ring, and a second synchronously moving brush, bridging the common printing ring to the segmented printing ring.

In witness whereof, I hereunto subscribe my name this 24th day of October, A. D. 1927.

WILLIAM A. KNOOP.