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PROTECTIVE DEVICE FOR TRANSISTOR REGULATORS

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FIG. 1

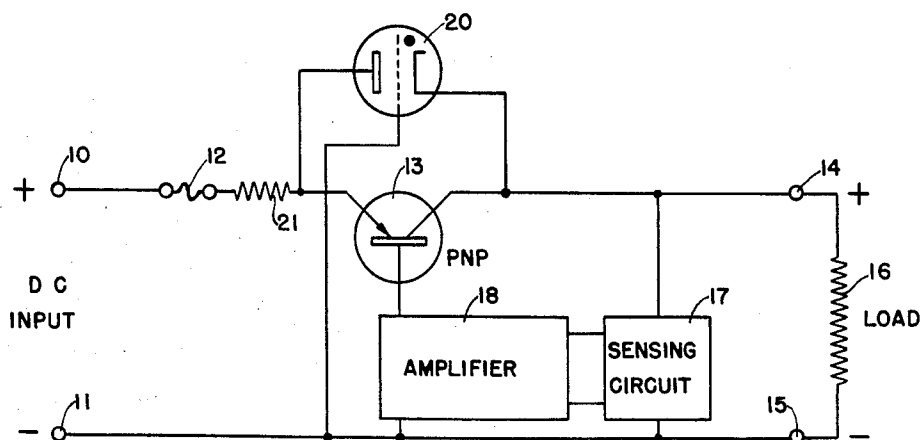
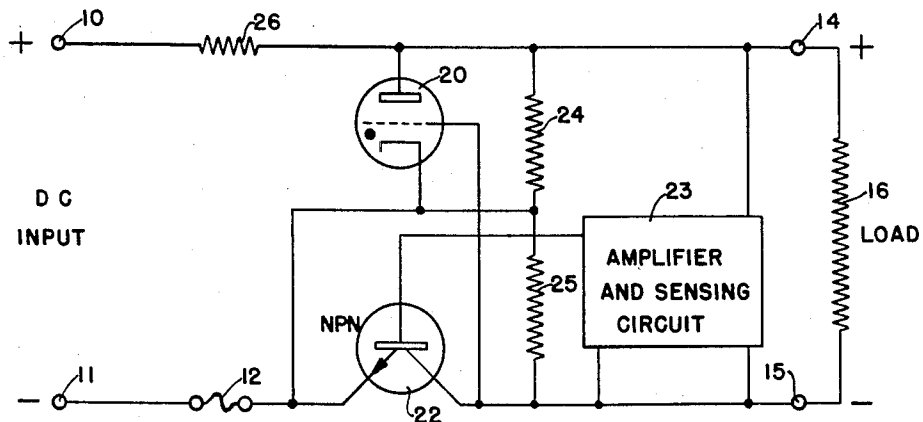


FIG. 2



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PROTECTIVE DEVICE FOR TRANSISTOR REGULATORS

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10 Claims. (Cl. 323—22)

This invention relates to a protective circuit for passing transistors and has specific relation to the momentary protection of passing transistors employed in direct current voltage regulators.

The use of transistors in voltage regulators is old and they have been adapted to the control of direct current voltages over a wide range of voltage values. It has been found, however, that when transistors are employed as variable impedance components in series connection between a power source and a load, they can be damaged easily when the load terminals are short-circuited. The use of a fuse does not correct the difficulty because the transistor will be damaged before the fuse blows due to thermal time lag. In some circuits the damage is done by the excessive currents causing abnormal temperatures within the transistor elements. In other circuits a short circuit produces excessive voltages which damage the base element. In the specification and claims, the recitation of "excessive currents" is intended to include the abnormal conditions which also produce excessive and abnormal voltages.

The present circuit solves this difficulty by the use of a gas-filled discharge device connected in shunt with the transistor and absorbing most of the current flow between the time the output terminals are short-circuited and the fuse blows.

One of the objects of this invention is to provide a protective device for transistors which avoids one or more of the disadvantages and limitations of prior art circuits.

Another object of the invention is to protect passing transistors from permanent damage whenever excessive currents pass through the transistor or whenever excessive voltages are impressed on the emitter and collector.

Another object of the invention is to provide a circuit component which will absorb power due to short circuit conditions until a fuse blows.

