Nov. 15, 1960 J. L. CONFALONE 2,960,635

RELAY CIRCUIT

Filed Jan. 24, 1957

FIG. 1

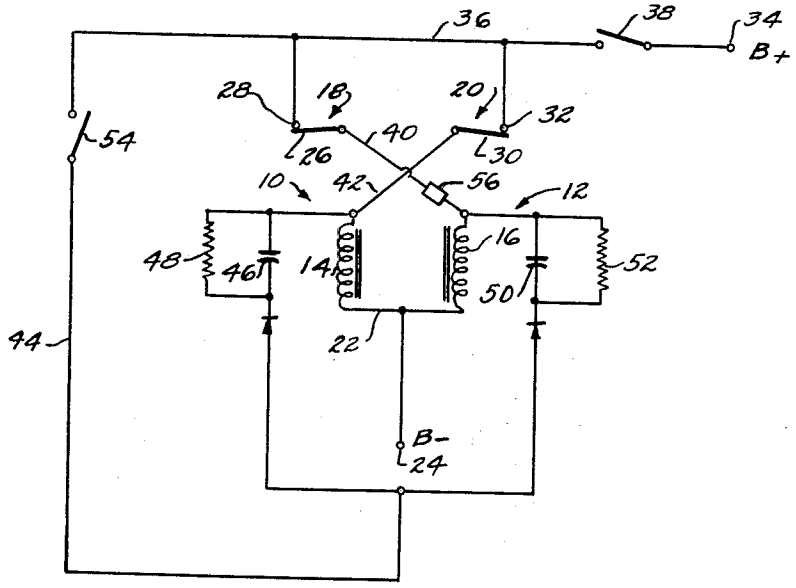
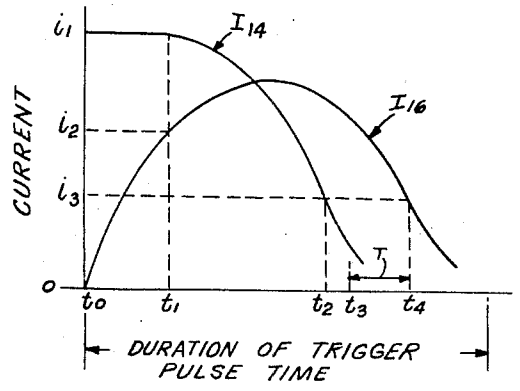



FIG. 2




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United States Patent Office 2,960,635 Patented Nov. 15, 1960



2,960,635

# RELAY CIRCUIT

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Filed Jan. 24, 1957, Ser. No. 636,218

1 Claim. (Cl. 317—137)

This invention relates to a relay circuit and particularly to a relay actuated bistable flip-flop circuit.

In the operation of such devices as stepping relays, square wave generators and other similar devices, it is desirable to have a bistable, low energy consuming flip-flop circuit.

The present invention provides a relay actuated circuit responsive to trigger impulses to change from one to the other of two bistable conditions.

In the construction according to the invention a pair of normally closed relay switches are connected in criss cross relation to a suitable source of energy so that the energization of either relay coil deenergizes the other relay coil and parallel trigger circuits energized through a trigger switch to energize the deenergized coil and operate the flip-flop.

It is accordingly an object of the invention to provide a bistable relay switch circuit.

It is a further object to provide a circuit for alternately energizing a pair of relay switches.

It is still another object to provide a relay operated flip-flop.

Other objects and advantages will be apparent from the following detailed description taken in conjunction with the accompanying drawing in which

Fig. 1 is a schematic diagram of a bistable circuit in accordance with the invention, and

Fig. 2 is a diagram illustrating the operation of the circuit of Fig. 1 during its transition between stable states.

In the exemplary embodiment according to the invention a pair of substantially identical relay devices **10** and **12** have actuating coils **14** and **16** controlling normally closed switches **18** and **20**. The coils **14** and **16** have a common connection **22** to a terminal **24** of a direct current supply source (not shown).

The switch **18** includes a movable contact **26** biased to closed position against fixed contact **28**. The movable contact **26** is movable to open position under compulsion of coil **14**. Likewise switch **20** includes a movable contact **30** biased to closed position against fixed contact **32** and movable to open position under compulsion of coil **16**.

Fixed contacts **28** and **32** are connected to the opposite terminal **34** of the source through a common connection **36** including a stop and start switch **38**. Movable contact **26** of relay **10** is connected to actuating coil **16** of relay **12** by conductor **40** and movable contact **30** of relay **12** is connected to actuating coil **14** of relay **10** by conductor **42**.

A trigger circuit **44** is fed from any suitable D.C. source, herein shown as terminals **24** and **34**. Circuit **44** is connected to coil **14** through a capacitor **46** shunted by a discharge impedance **48** and to coil **16** through capacitor **50** shunted by impedance **52**. A trigger switch **54** controls trigger circuit **44**.

In operation of the circuit with switch **38** open both movable contacts **26** and **30** will be in closed position. Then upon closure of switch **38**, the coils of both relays would be energized and the relays would race. In practice



it has been found that commercially identical relays have minute differences so that one will operate faster than the other and the fastest operating relay will open its switch and deenergize the other. If it is desirable that one relay always opens first a regulating impedance **56** may be placed in one of the cross conductors such as conductor **40**.

