March 10, 1931. B. G. BJÖRNSON 1,795,924

RELAY CIRCUITS

Filed March 18, 1926

Fig. 7.

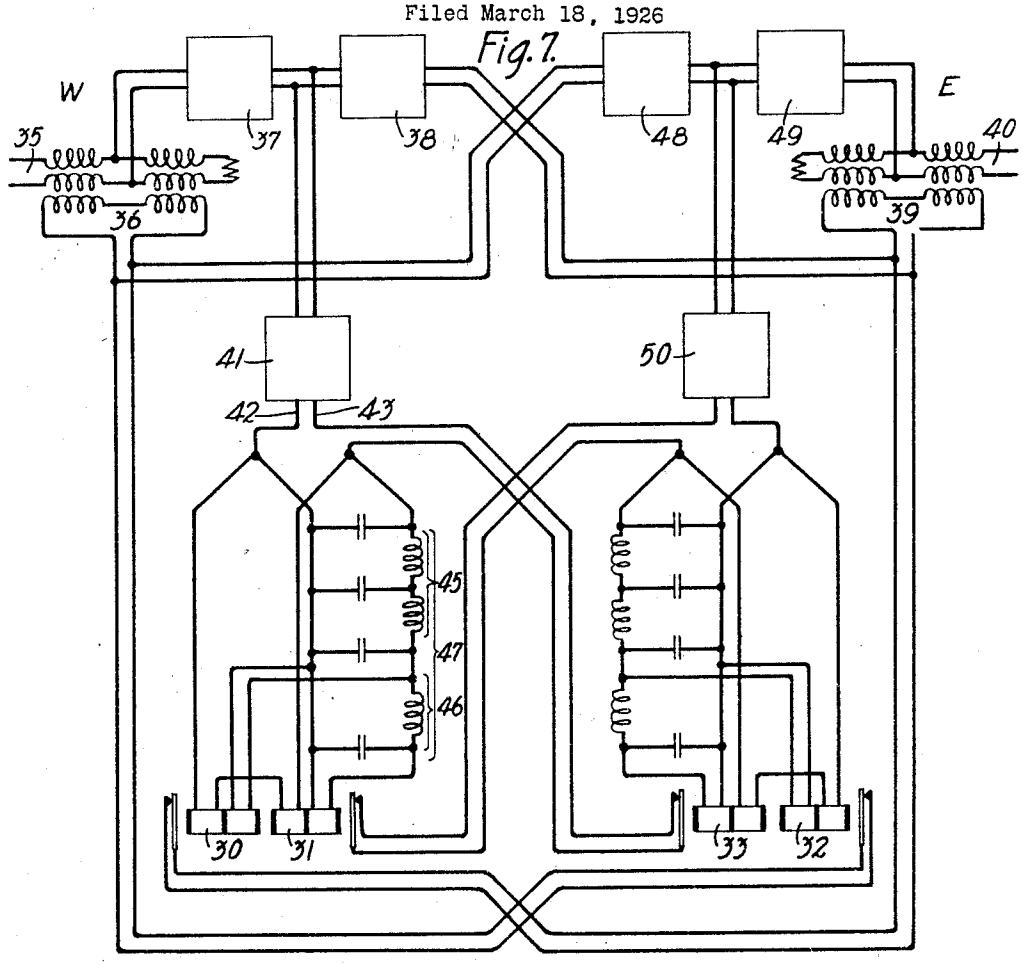


Fig. 1.

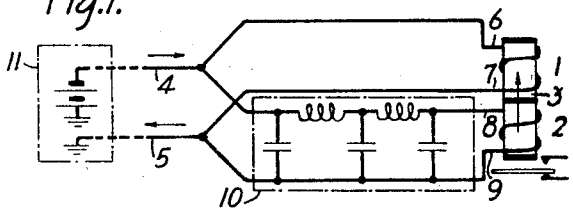


Fig. 2.

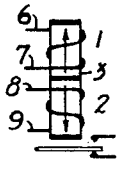


Fig. 3.

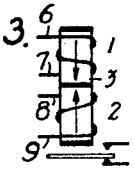


Fig. 4.

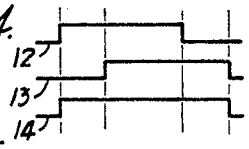


Fig. 5.

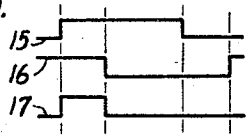
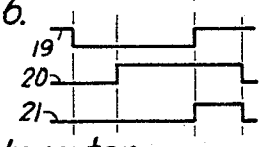


Fig. 6.



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Patented Mar. 10, 1931

1,795,924

UNITED STATES PATENT OFFICE

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RELAY CIRCUITS

Application filed March 18, 1926. Serial No. 95,676.

