

1

3,299,369

CONDITION RESPONSIVE ON-OFF BLOCKING OSCILLATOR

Leonard C. Vercellotti, Penn Hills Township, and Richard A. Johnson, Monroeville, Pa., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed July 22, 1964, Ser. No. 384,321

6 Claims. (Cl. 331-112)

This invention relates to a pulse generator which can be turned on or off abruptly, and more particularly to a snap-action pulse generator for firing semiconductive controlled rectifiers.

As is known, semiconductive controlled rectifiers, similar in operation to thyratrons, have found increasingly widespread use in electrical control systems. Such devices are quite adaptable for use in phase controlled systems wherein the rectifiers are cut off at the beginning of a cycle of an alternating current source, but are gated on after a predetermined time delay in the cycle whereby the rectifiers will deliver to the load only a selected part of the available power.

In addition to power control systems, semiconductive controlled rectifiers can be used as on-off switches and, in this respect, are particularly adapted for use when the switch is to be controlled by a suitable voltage signal resulting from a variable impedance, voltage or other electrical quantity. In the control of a refrigerator, for example, the compressor motor is turned on and off in response to variations in the impedance of a temperature responsive resistor located within the refrigerator and sensitive to temperature variations therein. When the temperature within the refrigerator increases and the impedance of the temperature responsive resistor changes, the control system must be such as to energize the motor as determined by the setting of a temperature control rheostat. Conversely, when the temperature falls to the desired level determined by the setting of the control rheostat, the motor must be deenergized.

As an overall object, the present invention seeks to provide an improved pulse generator which can be better turned on and off abruptly.

More specifically, an object of the invention is to provide simple low-cost circuitry for on-off control of semiconductive controlled rectifiers.

Still another object of the invention is to provide a system for on-off control of semiconductive controlled rectifiers wherein the rectifiers are controlled as a function of a variable electrical quantity.

In accordance with the invention, there is provided a blocking oscillator having a normally cut-off electron valve therein and adapted to oscillate to produce a train of pulses when the electron valve is rendered conducting, a first voltage supply means for controlling conduction through the electron valve including a variable impedance element which causes conduction in the electron valve whenever its impedance is outside a predetermined range within which the electron valve is cut off, a second voltage supply means responsive to current flow through said electron valve for latching the oscillation of the electron valve, and means for deriving output pulses from the oscillator which may be applied to the gate element of a semiconductive controlled rectifier or utilized for other purposes.

The blocking oscillator includes a coupling transformer which inductively couples the collector and the base of a semiconductive electron valve. Conduction through the electron valve is controlled by means of the aforesaid variable impedance element, while means are provided for obtaining a direct current positive feedback voltage

2

from the coupling transformer such that once the oscillator produces an output pulse, oscillation is sustained until the impedance of the variable impedance element is reduced to a value sufficient to offset the effect of the positive feedback. As a result, the aforesaid abrupt or snap-action control of the oscillator is obtained.

The above and other objects and features of the invention will become apparent from the following detailed description taken in connection with the accompanying single figure drawing comprising a schematic circuit diagram of the invention.

Referring now to the drawing, a power supply system is shown including a source of alternating current voltage 10 connected through conductors 12 and 14 and to a load 16. For purposes of explanation, it will be assumed that the load 16 comprises the compressor motor of a refrigerator; however it will be appreciated that other and different type of electrical utilization devices may be used in accordance with the invention. In series with the conductor 14 is a first silicon controlled rectifier 18; and in shunt with rectifier 18 is a second silicon controlled rectifier 20 arranged to conduct current in a direction opposite to the current passing through rectifier 18.

As is well known to those skilled in the art, the silicon controlled rectifiers 18 and 20 are the equivalents of thyratrons. Each rectifier includes an anode 22, cathode 24 and gate electrode 26. Each silicon controlled rectifier acts as a two-terminal switch and will block current flow in either direction until a critical break-over voltage is exceeded, or until a positive voltage is applied to its gate electrode 26. When positive pulses are applied to the gate electrode of rectifier 18, it will pass one-half cycle of the voltage from source 10; whereas rectifier 20 will pass the other half cycle when positive pulses are applied to its gate electrode. With no positive pulses applied to either electrode, the controlled rectifiers 18 and 20 after recovery and becoming non-conductive will block the flow of current between source 10 and load 16; and in this manner the switching action is obtained.

Connected to the conductors 12 and 14 is the primary winding 28 of an isolation transformer 30. Connected in series across the secondary winding 32 of transformer 30 is a diode 34 and a capacitor 36; and it will be appreciated that the combination just described comprises a rectifier which applies a direct current voltage across the input terminals 38 and 40 of the pulse generator about to be described, the one input terminal 40 comprising ground.

The pulse generator itself includes an NPN transistor 42 having its emitter connected to ground through the parallel combination of resistor 44 and capacitor 46. The emitter of transistor 42 is also connected to input terminal 38 through resistor 48. The collector of transistor 42 is connected to input terminal 38 through the primary winding 50 of coupling transformer 52, the winding 50 being shunted by a well known clamping diode 54 as shown.

