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2,685,052

CONDENSER-TIMED RELAY INTERRUPTER

Filed May 29, 1951

FIG. 1

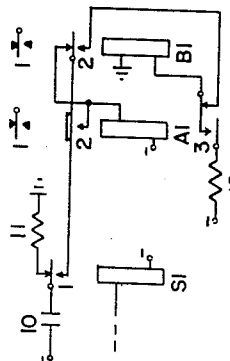


FIG. 2

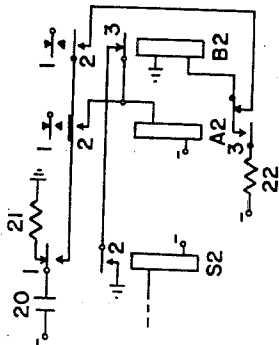


FIG. 3

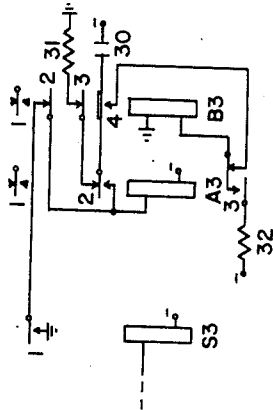


FIG. 4

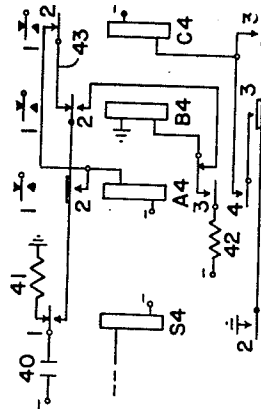
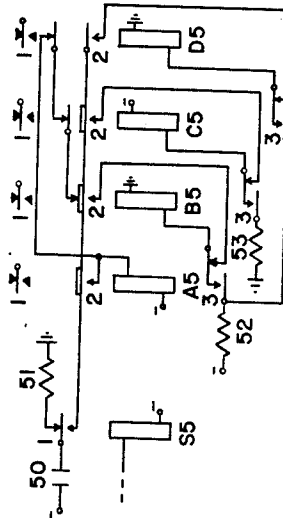


FIG. 5



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CONDENSER-TIMED RELAY INTERRUPTER

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2 Claims. (Cl. 317-139)

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This invention relates to condenser-timed relay interrupters and more particularly to relay-type multi-step interrupters adaptable for use in automatic telephone equipment.

It is an object of the present invention to provide a simple and economical electrical interrupter flexibly adaptable to the control of cyclic circuit functions.

Another object is to provide a multi-step sequential interrupter in which the time between steps may be individually adjusted to provide any one of a wide range of timing cycles.

A further object is to provide a multi-step circuit interrupter in which as many steps may be incorporated as may be needed to meet any of a wide variety of specific circuit applications.

It has been found that relay-type interrupters efficiently capable of fulfilling the above objects may be attained by utilization of circuit arrangements in which both the charge and discharge characteristics of condensers are used for timing purposes. Briefly, each of the basic circuit arrangements herein disclosed for accomplishing the desired results, in general, require merely a condenser and one or more pairs of relays. The relays are so arranged that all are first pulled-in in quick succession, and are then allowed to restore successively at times dependent upon the rate of change of the charge on the condenser. The first relay of each pair restores in its proper sequence when the discharge current flowing through it from the condenser drops to the restoring value of the relay. Upon restoration of the first relay, the condenser is arranged to be recharged through the second relay, during which period the second relay is maintained operated until the charging current drops to the restoring value of that relay.

A feature of the invention lies in the fact that each of the basic circuits may be extended to increase the number of steps in its cycle of operation to meet any of a large variety of specific needs by adding pairs of relays until the desired number of steps are provided. Such an extended circuit, like the basic circuits, is operated by pulling in all of its relays in quick succession at the start of the cycle, following which, all are restored in succession at times determined by the current values at which the individual relays restore and the rate at which the charge on a common condenser is permitted to change during each step of the cycle.

Another feature of the invention resides in the fact that it may be arranged to be stopped at any instant during the cycle, or may be so ar-

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ranged that each initiated cycle will continue to completion before it can be stopped.

