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[73] Assignee General Electric Company
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[54] **VANE OPERATED SOLID STATE LIMIT SWITCH**
15 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **307/252,** 200/47, 307/305, 307/309
[51] **Int. Cl.** **H03k 17/00,** H03k 17/56
[50] **Field of Search** 307/252, 305A, 309; 200/47

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3,009,033 11/1961 Werts 335/207

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G. E. Application Note 200.35 May 1964, "Triac Control for AC Power" by E. K. Howell (page 3).

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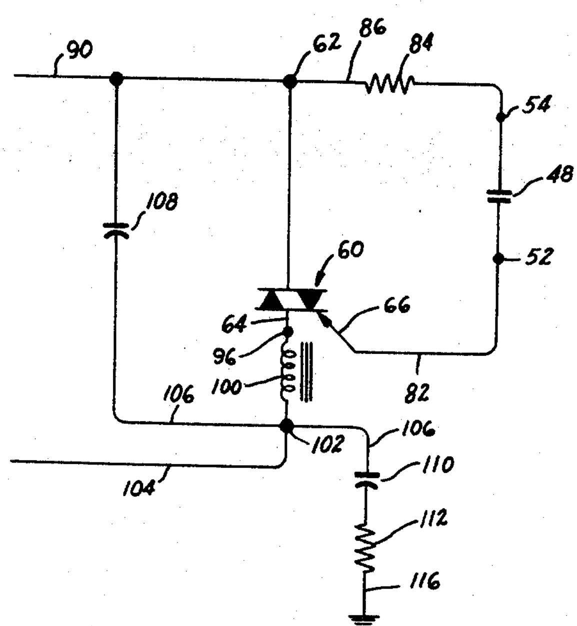
ABSTRACT: A limit switch for use with alternating current which is responsive to the position of a magnetic vane. A Triac is employed as the current interrupting element of the limit switch, interrupting current while exhibiting its normal or high impedance characteristic and conducting current while exhibiting its low impedance characteristic. A magnetic reed switch which is actuated by the magnetic vane, is connected in series with the gate of the Triac, so as to control the impedance characteristic of the Triac.



