July 7, 1959 R. J. PRICE 2,894,180

TRANSISTOR-SATURABLE REACTOR RELAY WITH OVER-FREQUENCY CUTOUT

Filed Oct. 20, 1955

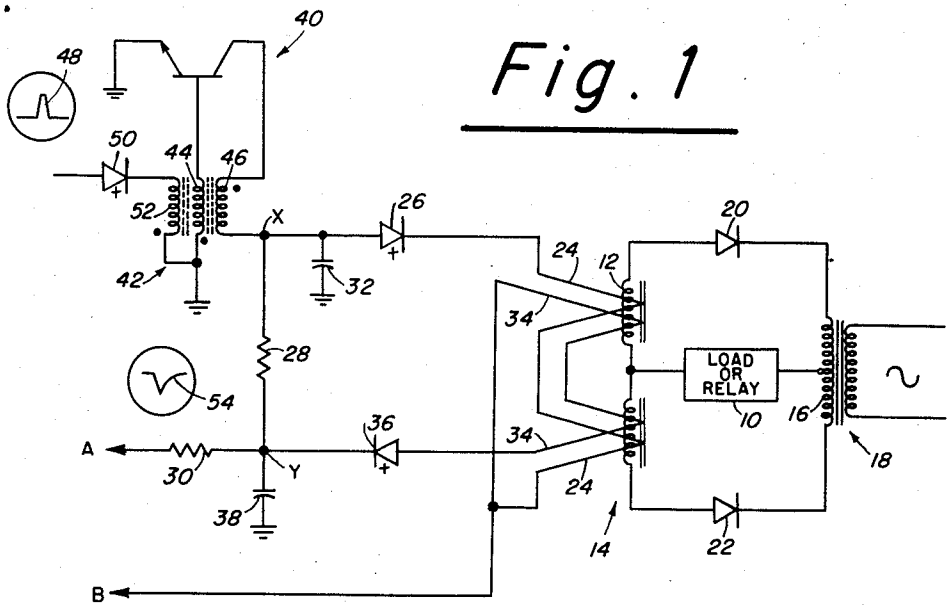


Fig. 1

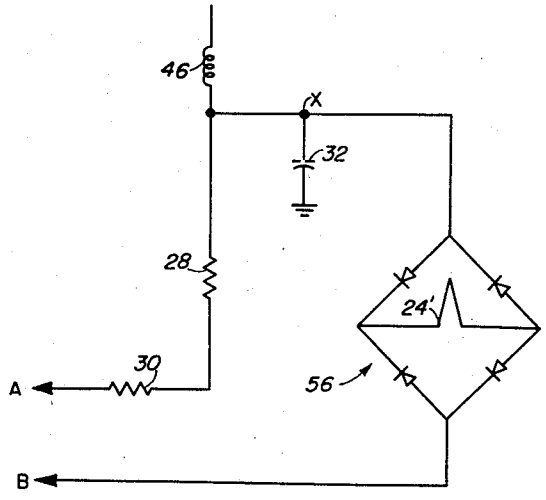


Fig. 2

INVENTOR.
ROBERT JOHN PRICE
BY George Sipkin
George E. Pearson
ATTORNEYS

United States Patent Office

2,894,180

Patented July 7, 1959

2,894,180

TRANSISTOR-SATURABLE REACTOR RELAY WITH OVER-FREQUENCY CUTOUT

Robert J. Price, Lakeside, Calif.

Application October 20, 1955, Serial No. 541,870

10 Claims. (Cl. 317—148)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to electronic relay devices and more particularly to apparatus for operating a relay or other load by a large central current which is controlled by a single trigger pulse or a group of trigger pulses.

It has been conventional practice for many years to utilize electric discharge tubes of various types, as the basic element of electronic relay devices. One of the electric discharge tubes commonly used in relay devices of the triggered type is the thyratron. In such an arrangement one or more additional tubes are required to cause the relay to open when the trigger pulses occur at a repetition frequency greater than some predetermined value. This type of approach requires unduly bulky equipment, a sensitive relay and heat dissipation is high. Furthermore, appreciable standby power is wasted and reliability is poor.

The present invention utilizes a saturable reactor for controlling the current through the load. A steady state potential across a reactor control winding maintains a current therethrough which prevents operation of the load device. This current is decreased by energization of an externally triggered transistor blocking oscillator which also operates to reestablish the current when the repetition rate of the triggering pulses reaches a predetermined value. The transistor is very small in size, simple in structure, requires no filament power supply, is operable at low power levels and has an exceedingly long life.

It is an object of this invention to provide an improved trigger control for electronic apparatus.

A further object of this invention is the provision of a trigger controlled load device of minimum size and increased reliability.

Still another object of this invention is to provide a trigger controlled relay which automatically becomes inoperative when the repetition rate of the control pulses reaches a predetermined value.

A further object of this invention is the provision of a current operated load device which may be actuated by trigger pulses of narrow width and small amplitude and requires a minimum of input power.

