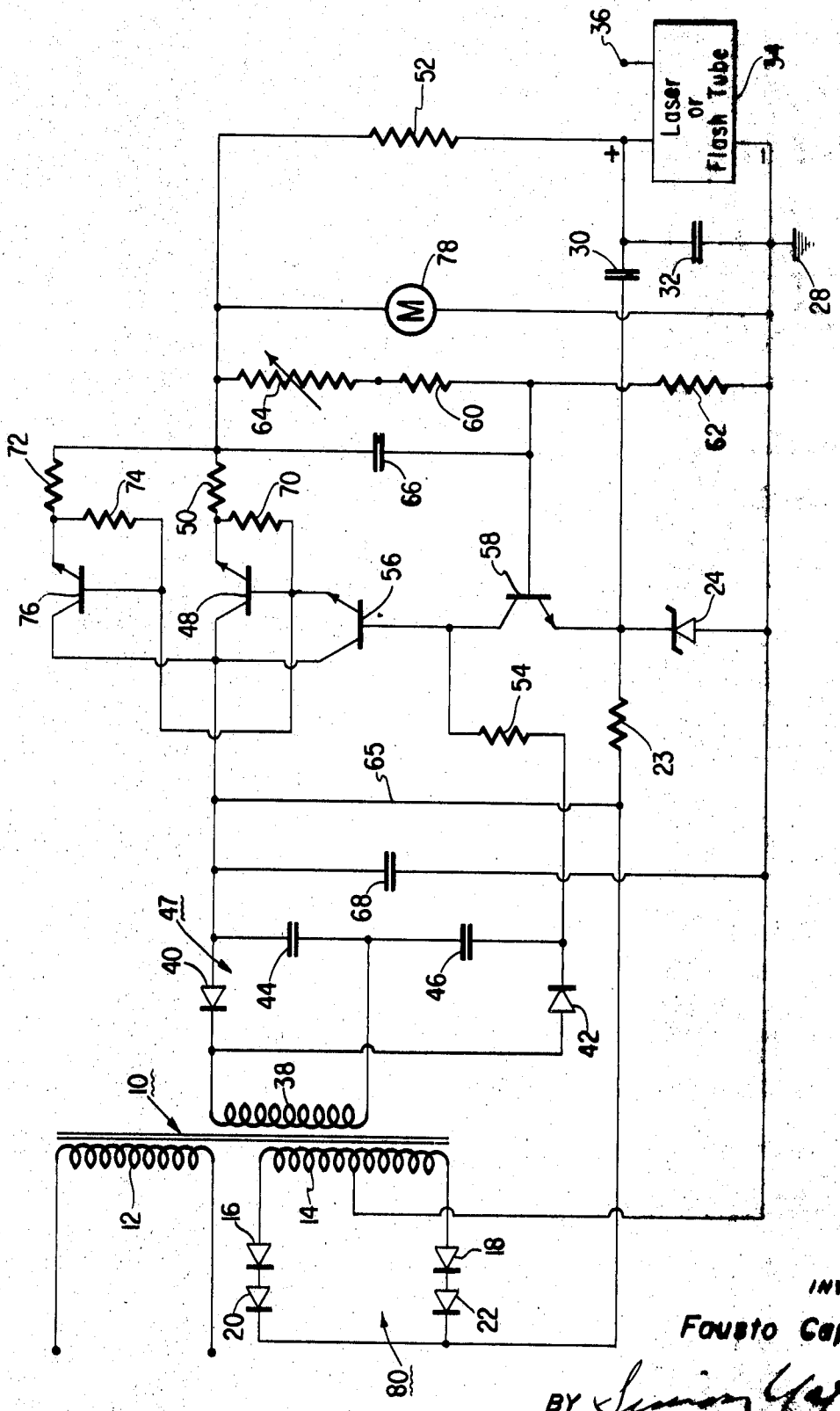
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SOLID STATE REGULATED POWER SUPPLY FOR INTERMITTENT LOADS WITH PLURAL CHARGING PATHS FOR A CAPACITOR

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SOLID STATE REGULATED POWER SUPPLY FOR INTERMITTENT LOADS WITH PLURAL CHARGING PATHS FOR A CAPACITOR

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ABSTRACT OF THE DISCLOSURE

A voltage regulator for use with intermittent loads such as flash lamps which require high voltage pulses. The regulator supplies voltages which vary from a regulated maximum between flashes to substantially zero at the end of a flash. Since the voltage of the regulator goes substantially to zero at the end of the flash, rapid repetition of the flash is made possible.