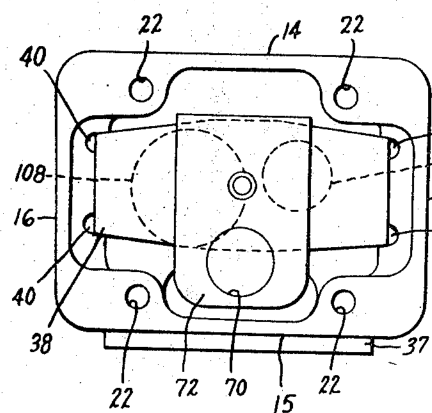


FIG. 2

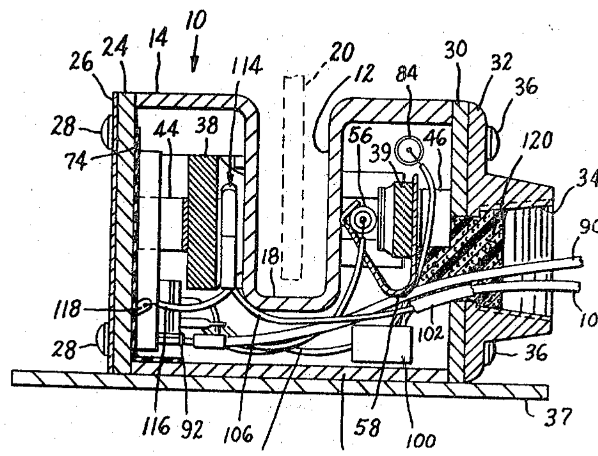


FIG. 1

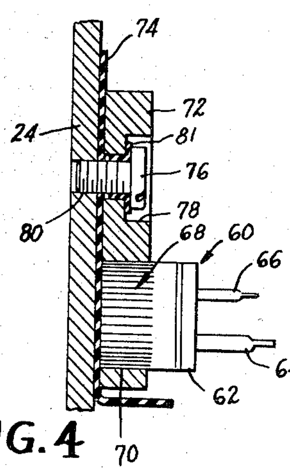


FIG. 4

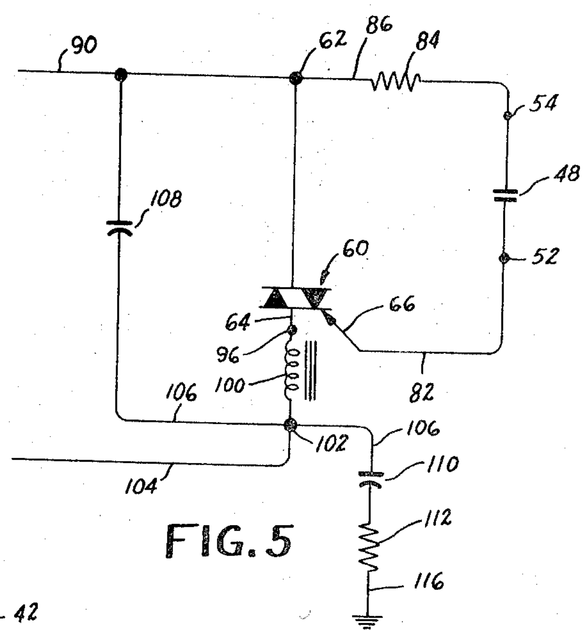


FIG. 5

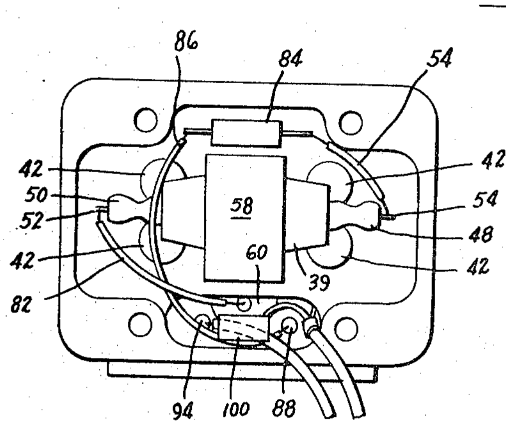


FIG. 3

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VANE OPERATED SOLID STATE LIMIT SWITCH

BACKGROUND OF THE INVENTION

Switches of the magnetic vane-operated type have previously been constructed to include magnetic flux producing means and a magnetic reed switch positioned in the path of the magnetic flux. The reed switch being operated in response to movement of a magnetic vane relative to the reed switch and relative to the magnetic flux, and the vane is effective in response to arrival at a point in its path of travel to alter the magnetic flux pattern sufficiently for operating the reed switch.

Switches of the type described above have been widely employed as limit switches wherein the switch is operated in response to arrival of a movable device, such as a part of a machine tool, at a particular point in its path of travel to effect a control function. Where the control function to be effected is to energize or to deenergize a motor such as for moving the part of the machine tool, the reed switch contacts are incapable of handling the motor current, which is generally well above the functional ampere current rating of the reed switch. Therefore it has been necessary to provide in addition an electromagnetic relay, the contacts of which control the energization of the motor, and the operating coil of which is energized through the reed switch contacts.

When a magnetic vane-operated switch is utilized as a limit switch with an electromagnetic relay as set forth above, the reed switch contacts may open at any point in the alternating current cycle. Should the contacts open near one of the peaks of a cycle, undesirable large inductive voltage transients will be generated. Similarly, bouncing of the reed switch contacts upon closing will cause arcing which has a deleterious effect upon the reed switch contacts. Thus, it would be highly desirable to provide a magnetic vane-operated switch for use with alternating current which has increased power handling capabilities so as to eliminate the need for an electromagnetic relay. It would also be highly desirable to provide a magnetic vane-operated switch which eliminates turn-off inductive voltage transients, and in which arcing upon contact bouncing when the contacts are closed is eliminated.