Another object of this invention is the provision of a triggered relay control which requires no filament current, presents no heat dissipation problem and will have an increased operative life.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a schematic diagram of one embodiment of this invention; and

Fig. 2 is a schematic diagram of a portion of a modification of the circuit of Fig. 1.

As shown in Fig. 1 a current actuated load device such as a relay **10** is connected between the junction of separately cored coils of saturable reactor **14** and the center tapped input coil **16** of a transformer **18** which is fed from an A.-C. source (not shown). A pair of unidirectional devices **20**, **22** are respectively connected between corresponding ends of coil **16** and winding **12** whereby a full wave rectified D.-C. current may be fed through the load. The devices **20**, **22** and all such devices mentioned herein are conventionally indicated as crystal rectifiers but it is to be understood that any diode usable as a rectifier may be employed therefor. A first source of fixed positive potential A and a lower source of fixed positive potential B are series connected by control winding **24** on the reactor, unidirectional device **26** and resistors **28**, **30**. Resistor **28** is connected at point X to the anode of device **26** to which is also connected one side of grounded capacitor **32**. Between point Y, the junction of resistors **28**, **30**, and potential B are series connected a second reactor control winding **34** and unidirectional device **36** which has its cathode connected to resistors **28**, **30** and to one side of grounded capacitor **38**. The two control windings are arranged on the reactor so as to have the unidirectional (by virtue of diodes **26**, **36**) current through each flowing in the same direction.

To control the potential at points X and Y there is provided a blocking oscillator **40** which comprises an n-p-n junction transistor having a grounded emitter and base. The collector of transistor **40**, which is returned to positive potential A through point X and resistors **28**, **30**, is regeneratively coupled to the base by transformer **42** which has windings **44**, **46** thereof connected and poled as shown. The actuating trigger pulse **48** is fed through unidirectional device **50** to the transistor base by means of a third winding **52** of transformer **42**.

For purposes of exposition, it may be assumed that potential A is +45 v. and potential B is +30 v. although it is to be understood that these are not necessarily optimum operating voltages. In steady state condition, in the absence of an input trigger pulse, an ampere flow of current moves from potential A (+45 volts) through R**30**, junction Y, R**28**, junction X, diode **26**, winding **24**, to potential B (+30 volts). At the same time the load current from secondary coil **16** of transformer **18** is directed through unidirectional devices **20**, **22**, both halves of coil **12** to the load or relay **10**. The opposing flux of coils **24** and **12** tends to neutralize the field, thereby reducing the saturation and presenting a high impedance to the load current thus rendering the relay inactive in the static or steady state. Due to the polarity of the potential difference across each winding and the operation of diodes **26**, **36**, current flows through winding **24** but not through winding **34** during said static or steady state.

The saturable reactor **14** is of the self saturating type. The control windings **24** and **34** are additive in their magnetic effect for the purpose of saturation of their common cores as a result of their unidirectional parallel current paths. The load coils **12** produce a flux poled to oppose the flux in the control coils whereby a current in either coil **24** or **34** tends to neutralize the flux set up by a current through the load coil **12**. However, the unopposed D.-C. current in either coil **24** or **34** will saturate their common cores. Thus, as long as a current is flowing through either control winding in the proper direction, the resultant flux is such that the reactor will not be saturated by the load current but will present a high impedance to the load current which will then be small, the unsaturated cores and load windings thereon having high inductance. The steady state current flowing through winding **24** is sufficient to magnetically bias the reactor to the high impedance condition wherein

there is drawn no load current or one which is too small to operate the load. If the current in winding **24** is decreased below a certain value the load current is then able to saturate the respective cores and the reactor presents a low impedance to the load current which then becomes great enough to operate the load.

When the potential at point X drops below 30 v. (the potential of source B) current ceases to flow through winding **24** and heavy load current is drawn. The oscillator **40**, operating at zero bias current, effects this drop in potential at point X in response to the input pulse **48** by virtue of the current drawn by the collector circuit when the oscillator is triggered. The potential at X has the wave shape as indicated at **54** which is determined by the capacitance of capacitor **32** and the resistances of winding **24** and resistors **28**, **30**. When the oscillator is triggered the capacitor **32** discharges rapidly through the transistor, diode **26** and winding **24** to the rapidly decreasing potential at X. At the termination of conduction of the oscillator the capacitor charges more slowly through resistors **28**, **30** and the potential at X rises to follow the capacitor charge. Thus one trigger pulse or a group of trigger pulses applied to diode **50** will cause the average potential at X (which is determined by the value of capacitor **32** and the pulse repetition rate) to drop below 30 v. whereby no current flows through winding **24** and heavy load current is drawn. The potential at point Y, in the absence of a trigger, may be on the order or 35 v., somewhat higher than the potential at X. As the trigger pulse repetition rate is increased the average potential at Y will drop below 30 v., the potential of source B and diode **36** will conduct a current through winding **34**. When the current through winding **34** reaches a predetermined value the reactor **14** is maintained in its high impedance condition whereby the load current is not sufficient to operate the relay even though the other control winding **24** and diode **26** is effectively disabled. The repetition rate at which the load current is cut off or minimized is largely determined by the value of resistor **28** which may of course be varied to vary the cut off repetition rate. Capacitor **38** serves as an additional filter to the sawtooth wave (similar to wave **54**) at point Y.

