FAIL-SAFE CIRCUIT
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ABSTRACT OF THE DISCLOSURE
A circuit having a transistor amplifier which is operated to control the current through a solenoid adapted to operate a mechanical device. A relay has a set of contacts and includes a holding coil which is connected in parallel across the transistor amplifier and which is energized with operation of the circuit to close the contacts to connect a potential source of the solenoid through the transistor amplifier. If the transistor amplifier shorts the potential across the coil is reduced so that the contacts open thereby open circuiting the solenoid.

This invention pertains generally to a fail safe circuit for protecting a load upon failure of one of the electrical components.

Fail safe circuits have been proposed that protect circuit components upon the shorting of the circuit load. It is also desirable to have fail safe circuits for protecting a load upon failure of one of the electrical components of the circuit. Such circuits are particularly important in control systems where failure of a component can cause operation of the system which can result in serious damage. For example, control systems for aircraft or other vehicles can, upon failure of a component, result in loss of control of the aircraft to endanger the lives of the crew and passengers, if any. Control systems fail because of shorting of the electrodes of the transistor, for example.

It is an object of this invention to provide an improved fail safe circuit.

It is another object of this invention to provide a fail safe circuit for protecting the circuit load upon the shorting of one of the circuit components, such as a transistor or other semiconductor devices.

A feature of this invention is an electrical circuit including an electron control device for regulating the current flow through the circuit load, having a relay with a set of contacts coupled between a current source and the load, and a relay coil responsive to increased current through the electron control device upon the shorting of that device to open the relay contacts thereby opening the load. The control device may be a transistor or other semiconductor device.

Another feature of this invention is an electrical circuit including an electron control device for regulating the current flow through the circuit load, having the relay coil coupled across the circuit load and between the current source and the electron control device, and having a higher impedance than the load so that with an increased current through the electron control device upon the shorting of the same the coil of the relay is energized to open the relay.

A further feature of this invention is an electrical circuit including an electron control device for regulating the current flow through the circuit load having the relay coil coupled across the electron control device and relay contacts that are normally open so that upon energizing the control device the relay will close the contacts, and upon shorting of the electron control device the relay coil will be de-energized thereby opening the contacts to open circuit the load.

In one embodiment of this invention, an electrical circuit has a current source coupled by the contacts of a relay to the circuit load. The power output stage of a transistor amplifier is series connected to the load and is biased by the driver stage of the amplifier to regulate the current through the load. The relay coil is coupled between the current source and the power output stage transistor and across the load and has an impedance greater than the load. Therefore, should the power output stage of the amplifier short out causing excessive current to flow through the load, the relay coil coupled across the load will be energized by the increased current flow to open the contacts thereby open circuiting the load to protect the same from excessive current. Variations of this circuit are possible, for instance, instead of having one coil coupled across the load two oppositely wound coils could be used. In this variation one coil is connected between the current source and a reference potential and operates to close the normally opened contacts. The second coil is coupled across the load and has an impedance greater than the load so that upon shorting out of the output transistor the second coil is energized, and its field being wound opposite the field of the second coil opposes that field permitting the contacts to open thereby effectively open circuiting the load from the current source.

In another embodiment of the invention, the coil of the relay is coupled across the power output stage of the amplifier. The contacts of the relay are normally opened. When the circuit is energized, the relay coil is energized to close the contacts thereby coupling the current from the source to the load. Should the power output stage transistor become shorted, the coil of the relay is de-energized permitting contacts to open thereby open circuiting the load.

In the drawing:
FIG. 1 is a schematic circuit diagram of one embodiment of the fail safe circuit in accordance with this invention;
FIG. 2 is a schematic wiring diagram of another embodiment of the fail safe circuit in accordance with this invention; and
FIG. 3 is a schematic wiring diagram of a further embodiment of the fail safe circuit in accordance with this invention.