This invention relates to electro-responsive devices and more particularly to the time control of electromagnetic devices such as relays.

It is an object of the invention to improve the control exercised over the operating characteristics of electro-responsive devices such as relays.

Operative control of relays may be accomplished by employing any of several well-known expedients such as, for example, the introduction of a time lag in the operation or release of the relay due to the inherent construction of the relay itself. This particular method is, however, subject to considerable variation and in general it is difficult to extend the time lag beyond a limited period without increasing the cost of manufacture or the maintenance expense of the relays.

In accordance with this invention transmission delay circuit arrangements are provided for use in connection with ordinary relays whereby such relays may be made to operate at the time current is applied to the relay and be maintained operated a predetermined period after the application of current has ceased, or whereby the relays may be made to operate as soon as the current is applied and released at predetermined periods thereafter regardless of how long thereafter the current is applied, or whereby the relays may be caused to operate, as soon as the application of current has ceased, and be maintained operated for predetermined periods thereafter.

Other objects and features not particularly set forth above will appear more fully hereinafter.

The invention has been illustrated in the accompanying drawings in which—

Fig. 1 shows a circuit arrangement according to this invention applied to a common relay for operating the relay during the time current is applied to the circuit and for a certain predetermined period after the application of current has ceased.

Figs. 2 and 3 show two different arrangements of the windings of a common relay that may be used in connection with the circuit arrangement according to this invention, Fig. 2 illustrating an arrangement whereby the relay may become operated at the time the current is applied and released a predetermined time thereafter irrespective of how long the current remains applied, while Fig. 3 illustrates an arrangement whereby the relay may become operated at the time the application of current ceases and remain operated a predetermined period thereafter.

Figs. 4 and 5 and 6 are graphic illustrations showing the relation between a current impulse applied to the windings of the relays shown in Figs. 1 and 2 and 3, respectively, and the time at which operation takes place, the duration of operation, and the time of release of these relays under the conditions outlined above, while Fig. 7 illustrates an application of relays equipped with circuit arrangements in accordance with this invention to a voice operated two-way telephone repeater system.

To clearly set forth the various features of this invention, a detailed description will first be made of the functions of the relays illustrated in Figs. 1, 2 and 3 followed by a description of the application of the invention to the voice controlled telephone repeater system shown in Fig. 7.

Referring now to Fig. 1, the two windings 1 and 2 of relay 3 may be connected in parallel to the conductors 4 and 5 through the conductors 6 and 7 and 8 and 9, respectively, so that current flowing, for example, from a grounded battery associated with conductor 4 to conductors 6 and 8, windings 1 and 2, conductors 7 and 9, back to conductor 5 to ground, causes these windings to independently produce electromagnetic flux in the core of relay 3 in the same direction, (indicated by an arrow point). The conductors 6 and 7 leading from winding 1 are connected directly to conductors 4 and 5, respectively, while conductors 8 and 9 are connected to conductors 4 and 5 through an ordinary well-known type of delay filter 10 such as shown within the dash-dotted line enclosure. Any other form of delay device may be used in place of the particular form shown. It is assumed in this case that the construction of the relay 3 is such that the electromagnetic flux induced in the core thereof by either

one of the windings 1 and 2 is sufficient to cause the relay to attract its armature. It should be understood that any well-known form of relay for producing this condition may be employed. Therefore, on the application of E. M. F. from the source 11 to the conductors 4 and 5, relay 3 will immediately respond by attracting its armature due to the current through winding 1. In this case the armature will be maintained attracted as long as the E. M. F. remains applied and also maintained attracted for a certain time after the application of the E. M. F. has ceased. This is due to the characteristic of the delay filter 10 whereby the flow of current is continued through the winding 2 for a predetermined period after E. M. F. has ceased to be applied to the filter. It is well-known that delay filters consisting primarily of capacity and impedance elements may be designed to produce a very sharply defined retarding action on currents passing through them. In this case, therefore, the constants of the circuit may be selected so that the relay 3 will become energized as soon as voltage is applied to the conductors 4 and 5 and remain energized for a predetermined period after the voltage has been removed. This period of maintenance of the relay 3 in an energized condition is dependent upon the characteristic of the delay filter 10, and it should be understood that by changing the characteristic of the delay filter employed the relay can be made to remain operated after the current ceases for an easily predetermined and definitely fixed period of time.

Fig. 4 illustrates the relation of the application of current as compared with the relay action in the case of the arrangement shown in Fig. 1. Curve 12 represents the period of application of current through winding 1; curve 13 represents the period of application of current through the winding 2, and the delay caused by the filter 10; while curve 14 represents the period during which the relay is actuated in response to the currents through these two windings.