Another object of the invention is to provide a safety device for the protection of transistors which can be used many times.

Another object of the invention is to provide a safety device which can be adapted to a wide variety of circuits using a wide range of voltages.

Another object of the invention is to provide a safety device which will operate only during short circuit conditions and at other times have no effect on the normal operation of the circuit.

The invention comprises a gaseous discharge device including a cathode, an anode, and a firing electrode with two of the electrodes connected to the emitter and collector of a passing transistor. The passing transistor is connected in series with a direct current power line and a direct current load and the variable resistance of the transistor is employed to maintain the load voltage at a constant value. The third electrode in the discharge device is connected to the power line which does not include the passing transistor. The gaseous discharge device is normally biased for non-conduction and is adapted to con-

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duct whenever the potential of the firing electrode is raised to a predetermined value.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

Fig. 1 is a schematic diagram of connections of a voltage regulator circuit and the protective device with a passing transistor connected in series with the positive conductor.

Fig. 2 is a schematic diagram of connections similar to Fig. 1 but with the passing transistor connected in the negative power line.

Referring now to Fig. 1 the voltage regulator circuit is provided with terminals 10, 11, for connection to a direct current power source which may vary considerably in applied voltage. In series with the positive conductor is a fuse 12 and a transistor 13 with its emitter and collector connected to the power line. The output of the voltage regulator circuit is connected to terminals 14 and 15 for connection to a load 16.

A sensing circuit 17 is connected across terminals 14 and 15 to sense the voltage variations across the load. This sensing circuit may be any one of the many known types of sensing devices and generally includes a voltage reference component which may be a battery, a voltage regulator tube, or a zener diode. The sensing circuit determines the difference between the voltage reference and the load voltage and transmits this difference or error signal to an amplifier circuit 18 which may include any of the well-known amplifier components such as transistors, vacuum tubes, or magnetic amplifiers. The output of the amplifier is connected between the negative power line and the base of the transistor, thereby controlling the transistor resistance to maintain a constant voltage on terminals 14 and 15.

In order to protect transistor 13, a gaseous discharge device 20 is employed with its anode connected to the emitter of the transistor and the cathode connected to load terminal 14 and the transistor collector. The firing electrode or grid is connected directly to the negative power conductor which joins terminals 11 and 15.

The operation of this circuit is as follows: During the normal operation with load 16 connected across terminals 14 and 15, the discharge device 20 is non-conductive because there is not enough voltage between the anode and cathode to maintain a discharge and because the control electrode is biased considerably more negative than the cathode. Since the device is non-conductive it does not interfere in any way with the operation of the voltage regulator circuit. Now, let it be assumed that terminals 14 and 15 are short-circuited. This action causes the cathode of device 20 to be lowered in voltage substantially equal to the potential of the negative supply conductor and for this reason the potential of the control electrode is the same as the potential of the cathode. Discharge device 20 is designed so that it will fire as soon as the control electrode is equal to the voltage of the cathode (or only a few volts more negative) hence the discharge device is rendered conductive and the major portion of the short circuit current passes through the discharge device, some of this current passing from the anode to the cathode through the short circuit to the negative conductor, while another portion of the current passes from the anode to the control electrode and to the negative conductor. The above stated condition remains only for a fraction of a second until fuse 12 blows or disintegrates, thereby opening the positive power conductor and eliminating all currents to other parts of the circuit. The limiting resistor 21 is employed only when high voltages are used. For lower input voltages

within the range of fifteen to fifty volts, resistor 21 may be omitted.

The circuit shown in Fig. 2 is similar to that shown in Fig. 1 except that the fuse 12 and the passing transistor 22 are placed in series with the negative conductor instead of the positive. In this arrangement the amplifier and sensing circuits 23 are similar to the circuits 17 and 18 shown in Fig. 1. The protective discharge device 20 has its anode connected to the positive terminal 10 and its cathode connected directly to the emitter of the transistor. In order to maintain the cathode at a small positive potential it is also connected to a voltage divider connected across the output terminals. This divider includes resistors 24 and 25.