Still another feature of the invention is that the timing cycle may be governed by a single condenser common to all relays of the circuit and may incorporate as many steps as desired, each individually adjustable to provide the timing desired before the next succeeding step in the cycle is effected.

Other objects and features of the invention will become apparent as the description progresses.

Referring now to the drawings.

Fig. 1 shows a basic two-relay, condenser timed interrupter circuit embodying the principles of the present invention.

Fig. 2 shows another form of two-relay condenser timed circuit, modified over the circuit shown in Fig. 1 in the manner in which the first relay of the cycle is initiated.

Fig. 3 is still another embodiment of the invention, differing from the circuits of Figs. 1 and 2 in that the cycle may be initiated by a mere pulse of voltage.

Fig. 4 shows a variation of the basic 2-relay timed interrupter circuit in which a third relay is utilized to halt operation of the circuit after completion of one cycle of operation whereupon the start relay must be released before another cycle can be started.

Fig. 5 is another circuit comprising an extension of the basic two relay timed interrupter circuit having twice as many steps in its cycle as in the basic circuits.

Wherever a terminal is shown at the apparent end of a circuit path, with a negative polarity mark associated therewith, a connection to the ungrounded negative pole of a grounded battery, or other source of direct current (not shown), is thereby intended.

In the embodiment of the invention shown in Fig. 1, the condenser 10 is normally retained in charged condition by being connected across the battery or direct current source through break contacts 1 of start relay S1 and a current limiting resistance 11. When the start relay S1 is operated by means external to the circuit (not shown), the condenser 10 is placed in series with the winding of relay A1 through the make contacts of start relay S1 and the break contacts of the break-make contact set 2 of relay B1, whereupon the condenser 10 begins to discharge, supplying discharge current to the winding of relay A1 and causing it to be pulled in.

Upon operation of relay A1, closure of its make

contact set 2 forms a holding path for the relay by connecting its winding directly in series with the condenser 10 through the contact set 2, independent of the energizing path already established through the break contacts of contact set 2 of relay B1.

Operation of relay A1 energizes relay B1 by closing the make contacts of the make-before-break contact set 3 of relay A1, which connects the winding of relay B1 between battery and ground through a current limiting resistance 12.

As soon as relay B1 is operated, the break contacts of break-make contact set 2 opens the external energizing path for relay A1 and causes relay A1 to be energized solely through its own holding path through which the condenser 10 discharges. Relay A1 remains operated so long as the discharge current of condenser 10 remains above the release value of relay A1. When such current diminishes to the value at which relay A1 restores, it disconnects its own holding circuit through the make contacts of contact set 2, and opens the energizing circuit for relay B1 at the make contacts of the make-before-break contact set 3. Before disconnecting the energizing circuit, however, it places the condenser 10 in series with relay B1 by closure of the break contacts of the contact set 3. The condenser can then be charged through the path formed by the winding of relay B1, the break contacts of contact set 3 of relay A1, and the make contact set 2 of relay B1, which are connected to the condenser 10 through the contact set 1 of start relay S1. The value of charging current for the condenser 10 flowing through the winding of relay B1 is initially high, but it diminishes gradually as the condenser becomes charged until the restoring value of relay B1 is reached, whereupon relay B1 is restored to make the circuit ready for another cycle of operation.

In this circuit, as long as the start relay S1 is energized, cyclic operation of the circuit will continue, and the condenser will alternately discharge through the winding of relay A1 and become charged again through the winding of relay B1. If the start relay S1 is deenergized at any point in the cycle, the circuit is restored to its normal condition ready to be initiated again.

In the modification of the invention shown in Fig. 2, the circuit is arranged so that the period of the cycle may be lengthened over that of the circuit of Fig. 1, by arranging the condenser 20 so that it becomes connected in series with a relay A2 after the relay has been operated by energy supplied independently of the charge on the condenser. The charge on the condenser is thus used solely for controlling the time of operation of relay A2, rather than being partly consumed for operation of relay A2. In other words, the period for which the first timing relay is maintained operated, after once being initiated, may be lengthened considerably with the circuit arrangement of Fig. 2, since none of the charge on condenser 20 is initially consumed in operating relay A2. This circuit, like that of Fig. 1 may be stopped at any time by deenergizing the start relay.