This invention relates to power supply devices that are particularly adapted to supply an intermittent load, that is a load that requires a high voltage followed very quickly by substantially zero voltage, such, for example, as flash lamps.

When a high voltage trigger pulse is applied to a flash lamp, the gas therein ionizes and the impedance of the lamp becomes very low. Furthermore, the condition of ionization continues even though the voltage applied to the lamp goes lower than the ionizing voltage, whereby the lamp does not go off unless the voltage applied thereto goes down to a very low value. The lamp cannot be flashed again until it goes off. Also, the lamp while ionized continues to draw current, greatly loading the voltage supply. Therefore, for providing discrete flashes by a flash lamp, high voltage must be applied thereto to cause ionization of the gases in the flash lamp to provide the flash. The high voltage must almost immediately be reduced to a very low value to permit the flash lamp to become deionized to permit further flashing at short intervals. Furthermore, to assure that the intensity of successive flashes does not vary, the voltage of the power supply must build up rapidly to the same predetermined voltage between successive flashes. In a known regulating power supply which includes a voltage regulating element and a control element for the regulating element, the voltage across the regulating element drops very low between flashes whereby the regulating element loses control of regulation. Furthermore, due to the rapid change in the voltage across the flasher, the control element controlling the conductivity of the regulating element does not properly control the regulating element. Also, in the known regulator, the voltage applied to the load is limited by the voltage that may safely be applied across the control element. Furthermore, the power supply efficiency is lower than desired.

According to the invention, a voltage regulator including two sources of voltage, is provided, said voltage regulator including a storage capacitor in which the energy required to cause a flasher to flash is stored. The energy that is stored is supplied to the storage capacitor over two paths. One of said sources is connected to apply a nearly constant voltage across the control element of the voltage regulator and to apply a keep alive voltage to the regulator element. The maximum current applied across the regulator element is reduced and also the efficiency of the power supply is increased since the regulator element regulates only the portion of the voltage that is applied to the capacitor through one of said paths.

The invention will be better understood by reading the following description in connection with the single figure of the drawing which illustrates an embodiment of this invention.

Turning to the figure, a three winding iron core transformer **10**, which may be of the constant voltage type if desired, is provided. The primary winding **12** of the transformer **10** may be connected across a source of alternating current not shown. The terminals of a first secondary winding **14** are connected to respective anodes of rectifying diodes **16** and **18**. The cathodes of the diodes **16** and **18** are connected to respective anodes of rectifying diodes **20** and **22**, and the cathodes of the diodes **20** and **22** are connected together and through a current limiting resistor **23** to the cathode of a Zener diode **24**. If convenient, one diode may be substituted for each of the pairs of diodes **16** and **20** or **18** and **22**. The center tap of the winding **14** is connected to the anode of the Zener diode **24** and to ground **28**. A voltage sensing and storage capacitor **30** and a storage capacitor **32** are connected in the order named between the cathode and the anode of the Zener diode **24**. The load **34**, which may be a flash lamp or a pulsed laser, is connected across the storage capacitor **32**. The load **34** is provided with a triggering terminal **36**.

One terminal of the second secondary winding **38** of the transformer **10** is connected to the cathode of a rectifying diode **40** and to the anode of another rectifying diode **42**. The other terminal of the winding **38** is connected to a point between two capacitors **44** and **46** which are connected in series between the anode of the diode **40** and the cathode of the diode **42**, whereby a doubled direct voltage, which is provided by the voltage doubler **47** comprising the elements **38**, **40**, **42**, **44** and **46**, appears across the two capacitors **44** and **46** in series in a known manner. The anode of the diode **40** is connected to the collector of a NPN transistor **48**. The cathode of the diode **42** is connected through a resistor **54** to the base of a NPN transistor **56** and to the collector of an NPN transistor **58**. The collector of the transistor **56** is connected to the collector of the transistor **48** and the emitter of the transistor **56** is connected to the base of the transistor **48**. It will be noted that the voltage doubler **47** supplies a current to the collector of the transistor **58** which is nearly constant. Since it is known that variation in current supply to the collector of the transistor **58** causes error in the regulation provided by the transistor **58**, this nearly constant current supply makes for better voltage regulation by the described regulator.

