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TIME-DELAY RELAY CIRCUIT

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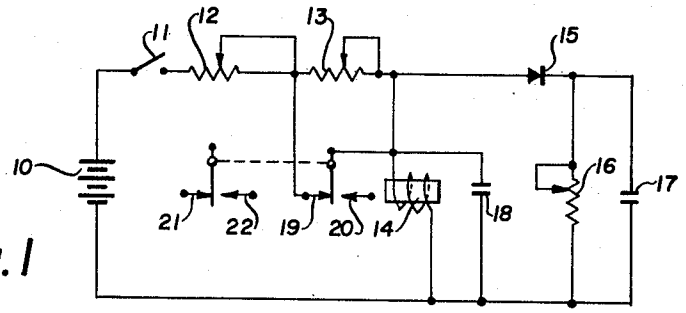


Fig. 1

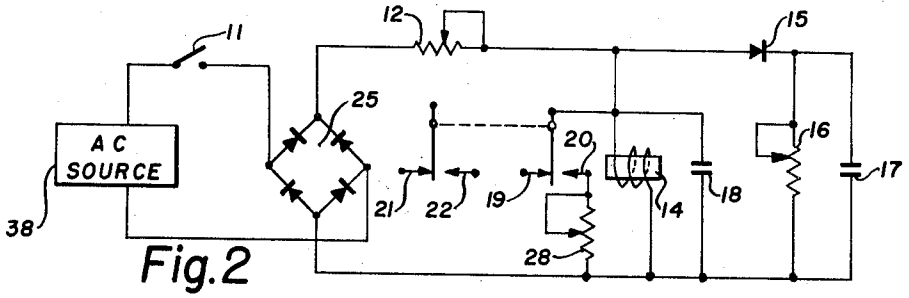


Fig. 2

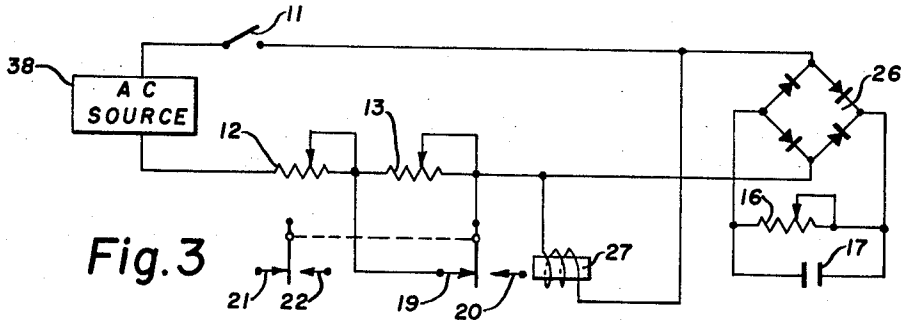


Fig. 3

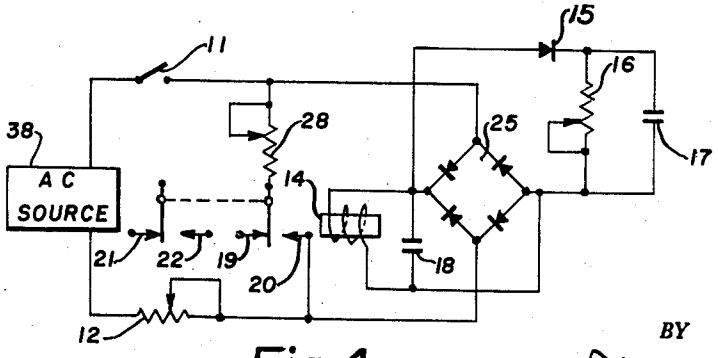


Fig. 4

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TIME-DELAY RELAY CIRCUIT

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6 Claims. (Cl. 317—141)

This invention relates to a means for controlling the operate time of a relay independently of its release time, by the use of a capacitor and resistor together with one or more rectifying elements. The circuit also embodies a marginal feature, so that the operate voltage and release voltage of the relay are independently adjustable.

The relay circuit of my invention is particularly suited for use with devices which are operated from commercial A.-C. power when it is available and from a source of standby power when the commercial A.-C. power fails. One of the requirements of this application is that the transfer from the normal A.-C. source to the standby source be as rapid as possible upon failure of the normal source. It is also important that the transfer to the standby source be effected if the voltage of the normal source falls below the minimum value at which satisfactory operation of the equipment is obtainable.

