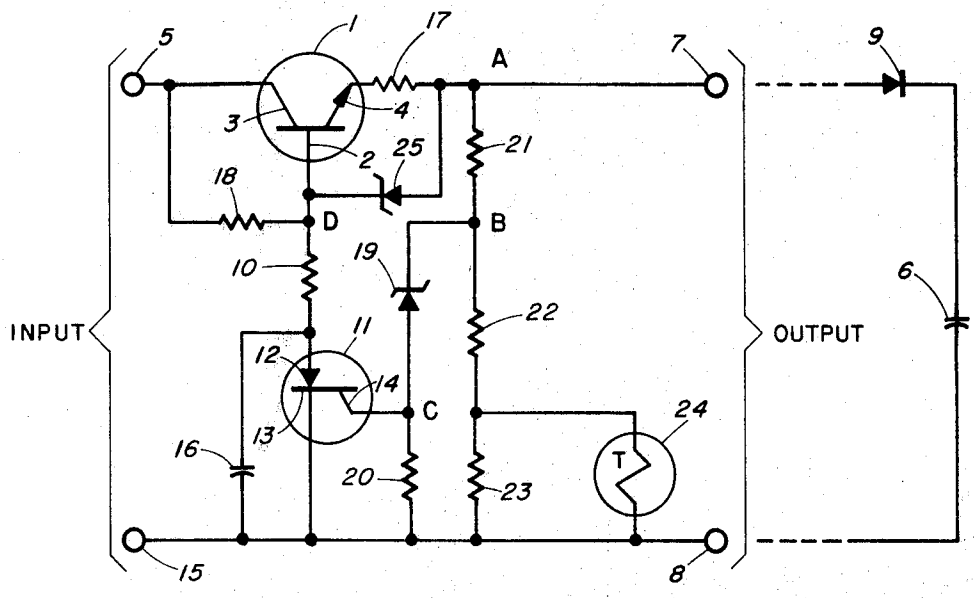
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VOLTAGE REGULATOR FOR A CAPACITIVE REACTIVE LOAD

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VOLTAGE REGULATOR FOR A CAPACITIVE REACTIVE LOAD

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ABSTRACT OF THE DISCLOSURE

A high voltage regulator for providing a constant reference voltage to reactive loads such as RC networks, employing a series connected transistor controlled by a SCR in its base circuit. Zener diodes are used to switch the SCR and to fix the base emitter voltage of the transistor. A thermistor compensates for temperature effects.

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 generally to voltage regulators, and more particularly to a high voltage pulse regulator useful for providing a constant reference voltage in RC timing circuits.

RC timing circuits are extensively employed in bomb fuzes and other ordnance devices. In the past, these timing circuits have relied on the stability of the input voltage supply to achieve a given timing accuracy. No attempt was made to divorce the timing system accuracy from variations in input voltage. Although such systems have served the purpose, much greater timing accuracies are now required in many ordnance devices. A voltage regulator is therefore required so that the timing accuracy will not be a function of input voltage. Most voltage regulators, however, provide a regulated D.C. level across a resistive load. Such regulators would not provide the regulation required in an RC timing circuit since a capacitive rather than a resistive load is presented to the regulator.

It is therefore an object of the instant invention to provide a voltage regulator capable of charging a capactitive load to a precise voltage with varying input voltages.

It is another object of this invention to provide a voltage regulator useful for providing a constant reference voltage in RC timing circuits.

It is a further object of the invention to provide a high voltage pulse regulator which substantially increases the timing accuracy in ordnance devices.

According to the present invention, the foregoing and other objects are attained by providing a transistor as a series control element which passes charging current to a capacitance. As the charge on the capacitance approaches a predetermined level, the transistor operating point is shifted thereby inhibiting the further flow of charging current. A voltage sensitive diode and a silicon control switch cause the shift in the transistor's operating point. A thermistor network is also provided to provide temperature compensation.

The specific nature of the invention, as well as other objects, aspects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawing, in which the sole figure is a schematic diagram of the preferred embodiment of a voltage regulator according to the invention.

Referring now to the drawing, the regulator comprises

an NPN silicon transistor 1 having a base electrode 2, a collector electrode 3, and an emitter electrode 4. Transistor 1 acts as a series control element which passes charging current from input terminal 5 to a lumped load capacitor 6. The load capacitor 6 is a part of an RC timing circuit (not shown) which is connected across the output terminals 7 and 8 of the regulator. A silicon diode 9, polarized in a direction to pass the charging current, is connected in series between output terminal 7 and capacitor 6.

The operating point of transistor 1 is determined by the base-collector network which includes resistor 10 connected in series with a silicon control switch 11. Silicon control switch 11 has an anode 12, a cathode 13, and a control electrode 14. Resistor 10 is connected between the base electrode 2 of transistor 1 and anode 12. Cathode 13 is connected to input terminal 15 which is common with output terminal 8. A capacitor 16 is connected in parallel with silicon control switch 11 between anode 12 and cathode 13. The network is completed by a current limiting resistor 17 connected between output terminal 7 and emitter electrode 4 and a resistor 18 connected between input terminal 5 and base electrode 2. The juncture of resistor 18 and resistor 10 at the base electrode 2 is identified in the drawing as point D.