The operation of this circuit is initiated by a start relay S2 which applies ground to the winding of relay A2 through the make contact set 2 of relay S2 and the break contact set 3 of relay B2. Relay S2 also causes the condenser 20, which is normally maintained in charged condition between connections to battery and ground through the break contacts of a break-make contact set 1 of relay S2 and a current limiting resistance 21,

to be connected to the back contact of the make contact set 2 of relay A2, preparatory to providing a holding path for relay A2 when it operates.

When relay A2 is operated, its holding path is formed by closure of its make contact set 2 through which the condenser 20 may be discharged. The condenser 20, however, will not discharge through this holding path until the ground connection to the winding of relay A2 established through the make contacts 2 of start relay S2, is opened at the break contacts 3 of relay B2. Operation of relay A2 causes relay B2 to be operated by closing the make contacts of the make-before-break contact set 3 of relay A2, thereby energizing the winding of relay B2 between ground and battery through a current limiting resistance 22. Relay B2 is thereby made to operate almost immediately following the operation of relay A2.

The operation of relay B2, in being effective to remove ground potential from the winding of relay A2, permits condenser 20 to start discharging through the winding, thereby keeping relay A2 in operated condition for a period governed by the time required for the condenser discharge current to reduce to the restoring value of the relay. Relay B2 also acts to prepare a holding path for itself through its own break contact set 2 which becomes effective when the condenser is placed in series with the relay winding through the break contacts of contact set 3 of relay A2, when relay A2 restores.

When the discharge current of condenser 20 diminishes to the restoring value for relay A2, the holding circuit for the relay is opened at its make contacts 2, and in addition, the energizing path for relay B2 through the make contacts of contact set 3 is also opened. Before the energizing path for relay B2 is opened, however, the condenser 20 is placed in series with its winding through the break contacts of the contact set 3 of relay A2 so that it will continue to be held in operated position by the condenser charging current flowing therethrough. Relay B2 will thus be maintained operated for a time following restoration of relay A2 dependent upon the time required for the charge on the condenser to build up through the holding path of relay B2. When the condenser charge reaches a point where the charging current has diminished to the value at which relay B2 restores, its make contacts 2 open the path leading to condenser 20, while its break contacts 3 are closed so that ground again may be placed on the winding of relay A2 to reinitiate the cycle.

In the embodiment of Fig. 3, the timing condenser 30 is so arranged with respect to the windings of the relays A3 and B3, that if the start relay is de-energized at any time during the cycle of operation of the circuit, the cycle will not be halted, but will continue until all steps have been completed, and only at such time will the circuit be ready for reoperation. Thus, only a pulse of voltage is required to initiate a cycle of operation of this circuit, but if desired, continuous operation of the circuit can be effected by application of a constant ground to the start relay S3.

Upon operation of the start relay S3, ground potential is applied to one side of the winding of relay A3 through the make contacts 1 of the start relay and the break contacts 2 of relay B3. Voltage is thus applied to relay A3 and it operates almost immediately following initial operation of the start relay.

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Operation of the relay A3 causes the charged condenser 30 to be placed in series with its winding through the make contacts of its break-make contact set 2. Condenser 30 is normally charged over the path formed by the break contacts of the contact set 2, the contacts 3 of relay B3, and the current limiting resistance 31. Operation of the relay A3 is also effective in energizing the winding of relay B3 between battery and ground and through the make contacts of the make-before-break contact set 3 of relay A3, as well as through the current limiting resistance 32.

When relay B3 operates, it disconnects ground from the winding of relay A3 by opening its break contacts 2. As long as the break contacts 2 of relay B3 remain closed, the condenser is maintained in charged condition because ground is applied to the condenser through the make contacts 1 of the start relay S3 and the make contacts of contact set 2 of relay A3. The timing for relay A3, therefore, does not begin until the contact set 2 of relay B3 is opened. Operation of relay B3 also opens its break contacts 3, thereby opening the initial charging circuit for the condenser 30. Thus, when contact set 3 of relay B3 is opened, restoration of the break contacts of the make-break contact set 2 of relay A3 will not cause condenser 30 to be supplied with charging current. As long as the start relay S3 is maintained operated such current can be supplied only through the winding of relay B3. The closure of the make contacts 4 of relay B3 places the condenser 30 in series with the break contacts of the make-before-break contact set 3 of relay A3 preparatory to the charging of condenser 30 upon restoration of relay A3.