OBJECTS OF THE INVENTION

It is therefore a primary object of this invention to provide a novel and improved magnetic vane-operated switch having power switching capability.

It is another object of the invention to provide a novel and improved vane-operated switch, the operating characteristics of which are such that turn-off inductive voltage transients are eliminated.

It is a further object of the invention to provide a novel and improved vane-operated switch which includes a magnetic reed switch in which power switching is accomplished on initial closing of the reed switch contacts and is unaffected by subsequent contact bouncing, and in which arcing between the reed switch contacts during contact bouncing is substantially reduced so as to greatly extend the useful life of the reed switch contacts and therefore of the reed switch itself.

It is still another object of the invention to provide a novel and improved vane-operated switch having power switching capabilities which is of compact and efficient design such that it requires essentially the same amount of space as the present vane-operated switch which includes only a magnetic reed switch as the switching element, thus saving the space of an electromagnetic relay which must be used with the present vane-operated switch in order to provide power switching capabilities.

SUMMARY OF THE INVENTION

The foregoing objects are accomplished in accordance with this invention in one form thereof by providing a vane-operated switch in which a semiconductive bidirectional device having two main current-carrying terminals and at least one additional gate terminal as the alternating current power-switching element. A flux-producing member and a reed switch are positioned in the vane-operated switching housing such that a magnetic vane may be moved to positions therebetween to interrupt the flux of the flux-producing member and thereby actuate the reed switch contacts. The reed switch contacts are connected to control the energization of the gate of the semiconductive bidirectional device. Upon the first closing of the reed switch contacts, an initiating signal is applied to the gate of the semiconductive bidirectional device, to cause it to conduct. Upon opening of the reed switch contacts the semiconductive device will continue to conduct until a current zero is reached, and will then stop conducting due to the absence of a gate signal to turn it on at the beginning of the next half cycle.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross-sectional view of one embodiment of the solid state vane-operated switch contemplated by this invention;

FIG. 2 is an end view of the left end portion of the solid state vane-operated switch of FIg. 1 illustrated with the end plate removed;

FIG. 3 is an end view of the right end portion of the solid state vane-operated switch of FIG. 1 illustrated with the end plate removed;

FIG. 4 is an enlarged cross-sectional view showing the semiconductive bidirectional device and the heat sink block in which it is supported, mounted on the left sidewall of the switch housing as shown in FIGS. 1 and 2; and

FIG. 5 is a circuit diagram of the solid state vane-operated switch shown in FIGS. 1—4.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawing, one embodiment of the magnetic vane-operated solid state switch of this invention will be described. In order to protect the elements of the limit switch they are assembled in a housing **10**, and the housing is completely sealed to prevent the entry of iron particles and other industrial contaminants into the housing. A casting **12** forms the top **14**, bottom **15**, and two sidewalls **16** of the housing **10**, as shown in FIG. 2. Since casting **12** also forms a slot **18** through which may pass a magnetic vane shown by dotted lines **20** in FIG. 1, it is formed of a nonmagnetic material such as aluminum. In order to close the right and left ends of the housing **10** as shown in FIG. 1, threaded apertures **22** as shown in FIGS. 2 and 3, are provided in the ends of the casting **12** to receive threaded members which fasten members forming the ends of the housing to the casting.

As shown in FIG. 1, the left end of the housing is formed of a first thicker metal plate **24** and a second thinner metal plate **26** both of which are secured to the casting by threaded members having heads **28**. The thinner metal plate **26** may have printed thereon a legend identifying the switch. The right end of the housing as shown in FIG. 1 is formed by an apertured metal plate **30** and a second metal member **32** having formed therein a threaded aperture **34**. The threaded aperture **34** is provided for receiving the end of a conduit through which extend the leads of the limit switch. The plate **30** and the metal member **32** are secured to the casting **12** by threaded members having heads **36**. The limit switch is mounted by a metal-mounting plate **37** secured to the bottom of the casting **12**.