When interruptions of the commercial A.-C. power occur, the A.-C. voltage frequently is erratic, remaining normal for a few seconds after interruption, and then failing again either partially or completely. It is highly desirable that the transfer device should not attempt to follow these rapid interruptions and return of normal power, but should keep the equipment running on the standby source of power until the normal power source has been restored for a sufficient period of time to indicate its probable permanent restoration. Prior devices designed for this service have made use of a number of relays and one or more timing devices. It is an object of my invention to provide a transfer relay circuit meeting the requirements just outlined with a single relay, making use of capacitors for time delay.

It is also an object of my invention to provide a time-delay relay circuit in which the operate time and release time of the relay are independently adjustable, and particularly so that the delay on operation of the relay may be long and the delay on release may be extremely short.

Another object of my invention is to provide a marginal relay circuit in which the operate value and release value of the relay are independently adjustable, and in which the operation of the relay is delayed for a predetermined time after the application of power to the circuit.

Another object of my invention is to provide a simple and inexpensive time delay for an alternating current relay.

A further object of my invention is to utilize the charging of a condenser to delay the operation of a relay, without having the release of the relay delayed by the discharge of the same condenser.

Another object of my invention is to provide a time delay relay circuit in which the release of the relay is instantaneous upon interruption of power to the circuit and in which the release of the relay is delayed when the input voltage to the circuit falls only slightly below the marginal release value.

An additional object of my invention is to provide

with a single relay a time delay circuit in which delayed operation of the relay is obtained regardless of how brief the power interruption may be.

Other objects and a better understanding of my invention may be obtained by referring to the following specification and claims in connection with the accompanying drawings in which:

Figure 1 is an embodiment of my invention operating from a source of direct current.

Figure 2 is a modification of the arrangement shown in Figure 1 operating from an alternating current source and utilizing a full wave bridge rectifier.

Figure 3 is an embodiment of my invention arranged for delaying the operation of an A.-C. relay.

Figure 4 is a modification of the arrangement shown in Figure 2 utilizing a full-wave bridge rectifier adapted to be energized from an alternating current source.

Specifically, Figure 1 shows a relay 14 energized from a direct current source 10 through series resistors 12 and 13. Capacitor 18 is connected in parallel with relay 14. The winding of relay 14 is also shunted by the series combination of capacitor 17 and half-wave rectifier 15. Resistor 16 is connected in parallel with capacitor 17.

The contacts 21 and 22 are operated by the relay 14 and these contacts may be used to control any device in accordance with the time delay operation of the relay 14. More specifically, contacts 21 and 22 may be used to transfer the operation of a device from normal commercial power to a standby source of power, as explained hereinabove. Switch 11 could be the circuit breaker in a power line, operated repeatedly or erratically due to trouble in the power network in which case the relay 14 would sense this trouble and take care of the power transfer of a device from normal commercial power to a standby source of power through contacts 21 and 22. It is to be understood that my novel circuit is not limited to the use of transferring the operation of a device from a normal source of power over to a standby source of power, but may be used for many purposes. My novel circuit, as will be explained later, provides for giving reliable operation when transferring from normal source to standby source.

The operation of the relay circuit shown in Figure 1 is briefly as follows:

Assume that capacitors 17 and 18 are fully discharged and switch 11 is then closed. Capacitor 17 will charge at an exponential rate to a final voltage equal to the steady-state voltage drop across resistor 16. At the same time, the voltage across the winding of relay 14 will also increase at an exponential rate until it reaches the voltage at which the relay operates. When the relay operates, the back contact 19 opens, removing the short-circuit from across resistor 13.