When the discharge current of condenser 30 passing through the winding of relay A3 diminishes sufficiently, relay A3 restores, thereby opening the break contacts of its make-before-break set 3, and placing the condenser 30 in series with the winding of relay B3 through which the condenser may again be charged. As long as the charging current is high, the relay B3 remains operated, but as soon as it diminishes to a low enough value, the relay restores. The rate at which condenser 30 becomes charged, and consequently the period required for relay B3 to be restored, is dependent upon the resistance, inductance and capacitance in the path of which it is a part.

Upon restoration of relay B3, its contact set 2 closes again to connect the ground through the contact set 1 of start relay S3 to the winding of relay A3, thereby causing the circuit to be recycled. If, however, at any time during the operating cycle, the ground connection through the start relay S3 is disconnected, it will be noted that the cycle will continue until completion, since relay A3 has its own holding path through the make contacts of the make-break contact set 2. Relay A3 will thus be kept operated until condenser 30 is discharged, after which operation of relay B3 will continue by reason of the condenser 30 being charged through its winding. In other words, the operating cycle after once being started, becomes independent of the ground on the start relay S3.

Fig. 4 shows a modification of the basic circuit shown in Fig. 1 in which an additional relay C4 is provided to prevent re-cycling following the first cycle of operation unless the start relay S4 is first restored. This circuit utilizes the basic circuit arrangement of Fig. 1, and accordingly may be stopped at any time during the cycle by

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de-energizing the start relay S4, but unlike the basic circuit arrangement, if the cycle is permitted to continue to the last step, the circuit will not re-cycle until the start relay S4 is first restored and then reinitiated. The relays A4, B4, and C4 are drawn up in quick succession, but after relay A4 and relay B4 have been restored following their timed period of operation, relay C4 will continue to be held operated. Operation of relay A4 and B4 is like that of the corresponding relays A1 and B1 in the circuit of Fig. 1, but the basic arrangement is changed slightly in that the lead 43 connected to the back contact of the make-break contact set 2 of relay B4 is connected to the break contacts 2 of relay C4 before returning to the make contacts 2 of relay A4. Additional make contacts 4 of relay A4, and make contacts 3 of relay B4 are provided to connect ground to relay C4 after relay A4 and B4 have been operated. After operation of relay C4, however, a pair of make contacts 3 of its own, causes it to hold itself until the start relay S4 is de-energized.

Thus, it will be seen that when relay C4 operates, the break contacts 2 thereof open the current path through which condenser 40 can operate relay A4, and even though the charged condenser may be connected to the front contact of the contact set 1 of the start relay S4, the relay A4 cannot be energized again until the break contacts 2 of relay C4 are closed. Such closure of contacts 2 of relay C4 can be effected only when the start relay S4 is first de-energized.

The circuit of Fig. 5 shows the manner in which the basic circuit may be extended to provide an increased number of timing steps as desired. Broadly, the relays of this circuit are all drawn up successively and then successively restored by alternate discharge and charge of the condenser 50. Upon restoration of the last relay, the circuit is again ready for recycling as in the basic two relay interrupter. It will be apparent that such an extension is not limited to only four steps of timing, but may be extended to include as many additional pairs of steps as might be required for any particular application.

The condenser 50 of this circuit is normally charged between battery and ground through the break contacts 1 of the start relay S5 and the current limiting resistance 51. When the start relay S5 is operated the condenser is placed in series with the winding of relay A5 through the break contacts of contact set 2 of each of the relays B5, C5, and D5 to operate relay A5.

When relay A5 operates, it provides a holding path for itself through the make contacts of its own contact set 2 so that it will be maintained operated as long as sufficient current is supplied from the condenser 50. The make contacts of the make-before-break contact set 3 of relay A5 also closes to energize the winding of relay B5 through the current limiting resistance 52.

When relay B5 is operated it opens the break contacts 2 of the break-make set 2 of relay B5, and prepares the series circuit for the condenser with the winding of relay B5 through the make contacts of the break-make contact set 2 of relay B5.