Referring to the drawing, in FIG. 1 a circuit is provided for controlling the energization of a load 16 which in this instance is a coil which could be a part of a solenoid for controlling a mechanical member. An amplifier includes a driver stage 18 and a power output stage formed by transistor 20. The power output stage 20 is connected in series with the load 16 to the energizing terminal 14. The coil 22 of relay 10 is coupled between the current source 14 and the power output transistor 20 and across the load 16. The impedance of the coil 22 is greater than the load impedance. Relay 10 includes normally closed contacts 12 that couple current from the current source 14 to the circuit load 16.

During normal operation of the circuit the driver stage 18 of the transistor amplifier biases the power output stage 20 to vary the current through the load 16. Because, in this instance, the load 16 is a coil and part of a solenoid, varying the current through the coil 16 varies the amount of pull on the solenoid armature (not shown). Should the transistor 20 become shorted, however, peak current will be drawn from the current source 14 through the load 16. This could both damage the load 16 and cause serious complications by applying full and uncontrollable force upon the armature of the solenoid. However, when the transistor 20 becomes shorted the flow of current from source 14 through coil 22 of relay 10 will
be increased to the point where the coil will be energized to open the contacts 12 of the relay 10 thereby effectively open circuiting the load 16 to protect that load from excessive current.

In a second embodiment of the invention, a relay 25 has normally open contacts 36 and includes two coils 27, and 29 which are oppositely wound. Coil 29 is coupled between the current source 30 and ground reference potential. The coil 27 is coupled between the current source 30 and the power output transistor 32 and across the load coil 34, and has an impedance greater than the load impedance.

In operation, when the circuit is energized, coil 29 acts to close the contacts 36 coupling the current source 30 to the load 34 and the output transistor 32. Should the transistor 32 become shorted, increased current through the transistor will cause an increase current flow through coil 27. Because coil 27 is wound opposite the winding of coil 29, its field will oppose the field of coil 29 thereby permitting the contact 36 of relay 25 to open. When the contacts open, this effectively open circuits the load 34 and protects that load from excessive current.

FIG. 3 illustrates still another embodiment of this invention. In this embodiment, a resistor 40 couples current from the current source 42 to the power output transistor 44. The coil 46 of relay 45 is connected in the circuit across the transistor 44. The contacts 48 of relay 45 are in the circuit between the current source 42 and the load coil 50 and are normally open.

When the circuit is energized, the transistor 44 will conduct supplying a potential across coil 46 which acts to close the normally open contacts 48 thereby coupling a current to load 50. Should the transistor 44 become shorted, however, the potential across coil 46 will drop to a point that permits the contacts 48 to open thereby removing the current from source 42 to the load 50 to protect that load from current overload.

What has been described, therefore, is an improved fail safe circuit that protects the circuit load upon the shorting of an element in the circuit.

What is claimed is:

1. In a circuit having current supply means and an electron device for controlling the flow of current from the supply means to the load, the combination including, relay contact means, said load and said electron control device connected in series across the terminals of said supply means, circuit means connecting said electron control device with said supply means to maintain current flow through said electron control device, said circuit means including relay coil means connected with said electron control device and said supply means, said relay coil means being responsive to the current flow through said electron control device reaching a predetermined level to open said relay contact means.

2. The circuit of claim 1 wherein said relay coil means includes first and second coils oppositely wound, said first coil being connected in series between the current supply means and the electron control device, and said second coil being connected between the current supply means and a reference potential and in parallel with the electron control device, said second coil acting to close said relay contact means with the circuit being energized thereby connecting the current supply means to the load through the electron control device, and said first coil means responding to the current in the electron control device exceeding a predetermined level to open said contact means and the potential across said second coil means being reduced with the increased current level to reduce the current through said second coil to expedite the opening of said relay contact means.

3. The circuit of claim 1 wherein said relay coil means includes a coil connected in series with the current source and the circuit load and in parallel across the electron control device, said coil acting to close said relay contact means with the circuit being energized, and the potential across said coil being reduced with the current in the electron control device exceeding a given level to open said relay contact means.

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