The insertion of resistor 13 in the relay circuit has a tendency to lower the voltage across the winding of relay 14. With certain types of relay construction, this may cause the relay contacts to buzz and prevent complete operation of the relay. In order to maintain sufficient voltage across the relay coil to make it operate positively, the capacitor 18 is added to the circuit. The charge stored on capacitor 18 prevents an instantaneous drop of voltage across the relay winding 14 and assures positive operation of the relay. In addition, the capacitor 18 can be increased in size to provide a delay in the release of the relay 14. Positive relay action is also aided by another factor. The voltage drop through resistor 12 during the time delay period is due in a large part to the charging current being drawn by capacitor 17 through the half wave rectifier 15. When the additional resistor 13 is inserted in the circuit by the opening of relay contact 19, the initial drop in voltage across the winding of relay 14 may be very small even if ca-

pacitor 18 is omitted from the circuit. This is true because as soon as the voltage across the winding of relay 14 drops, the voltage across capacitor 17 becomes larger than the voltage across the winding of relay 14. Under this condition, the half-wave rectifier 15 prevents discharge of capacitor 17 through the relay winding, but, during the time that capacitor 17 is discharging through resistor 16, the parallel combination of capacitor 17 and resistor 16 draws no current from the source 10. As a result, the drop in voltage upon opening of the relay contact 19 is much less than would normally be obtained, and the positive relay action can be obtained even if capacitor 18 is omitted from the circuit, provided the mechanical construction of relay 14 is suitable for this purpose.

Resistor 13 is adjusted to provide the required release value in the relay circuit. By adjustment of the resistor 13, the release voltage of the relay can be brought as near as required to the operate voltage. As previously mentioned, the voltage across the winding of relay 14 does not immediately drop to its final value upon opening of relay contact 19 but falls gradually as capacitor 17 discharges through resistor 16. Because of this fact, a momentary drop in the voltage of source 10 below the voltage at which the relay is adjusted to release in a steady state condition will not cause a release of the relay. In case of a momenary drop in the voltage of source 10 the distribution of voltage between the relay 14 and the dropping resistors 12 and 13 is changed by the energy stored in capacitor 17. However, in case of a complete failure of voltage from source 10 as when switch 11 is open, the relay 14 is completely de-energized except for the charge stored on capacitor 18. The charge stored on capacitor 17 is prevented from discharging through the relay windings by the half-wave rectifier 15. The time delay on operation of the relay is proportional to the sum of the capacitors 17 and 18, whereas the time delay on release of the relay depends only on capacitor 18 which may be made as small as required, or even omitted when the mechanical construction of the relay provides the positive relay action previously described. By means of this circuit, I am, therefore, able to obtain an extremely long delay on operation of the relay 14 and a practically instantaneous release of the relay when the circuit is de-energized.

The circuit shown in Figure 1 has another extremely valuable characteristic. After the relay 14 operates, the voltage across capacitor 17 drops as the capacitor discharges through resistor 16 until the voltage across capacitor 17 becomes substantially the same as that across relay 14. This voltage will normally approach the release voltage of the relay 14, as adjusted by resistor 13, and may be considerably less than the operate voltage of the relay. After the steady state condition has been reached, with the relay operated, if the relay is released by a momentary opening of the switch 11, the switch then being reclosed, substantially the entire time delay of the circuit will be obtained before the relay again operates, because the capacitor 17 must be recharged from the release voltage of the relay 14 to the operate voltage of relay 14 before the relay 14 can again operate.

Figure 2 shows a modification of the circuit shown in Figure 1 utilizing a full-wave rectifier 25 to supply direct current to the circuit from alternating current source 38. The series resistor 13 in Figure 1 is replaced by a shunt resistor 28 in Figure 2.

The shunt resistor 28 is connected through the normally open contact 20 of relay 14, so that when relay 14 operates, additional current is passed through resistor 12 dropping the voltage to relay 14, providing operating conditions similar to those in Figure 1.

In the circuit of Figure 2, resistor 28 is not introduced into the circuit until the relay armature has almost completed its travel and the front contact 20 of relay 14 is closed. This is particularly advantageous when capacitor 18 is to be made very small or omitted to obtain rapid release of the relay, as positive relay action is more easily obtained if the relay voltage is not reduced until the relay armature has almost completed its travel.

Figure 3 is a circuit diagram of an arrangement for delaying the operation of an A.-C. relay. The resistor or impedance element 12 in Figure 3 provides the voltage drop to delay the operation of the A.-C. relay 27 until capacitor 17 has been charged through the rectifier 26. If marginal relay operation is required, it can be obtained through the use of the resistor or impedance element 13 controlled by the back contact 19 of relay 27 as in Figure 1. The operation of the circuit of Figure 3 is similar to that of Figure 1 except that in Figure 3 there is no provision for delaying the release of the relay after switch 11 is opened.