The apertures **22** in the ends of the casting **12** and similar apertures in the bottom of the casting (not shown) are identically spaced, and an aperture is provided in the center of the bottom of the casting (not shown), such that metal member **32** may be positioned on either the side or on the bottom, as may mounting plate **37**.

The vane operated solid state limit switch of this invention as shown in FIGS. 1—4 is similar to prior magnetic vane-operated switches as set forth above, in that it includes magnetic flux-producing means and a magnetic reed switch positioned in the path of the magnetic flux. More particularly, the switch includes a first magnetic flux-producing member 38 positioned on the left side of the slot 18 as shown in FIG. 1, and a second magnetic flux-producing member 39 positioned on the right side of the slot 18. The magnetic flux-producing means are shown as permanent magnets 38 and 39 which are of a generally U-shaped configuration and include a pair of short legs connected by an elongated base section. In order to properly position the magnets 38 and 39 with respect to the housing 10, positioning means are provided on the inside walls of the slot 18. Magnet 38 as shown in FIGS. 1 and 2 is positioned by rectangularly spaced projections 40 which engage the corners of the ends of the legs of the magnet. Similarly, magnet 39 rests on four projections 42 which extend from the inside wall of the slot 18 and engage the corners of the ends of the legs of the magnet. The magnets 38 and 39 are each held in position within the housing by spring members. These spring members engage the elongated base sections of the magnets and the metal plates forming the ends of the housing, to apply restraining forces to the magnets. Thus, formed sheet metal spring 44, the cross section of which is shown in FIG. 1, engages the elongated base section of magnet 38 and the metal end plate 24. Similarly, a formed sheet metal spring 46 engages the metal end plate 30 to maintain magnet 39 in engagement with projections 42.

It will be observed in FIG. 1, that the magnets 38 and 39 are arranged facing each other on opposite sides of a magnetic reed switch 48, such that dissimilar poles are juxtaposed. The arrangement forms a series magnetic circuit with oppositely disposed air gaps spanned by the magnetic reed switch. The reed switch 48 may be of any suitable construction and is illustrated in FIG. 3 as comprising a glass tube 50 within which are sealed a pair of elongated magnetic flexible contacts (not shown) the ends of which extend from opposite ends of the glass tube and are sealed therein. The ends of the contacts form the terminals 52 and 54. The magnetic reed switch 48 is enclosed with an insulating tube 56 and is held in position against the ends of the legs of magnet 39 by one end of a spring clip 58, the other end of which is positioned between the elongated base of magnet 39 and sheet metal spring 46.

A limit switch comprising a reed switch and a pair of magnets positioned as thus described is the subject matter of my U.S. Pat. 3,009,033 Limit Switches, U.S. Pat. Nov. 14, 1961, and assigned to the assignee of the present invention. The magnetic flux-producing member 38 which may be considered the operating magnet is of larger dimensions and greater pole strength than the magnetic flux-producing member 39 which may be considered the bias magnet.

The positions of the magnets are so determined that the reed switch is positioned in a region wherein the magnetic field strength is very low due to the cancellation in the aforesaid region of the opposing leakage fluxes of the operating magnet 38 and the biasing magnet 39. The resultant magnetic vector along the two reed contacts is therefore normally not great enough to magnetize the reed to a degree sufficient to overcome their resilience and cause them to close. Thus, the contacts of reed switch 48 are normally open.

The reed switch contacts are actuated to their closed position when the magnetic vane 20 is moved to a position within the slot 18 where it shunts the major portion of the total field contributed by the operating magnet 38 and has upset the balance between the two magnetic fields within the area occupied by the overlapping contact element of the reed switch. Since the flux component contributed by the bias magnet 39 in a direction longitudinal of the reed switch no longer has an opposing flux component to cancel its effect, the consequent magnetic vector along the reed switch results in a magnetic attraction more than sufficient to overcome the inherent resilience of the reed contacts and cause them to close with a snap action. This closure of the contacts actually takes place before the vane 20 has advanced to a fully effective shunt position, that is where it extends between both opposing poles of the operating magnet 38 and the biasing magnet 39.