The circuit has two stable states, as follows:

(1) Relay **10** energized (contacts **18** open) and relay **12** deenergized (contacts **20** closed),

(2) Relay **12** energized (contacts **20** open) and relay **10** deenergized (contacts **18** closed).

The circuit may be switched from either stable state to the other by a triggering pulse applied to conductor **44**, as by the momentary closure of switch **54**. When this occurs each relay coil will receive a momentary pulse through condensers **46** and **50**. The energized relay will not be affected by this pulse. However, the deenergized relay will momentarily draw sufficient current to cause its normally closed contacts to open. This will break the circuit to the energized relay permitting its contacts to close and establish a circuit from B+ to the coil of the momentarily energized relay, holding it in an energized state and completing the transition to the other stable state. Although the presence of the triggering pulse on the coil of the initially energized relay retards somewhat the release of this relay, nevertheless its contacts close soon enough to establish a circuit to the momentarily energized relay before its momentary energization has ceased. That this is true will be more apparent from a closer consideration of the operation of the circuit during the transition period, as illustrated in Fig. 2.

In Fig. 2, the curves $I_{14}$ and $I_{16}$ represent the behavior of the currents in coils **14** and **16** during the transition period. With the circuit in the stable state in which relay **10** is energized and relay **12** is deenergized, assume that switch **54** is closed at the instant $t_0$. At this instant $I_{14}$ has a maximum value $i_1$, equal to the B+ voltage divided by the resistance of coil **14**, and $I_{16}$ is zero. $I_{16}$ now begins to increase from zero, first at a maximum rate and then at a declining rate as the voltage across condenser **50** increases and that across coil **16** decreases. As the condenser charge increases further, $I_{16}$ passes through a maximum and then declines, finally becoming zero when condenser **50** is charged to a voltage equal to B+. The maximum value of $I_{16}$ is determined by the size of condenser **50**, increasing toward $i_1$ as a limit as the capacity of the condenser is increased. In Fig. 2, the capacity of condenser **50** is such that the maximum value of $I_{16}$ is somewhat less than $i_1$.

In order to insure positive operation relay circuits are normally designed so that the energizing voltage produces a current in the coil considerably in excess of the minimum current required to actuate the relay. Accordingly, relays **10** and **12** are actuated at a value of current $i_2$. Also, relays normally release at a value of current smaller than the minimum actuating current. Hence, relays **10** and **12** release at a current level $i_3$.

It is seen in Fig. 2 that $I_{16}$ reaches the value $i_2$ and relay **12** is actuated to open contacts **20** at $t_1$. When contacts **20** open B+ voltage is not immediately removed from coil **14** since it is now supplied over conductor **44** and through condenser **46** which has zero charge at $t_1$. However, the current $i_1$ flowing in coil **14** must now be supplied from condenser **46** and, as this condenser charges, the voltage across coil **14** and the current $I_{14}$ decline, eventually reaching zero when the condenser becomes charged to the full B+ voltage. Therefore, at the instant $t_1$, when contacts **20** open, $I_{14}$ begins to decline. At $t_2$, $I_{14}$ has fallen to the release value $i_3$ for relay **10** and movable contact **26** starts toward stationary contact **28** which it reaches after a short

interval. Contacts 18, therefore, close a short time after $t_2$, for example, at $t_3$.

It will be noted that at the instant $t_1$, when $I_{14}$ begins to decrease, $I_{16}$ is still increasing and does not start to decrease until after its maximum value has been reached. Consequently, if contacts 18 were held open, relay 12 would not release until $t_4$ when $I_{16}$ had fallen to the release value $i_3$. Therefore, it is seen that the closure of contacts 18 precedes release of relay 12 by an interval T.

The duration of the trigger pulse indicated in Fig. 2 is about the minimum. It may exceed this length by any amount; however, there must be a sufficient interval between successive triggers to allow condensers 46 and 50 to discharge through resistors 48 and 52.

The transition of the circuit between stable states in the opposite direction is identical to that described above and illustrated in Fig. 2, it merely being necessary to interchange the designations $I_{14}$ and $I_{16}$ in the drawing.

For simplicity of illustration, the utilization circuits such as auxiliary switches, current responsive devices and the like have been omitted from the drawing.

For purpose of illustration a preferred embodiment has been shown and described according to the best present understanding thereof, however, it will be apparent that many changes and modifications may be made therein without departing from the true scope and spirit of the invention.



I claim:

A bistable circuit comprising a pair of relays each having a set of normally closed contacts and an actuating coil therefor, a source of electrical power, a common connection between one end of each relay coil and one terminal of said source, means connecting the other terminal of said source to the other end of each relay coil through the contacts of the other relay, a capacitor having one terminal connected to the said other end of one relay coil, a capacitor having one terminal connected to the said other end of the other relay coil, means for applying a trigger pulse between said common connection and each of the other terminals of said capacitors simultaneously, and means providing discharge paths for said capacitors.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,127,414 | Lohsse | Aug. 16, 1938 |
| 2,347,481 | Hooven | Apr. 25, 1944 |
| 2,426,595 | Busch | Sept. 2, 1947 |
| 2,528,777 | Persons | Nov. 7, 1950 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 466,323 | Great Britain | May 26, 1937 |