Inductively coupled to the transformer 52 is a first secondary winding 56 connected at one end of the base of the transistor 42, and connected at its other end through resistor 58 to the junction of resistors 60 and 62. Resistors 60 and 62 are included in a direct current path connected between the input terminals 38 and 40, which current path includes a variable resistor 64, a fixed resistor 66 and a diode 68. In shunt with elements 62, 64, 66 and 68 is a capacitor 70.

The windings 50 and 56 are wound on the core of transformer 52 such that a positive feedback signal is applied to the base of transistor 42, thereby facilitating oscillation. The resistor 62 may, for example, comprise a temperature responsive element. For purposes of ex-

planation, it will be assumed that it comprises a temperature sensitive resistor employed in a refrigerator for the purpose of controlling a compressor motor, which motor would correspond to the load 16 as mentioned above. Furthermore, the variable resistor 64 would, in the case of a refrigerator control, comprise the temperature control rheostat which is manually adjusted for a preselected desired temperature.

Also coupled to the core of transformer 52 is a second secondary winding 72 having its opposite ends interconnected through diode 74, resistor 76 and capacitor 78. Thus, the alternating current voltage appearing across winding 72 is rectified by elements 74, 76 and 78 and applied across resistor 66 and diode 68.

Finally, output pulses from the oscillator are derived across windings 80 and 82 and applied between the gate electrodes and the cathodes of the semiconductive controlled rectifiers 18 and 20, respectively.

The operation of the circuit is as follows: when the voltage V_1 at the junction of resistors 60 and 62 exceeds the voltage V_2 at the emitter of the transistor 42 by the forward base-emitter drop of the transistor, transistor 42 is gated on and oscillations are produced across windings 56, 72, 80 and 82. In this respect, it will be appreciated that the transistor 42, coupling transformer 52 and associated circuit elements comprise a blocking oscillator wherein the winding 56 provides a positive feedback to facilitate oscillation. The oscillation is maintained by the charging and discharging of the emitter capacitor 46.

When the transistor 42 turns on, the capacitor 46 charges until the base of the transistor 42 is no longer sufficiently greater in potential than the emitter to hold the transistor in saturation. The transistor then begins to pull out of saturation and is aided in cutting off by a decrease in the voltage across the secondary winding 56. Finally, the transistor is cut off and remains blocked until capacitor 46 is discharged to the point where the transistor can once more conduct.

The secondary winding 72 also provides a positive feedback. However, whereas winding 56 provides positive feedback to sustain oscillation, winding 72 provides an increase in the direct current value of the voltage V_1 at the junction of resistors 60 and 62. Therefore, once the oscillator produces an output pulse, oscillation is sustained until the impedance of the variable resistor 62 is reduced to a value sufficient to offset the effect of the positive feedback from winding 72. Snap-action control of the oscillator is thus obtained with the amount of hysteresis being controlled by resistor 76. The semi-conductive controlled rectifiers 18 and 20 since connected back to back will, therefore, function as a snap-action alternating current switch, with each being conductive for respective half cycles of load current.

In the control of a refrigerator with the circuit of the invention, variable resistor 64 will be adjusted to the desired temperature setting. Assuming that the temperature is above the desired value, the impedance of the temperature responsive resistor 62 will be at a value such that the voltage V_1 exceeds the voltage V_2 by the forward base-emitter voltage drop of transistor 42. Consequently, the blocking oscillator breaks into oscillation and turns on the rectifiers 18 and 20, thereby applying power from source 10 to the load 16. Thus, the load 16, comprising a compressor motor in the case of a refrigerator, is abruptly turned on whenever the temperature within the refrigerator increases to the point where the impedance of resistor 62 rises to the point where the voltage V_1 exceeds the voltage V_2 by the forward base-emitter voltage drop of transistor 42. As the temperature within the refrigerator falls, the impedance of resistor 62 will also decrease; however, the effect on voltage V_1 due to this decrease in impedance of resistor 62 is opposed by the positive feedback from winding 72. Finally, the temperature will fall to the point where voltage V_1 is no longer greater than voltage V_2 to sustain oscillation;

whereupon the transistor 42 will be abruptly cut off; the oscillations or pulses will cease; the rectifiers 18 and 20, after recovery, will remain cut off; and the compressor motor will stop.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention. In this respect, it will be apparent that while the circuit has been described with specific reference to a refrigerator control, it also has application in any installation where snap-action on-off control is required as a function of a change in impedance of a variable impedance element. It will be noted that extremely good stability of the switching point with supply voltage variation occurs since both the voltage V_2 and the voltage V_1 track. Diode 68 compensates for the effect of temperature variations on the base-emitter voltage of transistor 42, thus tending to maintain the switching point. A further modification of this invention could substitute a variable impedance in place of resistor 60 or resistor 44 as may be desired for a particular application. Also, modifications to make the tripping action responsive to voltage or current input signals can be made within the scope of the present invention.