Referring now to Fig. 2; if the conductors 8 and 9 are connected to the winding 2 in the reverse manner to that shown in Fig. 1, or this winding is itself reversed as shown in Fig. 2, the connections to winding 1 remaining the same as in Fig. 1, the flux produced through winding 2 will be in the opposite direction to the flux produced by winding 1. In this case, therefore, the relay may be constructed so that it will be energized to attract its armature the moment current is applied through winding 1 and actuated to release its armature when current later is applied to the winding 2. It is evident that the relay in this case may be of the polarized construction so that the current through the winding 2 will cause the armature to remain released after current through the winding 1 has ceased. In other words, in this case the relay may be operated for a period predetermined by the character of the delay filter 10 in the manner illustrated by the curves in Fig. 5. Curve 15 represents the period of application of current to winding 1. Curve 16 represents the period of application of current to winding 2, while curve 17 represents the period during which the relay is actuated to attract its armature, which is the period between the application of current to winding 1 and the application of current to winding 2.

Referring now to Fig. 3; if the conductors 6 and 7 were reversely connected to the winding 1 or if the winding 1 itself is reversed as shown in this figure, the connections to winding 2 remaining the same as in Fig. 1, and the relay 3 is of polarized construction, its action will be different, i. e., the effect of the application of current to the windings may be such that current applied only to winding 1 will not affect the relay in respect to the armature action and this condition being still maintained when current is later applied to winding 2, because of the opposing action of the current due to winding 1, so that the armature will not be attracted as long as current is applied to both windings; but when the application of current through winding 1 ceases, the current through winding 2 will be sufficient to cause the relay to operate to attract its armature, and the armature will thereafter remain attracted for a predetermined period depending on the characteristics of the delay filter 10. It should be understood that any well-known relay construction having the desired characteristics, as set forth above, may be employed for this circuit arrangement.

Fig. 6 illustrates the following relations; curve 19 represents the period of application of current through winding 1; curve 20 represents the period of application of current through winding 2; and curve 21 represents the period during which the relay is actuated to attract its armature in response to the currents through the two windings.

In utilizing relays arranged in accordance with this invention with circuits containing delay filters, a plurality of different operative effects may be produced. For example, the relays shown in Figs. 1, 2 and 3 may be connected together, to be controlled simultaneously from the same source, that is, the windings 1 of these relays may be connected in parallel or in series to conductors 6 and 7 and similarly the windings 2 of these relays may be connected in parallel or in series to conductors 8 and 9 through the delay filter 10 or to different points in the filter 10 to include different portions thereof. Relays combined in this manner may, therefore, be used in various switching circuits to cause inde-

pendent circuits to be closed or opened for sharply defined intervals, such intervals having definitely predetermined relations to each other. To illustrate how this invention may be applied in practice, Fig. 7 has been prepared.

In Fig. 7, relays designed in accordance with this invention are shown applied to a voice controlled two-way repeater telephone circuit. A repeater of this general type is disclosed in the United States patent of Robert C. Mathes No. 1,695,813 issued December 18, 1928. In the circuit shown in this figure, the relays are used for placing in operation the repeater equipment for transmission in one direction and at the same time disabling the other side of the repeater so that speech can only be transmitted through the repeater in one direction at a time. Relays 30 and 31 are used for controlling the repeater for transmission from east to west and relays 32 and 33 for controlling the repeater for transmission from west to east. Relays 30 and 31 are connected through a circuit arrangement, according to this invention, and amplifier-rectifier equipment indicated by box 41 to the west to east repeating path whereby relay 30 will be maintained operated a certain definite period of time after the transmission from the west has ceased, and relay 31 will be maintained operated, after the transmission from the west has ceased for a certain longer period than the relay 30. Relays 33 and 32 are arranged in a similar circuit connected to the west to east repeating path through the amplifier rectifier equipment indicated with a box 50. The period for maintaining relay 32 operated after the east to west transmission has ceased is of the same length as the period for maintaining relay 30 operated after cessation of transmission from west to east, and the period for maintaining relay 33 operated is of the same length as that for maintaining relay 31 operated. The functions of these relays in the repeater circuit shown may be made clear by describing the transmission of speech current from west to east. The networks illustrated with the hybrid coils 36 and 39 do not necessarily provide a complete balance for the incoming lines 35 and 40.