Silicon control switch 11 is controlled by a voltage divider which includes a Zener diode 19 connected in series with a resistor 20. The juncture of Zener diode 19 and resistor 20 is identified in the drawing as point C and is connected to the control electrode 14 of silicon control switch 11. The other end of resistor 20 is connected to the common line between terminals 8 and 15, while Zener diode 19 is connected through resistors 21 and 17 to the emitter electrode 4 of transistor 1. Collector electrode 3 is also connected to input terminal 5. The junctions of resistor 21 with resistor 17 and with Zener diode 19 are identified as points A and B, respectively, in the drawing. Zener diode 19 is polarized so as to be back biased when a positive voltage appears at point A. A second Zener diode 25 is connected between the base electrode 2 of transistor 1 and the junction of resistors 17 and 21. Zener diode 25 is polarized so as to be normally back biased.

The circuit thus far described operates in the following manner. Upon the application of a positive voltage across input terminals 5 and 15, transistor 1 begins to conduct and rapidly charges capacitor 6 through diode 9. As the voltage at point A approaches a predetermined value, the voltage at point B rises to the regulating voltage of Zener diode 19. Zener diode 19 then begins to conduct, and the voltage at point C rises from essentially zero volts to the gating voltage of silicon control switch 11. When silicon control switch 11 turns on, the voltage at point D drops thereby effectively back-biasing diode 9. This result obtains since the voltage at point A falls due to transistor 1 having its operating point shifted into cutoff by the conduction of silicon control switch 11. Capacitor 6 is thus charged to a predetermined voltage and then isolated from the charging circuit by diode 9. The reference voltage across capacitor 6 is independent of the magnitude of the input voltage as long as the input voltage exceeds the regulated voltage by approximately 10 volts. Obviously, the time required to charge capacitor 6 to the required reference voltage will vary depending on the input voltage. Zener diode 25 fixes the base to emitter voltage of transistor 1 thereby producing a constant charging current effect. This minimizes the voltage differential across capacitor 6 produced by changes in input voltage.

The temperature characteristics of the Zener diode 19 and silicon control switch 11 determine the output voltage characteristic over a temperature range. Temperature com-

pensation is achieved by a thermistor network which parallels the voltage divider that includes Zener diode **19**. This network comprises a pair of series connected resistors **22** and **23** connected between point B and the common line between point B and the common line between terminals **15** and **8**. A thermistor **24** parallels resistor **23**. The behavior of the regulator circuit over a temperature range without the thermistor network would be such as to allow an increase in voltage at lower temperatures and a decrease in voltage at higher temperatures. With the thermistor network in the circuit, the regulator output can be adjusted to match the temperature coefficient of the RC timer.

An alternative approach to the temperature compensation problem is to replace Zener diode **19** with a low voltage four layer diode. The use of such a device eliminates the silicon control rectifier triggering characteristic as a determinant of the output voltage. The operation of the four layer diode is such that when point B reaches the conducting voltage of the diode it switches almost instantaneously from a high impedance state to a very low impedance state. Point C rises correspondingly almost instantaneously to a voltage sufficient to turn on the silicon control switch regardless of its triggering voltage. In removing the silicon control switch as a determinant of the temperature coefficient of the regulator, the four layer diode then assumes the dominant role in determining this coefficient. The thermistor network therefore needs only to compensate for temperature variations due to the four layer diode.

It will be apparent that the embodiment shown is only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

We claim as our invention:

1. A voltage regulator for charging a capacitively reactive load to a precise voltage with varying input voltage comprising in combination:

control means having a base, emitter and collector electrodes for completing a circuit path from a source of charging voltage to a capacitive load, said source of charging voltage connected to said collector electrode and said capacitive load connected to said emitted electrode,

current limiting means connected in series between said emitter electrode and said capacitive load for limiting initial peak current flow from said voltage source to said capacitive load when said control means is rendered conductive,

breakdown means connected between said current limiting means and said base electrode for producing a constant charging current,

electronic switch means connected between said base electrode and said voltage source for changing the operating point of said control means to disconnect said voltage charging source from said capacitive load,

voltage sensing means for sensing the voltage across said capacitive load and for operating said electronic switch means when said voltage across said load reaches a predetermined value,

unidirectional switch means responsive to said electronic switch means connected in series between said capacitive load and said current limiting means for abruptly stopping the charging of said capacitive load from said voltage charging source when said voltage source is disconnected and for isolating the remaining charge on said capacitive load from said regulator when said capacitive voltage reaches said predetermined value, and

temperature responsive circuit means for controlling the voltage across said voltage sensing means thereby minimizing the effect of changing temperature on said regulator.

2. A voltage regulator as recited in claim **1** wherein said unidirectional switch means is a diode.

3. The voltage regulator of claim **1** wherein said temperature responsive means comprises a temperature compensating network connected in parallel with the voltage sensing means.

4. The voltage regulator of claim **1** wherein said breakdown means comprises a Zener diode.

5. A voltage regulator as recited in claim **1** wherein said voltage sensing means is a Zener diode.

6. A voltage regulator as recited in claim **1** wherein said voltage sensing means is a low-voltage, four layer diode.

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