Similarly, relays C5 and D5 are operated successively upon operation of the contact set 3 of relay B5 and contact set 3 of relay C5, respectively.

It will be noted that relay A5 of this circuit is the only one which is initiated by the charge on the condenser 50, while the rest of the relays, namely relays B5, C5, and D5 are each operated

by separate circuits established by closure of the contacts of the relays preceding them in operation. Thus, the timing of the relays following the first are each independent in their operation. If, however, it is desired, the first relay in the series may also be made independent in its operation, by connecting the first relay to ground in the manner shown in Figs. 2 and 3.

It may be that the time constant of the discharge circuit for condenser 50 through relay A5 is such that the last relays in the series might not be operated, or may be in the process of being operated, while the first relay A5 is in the process of being restored. That is, relay A5 may restore in such a short time that the succeeding relays in the series may not have had sufficient time within which to be operated. Particularly is this so, when the circuit is extended to a large number of steps beyond the basic two relay circuit. Regardless of this fact, however, cycle timing of each of the relays by alternate discharge and charge of the condenser 50 will continue as long as the start relay S5 is held operated.

An advantage of extended arrangements of the basic circuits of the invention is that a reduction in the number of elements may be accomplished by utilizing elements common to more than one relay. An example of such a common element is resistance 52 in the energizing circuit for the windings of alternate relays B5 and D5. This combination to eliminate one resistance element is accomplished merely by joining the normally open contacts of the make-before-break contact sets of the energizing circuits with which the resistance is associated. Resistance 53 could likewise be made a common element for a number of relays. Thus, it is apparent that a pair of such current limiting resistances as resistances 52 and 53 may be made to function satisfactorily for all the relays of a multi-step timing circuit.

Although the interrupters herein disclosed are not shown as they might be applied in actual use in conjunction with specific apparatus, it will be readily apparent to those skilled in the art that with the provision of the work contacts 1 on each of the timing relays, the interrupters will readily lend themselves to numerous applications in circuit design. For example, the basic two-step circuits find application in conjunction with apparatus requiring periodic interruption of circuit continuity as for busy tone signalling in telephone systems, or pulsing of voltages for purposes such as signal lamp flashing or pulse generation. In addition, any of the basic two step circuits might be extended into circuits having four or more relays, as related above, to make the interrupters adaptable to even a much wider range of application.

I claim:

1. In combination, a series comprising an even number of normally restored electromagnetic relays each having normally open contacts and normally closed contacts controlled thereby, a source of direct current, a control condenser, means for establishing respective operating cir-

uits for the relays successively, the operating circuit of the first relay excluding all contacts of the first relay but including normally closed contacts of the last relay, the operating circuit of each relay succeeding the first including normally open contacts of the immediately preceding relay, means for establishing respective holding circuits for the relays successively, each holding circuit including said condenser and normally open contacts of its own relay, the holding circuit of each relay succeeding the first including normally closed contacts of the immediately preceding relay, whereby the restoration of each relay preceding the last closes the holding circuit and opens the operating circuit of the next succeeding relay, the holding circuit of each alternate relay, when closed, including said current source in series with the condenser, whereby the condenser charges therein, the holding circuit of each remaining relay, when closed, excluding said current source, whereby the condenser discharges therein.

2. In combination, a series comprising an even number of normally restored electromagnetic relays each having normally open contacts and normally closed contacts controlled thereby, a source of direct current, a control condenser having one terminal connected to one pole of the current source leaving one free terminal, means for establishing respective operating circuits for the relays successively, the operating circuit of the first relay excluding all contacts of the first relay but including normally closed contacts of the last relay, the operating circuit of each relay succeeding the first including normally open contacts of the immediately preceding relay, means for establishing respective holding circuits for the relays successively, each holding circuit including normally open contacts of its own relay connected between the free terminal of said condenser and the winding of the concerned relay, the holding circuit of each relay succeeding the first also including normally closed contacts of the immediately preceding relay, whereby said condenser is successively connected in the holding circuit of each relay of the series upon closure of the holding circuit of each such relay responsive to restoration of the immediately preceding relay, the holding circuit of each alternate relay, when closed, including said current source in series with the condenser, whereby the condenser charges therein, the holding circuit of each remaining relay, when closed, excluding said current source, whereby the condenser discharges therein.

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