The emitter of the transistor **48** is connected through a current equalizing resistor **50** and a current limiting resistor **52** in series to the junction of the storage capacitor **32** and the load **34**.

The emitter of the NPN transistor **58** is connected to the cathode of the Zener diode **24**, and the base of the transistor **58** is connected to terminals of two resistors **60** and **62**. A variable resistor **64** is connected between the junction of the resistors **50** and **52** and one terminal of the resistor **60**. The other terminal of the resistor **62** is connected to the anode of the Zener diode **24**. A connection **65** is made between the collector of the transistor **48** and the cathode of the diodes **20** and **22**. A filter capacitor **66** is connected across the resistors **60** and **64**, and a further filter capacitor **68**, which may be several filter capacitors connected in parallel if desired, is connected between the anode of the diode **40** and the anode of the Zener diode **24**.

A bleeder resistor **70** is connected between the base of the transistor **48** and its emitter. A pair of resistors **72** and **74** are connected in series between the junction of the two resistors **50** and **52** and the base of the transistor **48**. The base of a NPN transistor **76** is connected to the base of the transistor **48** and the collectors of the transistors **48** and **76** are connected together, while the

emitter of the transistor **76** is connected to the junction of the resistors **72** and **74**. The resistors **50** and **72** act to equalize the current flow through the two parallel connected series regulating transistors **48** and **76**. If desired, a voltmeter **78** is connected between the junction of the rsistors **50** and **52** and the anode of the Zener diode **24**.

In explaining the operation of this device, it will be assumed that an A.C. voltage is applied across the primary winding **12** and that no triggering pulse is applied to the triggering terminal **36**. Then, since the direct voltage supplied by the full wave rectifier **80** comprising the elements **14**, **16**, **18**, **20** and **22** across the Zener diode **24** is higher than the break down voltage thereof, the Zener diode **24** breaks down, the resistor **23** protecting the Zener diode **24** and the rectifier **80**. Since the capacitors **30** and **32** are about the same size, the capacitor **32** charges to about one half the break down voltage of the Zener diode **24**. As previously stated, the voltage doubler **47** applies a nearly steady direct current to the collector of the transistor **58**. The voltage doubler **47** in series with the full wave rectifier power supply **80** supplies collector current for the transistor **58** and base current for the transistors **48**, **56** and **76**. The transistors **48**, **56** and **76** therefore become fully conductive during the operation of the described circuit. Charging current for the capacitor **32** flows from the cathode of the diodes **20** and **22**, through the connection **65**, the collector to emitter paths of the transistors **48** and **76**, the current equalizing resistors **50** and **72**, the current limiting resistor **52** and into one terminal of the storage capacitor **32**, it being noted that the other terminal of the storage capacitor **32** is connected to the center tap of the winding **14**. Therefore, initial charging of the capacitor **32** is provided by way of the resistor **23** and additional charging of the capacitor **32** is provided by way of the transistors **48** and **76** and the resistor **52**. The voltage across the resistors **64**, **60** and **62** in series varies very rapidly, while the voltage across the capacitor **32** varies at a much slower rate, due to the operation of the resistor **52**. The maximum voltage across the capacitor **32** is determined by the setting of the variable resistor **64**.