During the normal operation of this circuit the discharge device 20 is non-conductive because the control electrode is maintained at a voltage more negative than the cathode. When a short circuit is applied between terminals 14 and 15, the firing electrode is made more positive than the cathode, the gas is ionized, and the discharge device 20 conducts, switching a large current directly from terminal 10 through the anode-cathode circuit of the tube to the load side of fuse 12. This action protects transistor 22 and causes the fuse 12 to blow, thereby cutting off all action in the voltage regulator components. A limiting resistor 26 may be applied to this circuit either in series with the positive conductor as shown or in series with the negative conductor.

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

I claim:

1. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor in series with a first conductor of a direct current power supply; said transistor having a base, a collector, and an emitter; a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected across the emitter and collector of said transistor; and a third of said discharge electrodes connected to a second conductor of said power supply.

2. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor in series with a first conductor of a direct current power supply; said transistor having a base, a collector, and an emitter; a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected across the emitter and collector of said transistor; and a third of said discharge electrodes connected to a second conductor of said power supply; said discharge device normally biased for non-conduction and adapted to conduct whenever the potential between said first and second conductors is reduced to a predetermined voltage.

3. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector connected with said emitter and collector in series with a first conductor of a direct current power supply; a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected across the emitter and collector of said transistor; and a third of said discharge electrodes connected to a second conductor of said power supply; said discharge device normally biased for non-conduction and adapted to conduct when the potential between said first and second conductors is reduced by a short circuit.

4. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector connected with said emitter and collector in series with a first conductor of a direct current voltage regulator;

a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected respectively to the emitter and collector of said transistor; and a third of said discharge electrodes connected to a second conductor of said regulator; said discharge device normally biased for non-conduction and adapted to conduct when the potential between said first and second conductors is reduced below a predetermined value by a short circuit.

5. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current voltage regulator circuit including input terminals for connection to a power source and output terminals for connection to a load; said emitter and collector connected in series between one of said input terminals and one of said output terminals; a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected respectively to the emitter and collector of said transistor; and a third of said discharge electrodes connected to the other of said output terminals.

6. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current power supply having positive and negative conductors connecting a power source and a load; said emitter and collector connected in series with said positive conductor; a gaseous discharge device including a cathode, an anode, and a firing electrode with the anode connected to the emitter and the cathode connected to the collector; and a connection between the firing electrode and the negative conductor.

7. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current power supply having positive and negative conductors connecting a power source and a load; said emitter and collector connected in series with said positive conductor; a gaseous discharge device including a cathode, an anode, and a firing electrode with the anode connected to the emitter and the cathode connected to the collector; and a connection between the firing electrode and the negative conductor; said discharge device normally biased for non-conduction and adapted to conduct whenever the potential between the positive and negative conductors is reduced to substantially zero by a short circuit.

8. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current power supply having positive and negative conductors connecting a power source and a load; said emitter and collector connected in series with said negative conductor; a gaseous discharge device including a cathode, an anode, and a firing electrode with the cathode connected to the emitter and the firing electrode connected to the collector; and a connection between the anode and the positive conductor.

9. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current power supply having positive and negative conductors connecting a power source and a load; said emitter and collector connected in series with said negative conductor; a gaseous discharge device including a cathode, an anode, and a firing electrode with the cathode connected to the emitter and the firing electrode connected to the collector; and a connection between the anode and the positive conductor; said discharge device normally biased for non-conduction and adapted to conduct whenever the potential between the positive and negative conductors is reduced to substantially zero by a short circuit.

10. A circuit for protecting passing transistors in voltage regulators from excessive load currents comprising: a passing transistor having a base, an emitter, and a collector; a direct current voltage regulator circuit including input terminals for connection to a power source and output terminals for connection to a load; said emitter and collector connected in series between one of said input terminals and one of said output terminals; a gaseous discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected respectively to the emitter and collector of said transistor; and a third of said discharge electrodes connected to the other of said output terminals.

age regulators from excessive load currents comprising: a passing transistor in series with a first conductor of a direct current power supply; said transistor having a base, a collector, and an emitter; a discharge device including a cathode, an anode, and a firing electrode with two of said electrodes connected across the emitter and collector of said transistor; and a third of said discharge electrodes connected to a second conductor of said power supply; said discharge device normally biased for non-

conduction and adapted to conduct whenever the potential between the first and second conductors is reduced to a predetermined voltage.

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