According to the present invention the vane-operated solid state limit switch has power switching capabilities, and other desirable operating characteristics. While the housing 10 as shown in FIGS. 1—3 is generally of the same size as that used for earlier magnetic vane-operated limit switches, such as the one shown in my previously mentioned U.S. Pat. 3,009,033, additional elements are provided within the housing which provide the power switching capability. The principle element is a semiconductive bidirectional device having at least one gate terminal which is employed as the current interrupting element of the limit switch.

A relatively recent addition to the growing family of semiconductive devices broadly referred to as semiconductors, are the bidirectional triode P-N-P-N switches. These bidirectional triode switches are provided with two main current-carrying terminals and at least one gate or trigger terminal. Current flow from the two main current-carrying terminals through the bidirectional triode switch in either direction can be controlled by the application of a low voltage, low current pulse between a gate terminal and one of the load current terminals. These devices have some similarity to the earlier developed silicon-controlled rectifiers. They are similar in their blocking current and voltage characteristics. But, unlike silicon-controlled rectifiers, they can switch load current of either polarity. For a more complete discussion of the bidirectional triode P-N-P-N switches reference may be made to an article entitled: Bidirectional Triode P-N-P-N Switches, Gentry, F.E. et al. in the "Proceeding of the IEEE," Volume 53, No. 4, Apr. 1965, pp. 355—369. Bidirectional triode P-N-P-N switches are also discussed in a book entitled: Semiconductor Controlled Rectifiers...Principles and Applications of P-N-P-N Devices by Gentry, F.E. et al. published by Prentice-Hall, Inc., Englewood Cliffs, N.J., 1964.

The semiconductive bidirectional device 60 shown in the drawing is commonly called a Triac and by the International Electro Technical Commission standards named a bidirectional triode thyristor. While this particular device is shown which will hereinafter be referred to as a Triac, any other semiconductive bidirectional device which has at least one gate terminal, may be employed. It is only necessary that the semiconductive bidirectional device which is employed exhibit a high impedance characteristic in the absence of a signal at its gate, and that it exhibit a low impedance characteristic in the presence of the signal at its gate.

The Triac 60 is shown in FIGS. 1 and 4 as having a cylindrical housing 62, which forms one of the main current-carrying terminals, and as having extending from one end of the housing 62 a main current-carrying terminal 64 and a gate or trigger terminal 66.

Wherein considerable heat is generated within the cylindrical housing 62 of the Triac 60 when it is conducting current, it is desirable to provide means for rapidly dissipating the heat therefrom. The means provided for dissipating heat is best shown in FIG. 4. A portion 68 of the cylindrical housing 62 of the Triac 60 is serrated and is press-fit into a cylindrical aperture 70 in a heat sink block 72. Since the cylindrical housing 62 and therefore the heat sink block 72 is a terminal of the Triac, it is desirable to electrically insulate them from the switch housing, and particularly from the metal plate 24 upon which they are mounted, However, it is also desirable that a path of low thermal resistance be provided between the heat sink block 72 and the metal plate 24 such that the heat from the Triac 60 may be rapidly dissipated by the switch housing 10. Such an arrangement is provided by placing a thin sheet of insulating material 74 between the heat sink block 72 and the metal plate 24. A metal screw 76 which passes through an aperture 78 in the heat sink block 72 and is received in a threaded aperture 80 in metal plate 24 is insulated from the heat sink block 72 by an insulating washer 81 having a cylindrical portion and an annular flange portion.