The capacitor **32** reaches a regulated voltage in a very short time. The flash tube comprising the load **34** is flashed by applying a triggering voltage to the triggering terminal **36**. The gas in the flash tube ionizes and the resistance thereacross goes to a fraction of an ohm. The capacitor **32** discharges through the load **34** very quickly. The resistance of the path to ground through the Zener diode **24** for the capacitor **30** is much higher than the resistance of the path to ground for the capacitor **32** (it being noted that one terminal of the capacitor **32** is grounded) whereby the capacitor **30** contributes little to the flow of current through the load **34**, most of the charge of the capacitor **30** remaining. However, as much current flows into the load from the capacitor **30** as flows into the capacitor **30** through the resistor **23**, whereby the voltage across the Zener drops to zero. Since the standard voltage is zero, the transistors **48** and **76** become fully non-conductive and the voltage across the meter becomes substantially zero. The flash tube deionizes whereby its resistance goes high again and the charge in the capacitor **30** spills into the capacitor **32**. The voltage across the Zener diode **24** again goes to its breakdown voltage and the transistors **48** and **76** become conductive again and the voltage across the capacitor **32** again builds up the voltage determined by the setting of the resistance **64** and the cycle is completed. Upon applying a starting voltage to the starting terminal **36**, the discharge and charge cycle of the described regulator is repeated.

Since in the circuit as described, the source comprising the doubler **47** supplies transistor current but does not supply a substantial amount of load current, the current variation across the control transistor **58** is substantially

reduced over a known regulator in which one source supplies both currents, resulting in better control regulation. Also, due to the fact that the doubler **47** continually supplies biasing current for the transistors **48** and **76**, the voltage across the emitter and collector of the pass and regulating transistors **38** and **76** may go down to a few volts without losing regulation. Also, the collector current of the transistors **76** and **48** is reduced and the power efficiency of the described regulator is increased over known regulators in which only one source of supply is provided. This is due to the fact that the capacitor **32** is charged by the capacitor **30**, without going through the transistors **48** and **76**; to about one-half of the breakdown voltage of the Zener diode **24**. Reduced collector current for the transistors **48** and **76** also results in lower collector dissipation in these transistors and in more stable operation. It is noted that while a voltage doubler **47** is shown, any suitable source may be used other than the doubler **47**.

What is claimed is:

1. A regulated power supply, adapted for connection to a voltage source, for providing pulses to a load, comprising:

a variable impedance device having a control electrode and two main electrodes, said voltage source being connectable to said load by way of said main electrodes;

means for supplying an operating bias to the electrodes of said device;

a voltage standard connectable across said voltage source;

first and second capacitors connected in series across said voltage standard; and

means by which said load can be connected across said second capacitor to cause said second capacitor to be charged initially to a voltage level related to the voltage across said voltage standard and subsequently to be charged through the path including the main electrodes of said variable impedance device.

2. The power supply according to claim **1** wherein said bias means comprises a second voltage source connected in series with the control electrode of said variable impedance device.

3. The power supply according to claim **1** further comprising:

a comparison device having a control electrode, a first main electrode and a second main electrode, the first main electrode of said comparison device being connected to the control electrode of said regulating device, the second main electrode of said comparison device being connected in series with said voltage standard; and

means connected to the control electrode of said comparison device for providing a voltage which is a measure of the voltage across said load.

4. The power supply according to claim **1**, wherein said voltage standard is a Zener diode.

5. The power supply according to claim **1**, further comprising means for discharging said second capacitor through said load at predetermined times.

6. A regulated power supply, adapted for connection to a first and a second voltage source, for providing pulses to a load comprising:

a voltage regulating transistor having a base, a collector and an emitter electrode, said first voltage source being connectable in series with said load by way of the collector and emitter electrodes of said voltage regulating transistor;

a voltage comparison transistor having a base, a collector and an emitter electrode, the collector of the comparison transistor being connected at a junction point to the base of said regulating transistor, said second voltage source being connected to said junction point;

means connected between the emitter electrode of said

regulating transistor and the base electrode of said comparison transistor for applying a voltage which is a measure of the voltage across said load to the base electrode of said comparison transistor;

a voltage standard connectable across said first voltage source and in series with the collector and emitter electrodes of said comparison transistor;

first and second capacitors connected in series across said voltage standard;

means by which said load can be connected across said second capacitor to cause said second capacitor to be charged initially to a voltage level related to the voltage across said voltage standard and subsequently to be charged through the path including the emitter and collector electrodes of said regulated transistor; and

means for discharging said second capacitor through said load at predetermined times.

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