Figure 4 is a circuit diagram of an arrangement using the full wave bridge rectifier 25 energized from an A.-C. source 38 through a resistor or impedance element 12 and a switch 11. Resistor 28 is connected in parallel with rectifier 25 through the normally open contact 20 of relay 14. Rectifier 25 supplies current to the parallel combination of relay 14 and capacitor 18, as well as to the parallel combination of resistor 16 and capacitor 17 through the half-wave rectifier 15.

The chief differences between Figure 4 and Figure 2 are that the rectifier 25 in Figure 4 may be of a lower voltage rating because the element 12 is in the A.-C. circuit, and the elements 12 and 28 in Figure 4 may be reactive rather than resistive to reduce the power consumption of the circuit.

Where marginal relay operation and maximum time delay with brief power interruptions are not required, the resistor 13 can be omitted from Figures 1 and 3 and resistor 28 can be omitted from Figures 2 and 4.

Although I have described my invention with a certain degree of particularity, it is to be understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as herein claimed.

What is claimed is:

1. In combination, a relay having a winding and a contact, said relay being operable to close said contact when the voltage across said winding is of an operating value and being operable to open said contact when the voltage across said winding is below a release value, a half-wave rectifier, a second rectifier, a first capacitor, a second capacitor connected across said relay winding, a first resistor, a second resistor, and a third resistor, first circuit means for energizing said relay winding and said second capacitor from an alternating current source through said second rectifier and said first resistor to apply an operating voltage to said relay winding and close said contact, second circuit means connecting said half-wave rectifier and said first capacitor in series with each other and with said half-wave rectifier and said first capacitor connected across said relay winding, said third resistor being connected across said first capacitor, said half-wave rectifier being polarized to pass charging current from said second rectifier to said first capacitor upon energization of said first and second circuit means for reducing the voltage across said relay winding to delay the operation of the relay and the closing of said relay contact until said first capacitor is charged to a voltage sufficient to operate said relay, third circuit means controlled by operation of said closed contact for directing current from said source through said first and second resistors to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said second capacitor assuring positive operation of said relay and the maintenance of said closed conact at said decreased voltage, said decreased voltage across said relay

winding causing said first capacitor to discharge, said polarized half-wave rectifier preventing discharge current of said first capacitor from traversing said relay winding and directing said discharged current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a re-charging of said first capacitor upon re-energization of said first circuit means.

2. In combination, a relay having a winding and a contact, said relay being operable to close said contact when the voltage across said winding is of an operating value and being operable to open said contact when the voltage across said winding is below a release value, a half-wave rectifier, a second rectifier, a first capacitor, a second capacitor connected across said relay winding, a first resistor connected between said second rectifier and said source, a second resistor, and a third resistor, first circuit means for energizing said relay winding and said second capacitor from an alternating current source through said second rectifier and said first resistor to apply an operating voltage to said relay winding and close said contact, second circuit means connecting said half-wave rectifier and said first capacitor in series with each other and with said half-wave rectifier and said first capacitor connected across said relay winding, said third resistor being connected across said first capactor, said half-wave rectifier being polarized to pass charging current from said second rectifier to said first capacitor upon energization of said first and second circuit means for reducing the voltage across said relay winding to delay the operation of the relay and the closing of said relay contact until said first capacitor is charged to a voltage sufficient to operate said relay, third circuit means controlled by operation of said closed contact for directing current from said source through said first and second resistors to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said second capacitor assuring positive operation of said relay and the maintenance of said closed contact at said decreased voltage, said decreased voltage across said relay winding causing said first capacitor to discharge, said polarized half-wave rectifier preventing discharged current of said first capacitor from traversing said relay winding and directing said discharged current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a re-charging of said first capacitor upon re-energization of said first circuit means.