Several additional circuit elements of the vane-operated solid state limit switch of this invention are enclosed within the housing 10, and their position therein will be described as then are referred to in discussing the circuit diagram shown in FIG. 5. Further, as connections shown in FIG. 5 are identified by a numeral, the same numeral will identify the lead if shown in FIGS. 1 and 3. Terminal 52 of the reed switch is connected to gate 66 of the Triac 60 by a conductor 82. Terminal 54 of the reed switch is connected through a current limiting resistor 84 to the main current-carrying terminal of the Triac formed by its housing 62. The connection to the housing 62 is made through a conductor 86 having a terminal pin which is received in an aperture 88 in the heat sink block 72.

The main current-carrying terminal of the Triac 60 formed by the cylindrical housing 62 is connected to the circuit to be controlled through a conductor 90 which is provided with a terminal pin 92 received in aperture 94 in the heat sink block. Main current-carrying terminal 64 of the Triac is connected by a conductor 96 to one terminal of an inductor 100. The other terminal of the inductor 100 is connected to a coupling 102 from which coupling extend to other conductors, one of which conductors 104 extends from the switching housing 10 for connection in the circuit to be controlled. A second lead 106 extends from the coupling to a pair of capacitors 108 and 110. As shown in FIG. 1, capacitors 108 and 110 and a resistor 112, one terminal which is connected to capacitor 110, are assembled as a package 114 which is placed between magnet 38 and the wall of the slot 18. The second terminal of the resistor 112 is connected by a lead 116 to a tab 118 which is welded to the metal sheet 24 so as to provide a ground to the housing. The terminal of capacitor 108 is connected to heat sink block 72 by the same terminal as is conductor 86 extending from resistor 84.

Finally, after assembly of the switch is completed the entire housing is filled with a plastic 120 through aperture 34, which serves to maintain all of the components mounted in the housing in place.

Having thus described the construction of the switch and the electrical connections of its circuit elements, its operation will now be described.

With the contacts of the reed switch 48 in their normally opened position, a signal cannot be applied to the gate 66 of the Triac 60, and therefore even though an alternating current voltage is applied to conductors 90 and 104, the Triac will not conduct. When magnetic vane 20 is moved into slot 18 to a position whereby the contacts of the magnetic reed switch 48 are closed as previously described a trigger signal is applied to the gate 66 of Triac 60 through current-limiting resistor 84. Wherein the Triac 60 is turned on within a microsecond after the contacts of reed switch 48 initially close, it is unaffected by subsequent bouncing of the reed switch contacts. Further, while the Triac is conducting a very low voltage appears between its main current-carrying terminals 62 and 64, and therefore the voltage between terminal 62 and gate 66 is also very low, such that the Triac provides contact protection for the reed switch contacts. This contact protection greatly extends the life of the reed switch as compared to its life in a conventional vane-operated limit switch wherein arcing between the contacts is brought about by the application of higher voltages to the contacts.

When the vane 20 subsequently moves out of the slot 18, such that the contacts of the reed switch 48 are opened, the Triac 60 will continue to conduct until the next current zero, at which time it will stop conducting. It will not start to conduct during the next half cycle since the open contacts of the reed switch 48 prevent the application of a signal to the gate 66.

In order to prevent false gating of the Triac 60 due to surges of voltage or transient occurring on the power line, a suppressor network is included within the vane-operated solid state limit switch. High frequency transient oscillations appearing in the power circuit are bypassed around the Triac 60 through the capacitor 108. In order to insure that the transients are bypassed around the Triac 60, their attempt to pass through the Triac 60 is delayed by inductor 100. An additional series network comprising capacitor 110 and resistor 112 is connected between conductor 104 which is connected to the circuit to be controlled, and the grounded housing 10 of the limit switch. This series RC circuit forms an internal-switching suppressor by balancing the high frequency pulses generated by an inductive load against the stray capacitance between the Triac, heat sink combination and the metal plate 24. This balancing network will prevent false firing of other vane-operated solid state limit switches by one which is being triggered, or by a refiring due to an inductive feed back from the load being controlled.