If speech current is incoming from the west over conductors 35, this current is transmitted through the hybrid coil 36, a well-known amplifier and a delay filter represented merely by boxes 37 and 38, respectively, and provided relay 30 has operated, through hybrid coil 39 and out over the conductors 40. A certain portion of this speech current is passed through the usual amplifier rectifier circuit represented by box 41 to the conductors 42 and 43. These conductors are connected in a manner similar to that of conductors 4 and 5 to windings 1 and 2 in the previous figures to relays 30 and 31, respectively. The connection in the case of relay 30 is as follows: Through the left hand winding of relay 30 from conductor 42 through left hand winding of relay 31, armature and back contact of relay 33 to conductor 43, and from conductor 42 also through the right hand winding of relay 30 through a portion 45 of a delay filter 47 to the armature and back contact of relay 33 to conductor 43. The circuit connections for relay 31 are identical to those for relay 30 except that in addition to the portion 45, portion 46 of the delay filter 47 is also connected through the right hand winding of relay 31 through the back contact of relay 33 to conductor 43. By this arrangement of the delay filter 47 in the circuits for relays 30 and 31, relay 31 will be maintained operated longer than relay 30 after speech current has ceased to be applied.

The purpose of this difference in the release characteristics of relays 30 and 31 on the operation of the repeater circuit will be clear from the following. On the application of speech current from the west, relays 30 and 31 are operated. Relay 30 opens the short-circuit for certain windings of the hybrid coil 39 so as to permit speech current from the west to be transmitted through this coil from the output of delay filter 38 to line 40. The operation of relay 31 opens the circuit for the control of relays 33 and 32 to prevent these relays from being operated by returning currents through the repeater 49 and the amplifier rectifier 50 during the transmission of speech current from west to east. When the transmission of speech from the west ceases it will be noted that the maintenance of relay 30 operated for a certain period thereafter will permit the last portion of the speech current incoming from the west to be transmitted to the east through the hybrid coil 39. This period of delay may be definitely determined so that when this relay finally releases the last portion of the speech current from the west has actually been transmitted to line 40. Relay 31 may now, therefore, be released to close the control circuits for relays 33 and 32 as no more speech current incoming from the west can be transmitted through the hybrid coil 39 to affect relays 33 and 32.

If speech is transmitted from the east to the west the speech current incoming through conductors 40 is transmitted through the hybrid coil 39, the repeater equipment and the delay filter represented respectively by boxes 49 and 48, and provided relay 32 has been operated, through the hybrid coil 36 to conductors 35. A certain portion of this speech current is transmitted through the amplifier rectifier circuit represented by box 50 to control the relays 32 and 33 in the same manner as were the relays 30 and 31 by speech incoming to conductors 35, i. e., in this case the operation of the relay 32 opens the short-circuit for

certain windings of the hybrid coil 36 to permit the transmission of speech from east to west and the operation of relay 33 opens the control circuit for relays 30 and 31 to prevent their operation under these circumstances.

What is claimed is:

1. The combination in a controlling system of an electro-responsive device having two current receiving elements, a movable member controlled thereby, a source of current common to said elements, both elements of said device being directly connected to the common source and controlled directly by the current so that each receives a different portion of the current therefrom, the resulting currents in the receiving elements controlling the movement of said movable member in the same direction, and a delay element connected between said source and one of said current receiving elements to delay the delivery of current to said one receiving element with respect to the delivery of current to the other of said receiving elements.

2. The combination in a controlling system of a relay, a source of intermittent current, and means responsive to the application of current from said source thereto for operating said relay and maintaining it operated for a predetermined period differing in duration from and having a fixed relation to the period of application of current to said means, said means including means for delaying the transmission of a portion of the applied current to said relay.

3. A controlling system comprising a relay, a source of potential, and means including a delay circuit and responsive to the application of electro-motive force from said source for operating said relay and maintaining it actuated for a predetermined period, said period beginning substantially simultaneously with the application of electro-motive force from said source to said means and continuing for a certain interval of appreciable length after the application of electro-motive force to said means has ceased, said interval having a fixed relation to the period of application of electro-motive force, said delay circuit operating to delay the transmission to said relay of a portion of the current due to the applied electro-motive force.

4. A controlling system comprising a relay, a source of potential, and means including a delay circuit and responsive to the application of electro-motive force from said source thereto for operating said relay and maintaining it actuated for a predetermined period, said period being of a longer duration than the period of application of electro-motive force to said means, said delay circuit operating to delay the transmission to said relay of a portion of the current due to the applied electro-motive force.

5. A controlling system comprising a plurality of relays, a source of intermittent current, means for supplying current from said source to each of said relays, and means including a delay device responsive to the application of current thereto for operating said relays substantially simultaneously and maintaining them operated for periods of different length relative to the period of application of current to said first mentioned means.

6. A controlling system comprising a plurality of relays each having two windings, a delay filter, one winding of each relay being connected at a different point of the delay filter, a common source of current connected to all of the windings and with the delay filter included between the source of current and the windings connected with said filter.

In witness whereof, I hereunto subscribe my name this 15th day of March, A. D. 1926.

BJÖRN G. BJÖRNSON.