3. In combination, a relay having a winding and a contact, said relay being operable to close said contact when the voltage across said winding is of an operating value and being operable to open said contact when the voltage across said winding is below a release value, a half-wave rectifier, a second rectifier, a first capacitor, a second capacitor connected across said relay winding, a first resistor connected between said second rectifier and said relay winding, a second resistor, and a third resistor, first circuit means for energizing said relay winding and said second capacitor from an alternating current source through said second rectifier and said first resistor to apply an operating voltage to said relay winding and close said contact, second circuit means connecting said half-wave rectifier and said first capacitor in series with each other and with said half-wave rectifier and said first capacitor connected across said relay winding, said third resistor being connected across said first capacitor, said half-wave rectifier being polarized to pass charging current from said second rectifier to said first capacitor upon energization of said first and second circuit means for reducing the voltage across said relay winding to delay the operation of the relay and the closing of said relay contact until said first capacitor is charged to a voltage sufficient to operate said relay, third circuit means controlled by operation of said closed contact for directing current from said source through said first and second resistors to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said second capacitor assuring positive operation of said relay and the maintenance of said closed contact at said decreased voltage, said decreased voltage across said relay winding causing said first capacitor to discharge, said polarized half-wave rectifier preventing discharged current of said first capacitor from traversing said relay winding and directing said discharged current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a re-charging of said first capacitor upon re-energization of said first circuit means.

4. In combination, a relay having a winding and contact means, said relay being operable when the voltage across said winding is of an operating value and being releasable when the voltage across said winding is below a release value, a rectifier, a capacitor, a first resistor, a second resistor, and a third resistor, first circuit means for energizing said relay winding from a current source through said first resistor to apply an operating voltage to said relay winding, second circuit means connecting said rectifier and said capacitor in series with each other and with said rectifier and said capacitor connected across said relay winding, said third resistor being connected across said capacitor, said rectifier being polarized to pass charging current from said source to said capacitor for reducing the voltage across said relay winding to delay the operation of said relay and said contact means until said capacitor is charged to a value sufficient to operate said relay, third circuit means controlled by said contact means upon operation of said relay for directing current through said second resistor to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said decreased voltage across said relay winding causing said capacitor to discharge, said polarized rectifier preventing discharged current of said capacitor from traversing said relay winding and directing said discharged current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a recharging of said capacitor upon re-energization of said first circuit means.

5. In combination, a relay having a winding and contact means, said relay being operable when the voltage across said winding is of an operating value and being releasable when the voltage across said winding is below a release value, a rectifier, a capacitor, a first resistor, a second resistor connected in series with said winding and shunted by said contact means, and a third resistor, first circuit means for energizing said relay winding from a current source through said first resistor to apply an operating voltage to said relay winding, second circuit means connecting said rectifier and said first capacitor in series with each other and with said rectifier and said capacitor connected across said relay winding, said third resistor being connected across said capacitor, said recti-

fier being polarized to pass charging current from said source to said capacitor for reducing the voltage across said relay winding to delay the operation of said relay and said contact means until said capacitor is charged to a value sufficient to operate said relay, third circuit means controlled by said contact means upon operation of said relay for directing current through said second resistor to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said decreased voltage across said relay winding causing said capacitor to discharge, said polarized rectifier preventing discharged current of said capacitor from traversing said relay winding and directing said discharged current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a recharging of said capacitor upon re-energization of said first circuit means.

6. In combination, a relay having a winding and contact means, said relay being operable when the voltage across said winding is of an operating value and being releasable when the voltage across said winding is below a release value, a rectifier, a first capacitor, and a second capacitor connected across said relay winding, a first resistor, a second resistor connected in series with said winding and shunted by said contact means, and a third resistor, first circuit means for energizing said relay winding from a current source through said first resistor to apply an operating voltage to said relay winding and said second capacitor, second circuit means connecting said rectifier and said first capacitor in series with each other and with said rectifier and said first capacitor con-

nected across said relay winding, said third resistor being connected across said first capacitor, said rectifier being polarized to pass charging current from said source to said first capacitor for reducing the voltage across said relay winding to delay the operation of said relay and said contact means until said first capacitor is charged to a value sufficient to operate said relay, third circuit means controlled by said contact means upon operation of said relay for directing current through said second resistor to decrease the voltage applied to said relay winding from said source to a value less than the operating voltage but greater than the release voltage, said decreased voltage across said relay winding causing said first capacitor to discharge, said polarized rectifier preventing discharge current of said first capacitor from traversing said relay winding and directing said discharge current to flow through said third resistor, said second and third circuit means establishing a steady state voltage condition approaching that of the release voltage of the relay and thereby providing a rapid release of said relay upon de-energization of said first circuit means and also providing a delay to the operation of the relay by a recharging of said first capacitor upon re-energization of said first circuit means.

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