As shown in Fig. 2 substantially the same operation may be achieved by using a single control winding **24'** on the reactor connected across two terminals of a diode bridge **56** which has the other terminals thereof respectively connected to potential B and point X. When the potential at X is greater than that at B, the flow of current through winding **24'** maintains the reactor in high impedance condition and little or no load current is drawn. When the potential at X equals the potential at B no current flows through the control winding and heavy load current is drawn through the saturated reactor. As the potential at X drops below the potential at B, current is reestablished in the control winding in the same direction as before (due to the action of the bridge circuit) and load current is again cut off or minimized. This arrangement is advantageous when it is not possible to place two control windings on the reactor but employs more diodes than the arrangement of Fig. 1.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a device of the class described, a load circuit, a voltage source for said circuit, means for establishing a first impedance in said circuit, a source of repetitive trigger pulses, means responsive to each pulse of a train of input trigger pulses for decreasing the impedance in said circuit, and means responsive to the repetition rate of said trigger pulses for establishing a second impedance in said circuit of the same polarity as the first impedance, when the repetition rate of said pulse train reaches a predetermined value.

2. Apparatus of the class described comprising a load circuit including a load, a voltage source and an impedance device, a source of repetitive trigger pulses, means for controlling the impedance of said device, said controlling means including actuating means responsive to the amplitude of each trigger pulse for varying the impedance of said device, said controlling means further including means responsive to the RC time base of a predetermined repetition rate of said pulses for disabling said actuating means.

3. Apparatus of the class described comprising a saturable reactor having saturated and unsaturated conditions, a load circuit including a voltage source and a first winding of said reactor, a pair of control windings for said reactor, a repetitive pulse source, means controlled by individual amplitude of said pulses and including one of said control windings and said voltage source for driving said reactor between said conditions, and means controlled by the repetition rate of said pulses and including the other of said control windings and said voltage source for maintaining said reactor in one of said conditions when said repetition rate reaches a predetermined value.

4. A trigger actuated relay comprising a saturable reactor having a center tapped first winding, a center tapped alternating current input coil, a pair of diodes respectively connected between corresponding ends of said coil and winding, a relay connected between the center taps of said coil and winding, a first source of fixed potential, a second source of fixed potential lower than said first source, a control winding on said reactor having one end thereof connected to said lower potential, a resistance connected at one end to said first potential, a diode series connected between said control winding and said resistance, the anode of said diode being connected to said resistance, a capacitor having one side connected to a third fixed potential lower than said second potential, the other side of said capacitor being connected to the junction of said diode and resistance, and means for controlling the potential at said junction.

5. The relay of claim 4 including a second control winding on said reactor having one end connected to said second potential, and a diode having the anode thereof connected to the other end of said control winding and the cathode thereof connected to a point intermediate the ends of said resistance.

6. The relay of claim 4 wherein said means comprises a blocking oscillator having said resistance in its output circuit.

7. The relay of claim 5 wherein said means comprises an n-p-n junction transistor having the emitter thereof coupled to said third potential, said transistor having a collector coupled to the junction between said resistance and first diode, said transistor having a base regeneratively coupled to said collector, and means for externally triggering said transistor.

8. Apparatus of the class described comprising a saturable reactor having high and low impedance conditions, a load circuit including a voltage source and a first winding of said reactor, a control winding on said reactor, control means including said control winding and said voltage source for maintaining said reactor in one of said impedance conditions, a source of control pulses, and transistorized blocking oscillator means provided with a collector output circuit responsive to said control pulses and adapted to reduce the potential across the first winding and produce said low impedance condition.

9. Apparatus of the class described comprising a saturable reactor having high and low impedance conditions, a load circuit including a voltage source and a first winding of said reactor, a control winding on said reactor, control means including said control winding and said

voltage source for maintaining said reactor in one of said impedance conditions, said control means including means for providing a steady state potential difference across said control winding to establish a steady state current therein in a direction to maintain said reactor in high impedance condition, and trigger pulse means for selectively varying said potential difference to decrease said current, including an "npn" junction transistor having a grounded emitter and base, and a collector regeneratively coupled to said transistor base and connected to a point intermediate the windings terminals and the high voltage source for controlling said potential difference and producing said low impedance condition.

10. Apparatus of the class described comprising a pair of conductive control elements, means for establishing a first potential difference across one of said elements and a second potential difference across the other of said elements, a trigger pulse source, means responsive to each pulse from said source including an "npn" junction transistor having a grounded emitter and base, and a collector regeneratively coupled to said transistor base and connected to said control element for varying the polarity of said first potential difference, said last mentioned means including means responsive to the pulse repetition rate for varying the polarity of said second potential difference when the repetition rate of the pulses from said source reaches a predetermined value.

References Cited in the file of this patent

UNITED STATES PATENTS

2,677,800	Phillips	May 4, 1954
2,802,945	Seeley	Aug. 13, 1957