We claim as our invention:

1. In apparatus for gating a controlled semiconductor rectifier on and off as a function of a change in impedance of a variable impedance element, the combination of a blocking oscillator, a semiconductive device in the oscillator having an emitter, a collector and a base, transformer means including a first feedback winding inductively coupling said collector and said base for applying a positive feedback signal to said base, means including said variable impedance element connected between said base and emitter for controlling conduction in the semiconductive device as a function of the impedance of said variable impedance element, said transformer means including a second feedback winding responsive to the conduction of said semiconductive device for providing an additional positive feedback signal to more rapidly effect the desired conduction of said semiconductive device, and winding means inductively coupled to said transformer means for applying said train of pulses to the gate element of said controlled semiconductor rectifier.

2. In an oscillator circuit, the combination of a pair of input terminals adapted for connection to a source of driving potential, a semiconductive device having an emitter, a collector and a base, means including the primary winding of a coupling transformer connecting said collector to one of said input terminals, a direct current path connecting said input terminals and including a variable impedance element, a second current path connecting said base and emitter and including said variable impedance element and a first secondary winding on said coupling transformer whereby a positive feedback to the base is obtained through said first secondary winding while conduction through the semiconductive device is controlled by the instantaneous impedance of said variable impedance element, a second secondary winding on the coupling transformer, and means for rectifying the voltage across said second secondary winding and for applying it as a positive feedback to the emitter and base of the semiconductive device to sustain conduction therein once the semiconductive device breaks into oscillation.

3. In an oscillator circuit, the combination of a pair of input terminals adapted for connection to a source of driving potential, a semiconductive device having an emitter, a collector and a base, means including the primary winding of a coupling transformer connecting said collector to one of said input terminals, the parallel combination of a resistor and capacitor connecting said emitter to the other of said input terminals, a direct current path

5

connecting said input terminals and including a variable impedance element, a second current path connecting said base and emitter and including said variable impedance element and a first secondary winding on said coupling transformer whereby a positive feedback to said base is obtained through said first secondary winding while conduction through the semiconductive device is controlled by the instantaneous impedance of said variable impedance element, a second secondary winding on the coupling transformer, a second impedance element in the direct current path connecting said input terminals, and means for rectifying the voltage across said second secondary winding and for applying it across said second impedance element to apply a voltage to the base of said semiconductive device tending to maintain oscillation therein after the semiconductive device initially breaks into oscillation.

4. In apparatus for gating a controlled semiconductor rectifier on and off as a function of a change in impedance of a variable impedance element, the combination of a pair of input terminals adapted for connection to a source of driving potential, a blocking oscillator including a semiconductive device having an emitter, a collector and a base, means including the primary winding of a coupling transformer connecting said collector to one of said input terminals, the parallel combination of a resistor and capacitor connecting said emitter to the other of said input terminals, a direct current path connecting said input terminals and including said variable impedance element, a second current path connecting said emitter and base and including said variable impedance element and a first secondary winding on said coupling transformer whereby positive feedback to the base is obtained through said first secondary winding while conduction through the semiconductive device is controlled by the instantaneous impedance of said variable impedance element, a second secondary winding on the coupling transformer, means for rectifying the voltage across said second secondary winding and for applying it to said second current path connecting the emitter and base of the electron valve to sustain conduction in the semiconductive device after it initially breaks into oscillation, and winding means inductively coupled to said coupling transformer for applying oscillations produced by said blocking oscillator to gate said controlled semiconductor rectifier.

6

5. In an oscillator circuit, the combination of a pair of input terminals adapted for connection to a source of driving potential, a semiconductive device having an emitter, a collector and a base, means including the primary winding of a coupling transformer connecting said collector to one of said input terminals, a diode connected in parallel with said primary winding, the parallel combination of a resistor and capacitor connecting said emitter to the other of said input terminals, a direct current path connecting said input terminals and including a variable impedance element, a second current path connecting said base and emitter and including said variable impedance element and a first secondary winding on said coupling transformer whereby positive feedback to the base is obtained through said first secondary winding while conduction through the semiconductive device is controlled by the instantaneous impedance of said variable impedance element, a second impedance device in said direct current path, a second secondary winding on the coupling transformer, means for rectifying the voltage across said second secondary winding and for applying it across said second impedance element to thereby apply a positive feedback voltage to the base of said semiconductive device tending to maintain conduction therein once the semiconductive device breaks into oscillation, and a capacitor connected in shunt with said variable impedance element and said second impedance element in the direct current path connecting said input terminals.

6. The combination of claim 5 and including an impedance element connected between said one input terminal and the emitter of said semiconductive device, and wherein an impedance element is included in said direct current path between said one input terminal and said variable impedance element.

References Cited by the Examiner

UNITED STATES PATENTS

3,129,414	4/1964	Rice	331—65 X
3,135,909	6/1964	Anderson et al.	331—109 X
3,139,595	6/1964	Barber	331—112 X
3,189,782	6/1965	Heffron	307—88.5

NATHAN KAUFMAN, *Primary Examiner.*

ROY LAKE, *Examiner.*

S. H. GRIMM, *Assistant Examiner.*