While the vane-operated solid state limit switch of this invention has been shown and described with an operating magnet 38 and a bias magnet 39, it might also be constructed without the opposing bias magnet 39, on an arrangement which would provide normally closed contact operation. That is, the field of the operating magnet 38 would normally create a magnetic vector along the axis of the reed switch 48 sufficient to maintain its contacts closed until the magnetic vane 20 is positioned in slot 18 so as to shield the reed switch 48 from the field of the operating magnet 38 thereby permitting the reed switch contacts to open under the influence of their natural resiliency. Thus, the Triac 60 would normally conduct and would stop conducting when the magnetic vane 20 entered the slot 18 to shield the reed switch 48 from the magnetic field of operating magnet 38.

While a particular embodiment of this invention has been shown and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention in its broader aspects, and therefore, it is intended that the appended claims cover all such changes and modifications that fall within the true spirit and scope of this invention.

I claim:

1. A vane-operated limit switch for controlling the energization of a load from an alternating current supply comprising:

a. a housing having a slot therein, said housing being formed of a nonmagnetic material;

b. at least one magnetic flux-producing device having spaced magnetic poles of opposite polarity mounted in said housing, said magnetic flux-producing device being positioned on one side of said slot with its poles facing said slot;

c. an elongated magnetic reed switch having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along its elongated dimension, said reed switch being mounted in said housing on the other side of said slot in a position where the magnetic flux from said magnetic flux-producing device passing through said slot will cause its contacts to close;

d. a semiconductive bidirectional device including a cylindrical housing, said semiconductive bidirectional device having two main current-carrying terminals and at least one additional gate terminal, said device normally exhibiting a high impedance characteristic between said two main terminals and exhibiting a low impedance characteristic between said two main terminals in response to application of a control signal to said gate terminal, said two main current-carrying terminals being connected to control the energization of a load from an alternating current supply and said reed switch contacts being connected to apply a control signal to said gate terminal when its contacts are closed; and

e. a heat sink block having an aperture in which said cylindrical housing of said semiconductive bidirectional device is received, said heat sink block being mounted on said limit switch housing with low thermal resistance between said limit switch housing and said heat sink block such that heat developed in said semiconductive bidirectional device may be rapidly transmitted through said cylindrical housing and said heat sink block to said limit switch housing to be dissipated by said limit switch housing.

2. A vane-operated limit switch as defined in claim 1 wherein a resistor and said reed switch contacts are connected in series between said gate terminal and one of said main terminals, said resistor limiting the gate current flowing through said reed switch contacts.

3. A vane-operated limit switch as defined in claim 2 wherein an inductor is connected in series with the other one of said main current-carrying terminals and a capacitor is connected in parallel with said semiconductive bidirectional device and said inductor, said capacitor bypassing high frequency transient oscillation around said semiconductive bidirectional device, and said inductor delaying the passage of the transients through said semiconductive bidirectional device to prevent false gating of the semiconductive bidirectional device by the transients.

4. A vane-operated limit switch as defined in claim 1 wherein a second one of said magnetic flux-producing devices is positioned on the other side of said slot with its poles facing said slot such that said first and second magnetic flux-producing devices form a single magnetic circuit having oppositely situated air gaps through which fluxes established by said devices pass in opposite directions through said slot, said reed switch being positioned between said devices spanning said gaps in a region where the resultant of the fluxes is normally insufficient to close said contacts, said contacts being closed by the magnetic flux of said second magnetic flux-producing device, when passage of the magnetic vane in the slot shunts the major portion of the magnetic flux of said first magnetic flux-producing device, whereby the load will normally be deenergized and will be energized in response to the presence of the magnetic vane in said slot.

5. The vane-operated limit switch as defined in claim 1 wherein said cylindrical housing of said semiconductive bidirectional device is one of its main current-carrying terminals, and said cylindrical housing and heat sink block are electrically insulated from said limit switch housing.

6. A vane-operated limit switch as defined in claim 5 comprising in addition a series network including a capacitor and a resistor connected between said limit switch housing and the other one of said main terminals, said series network forming a switch transient suppressor.

7. A vane-operated limit switch as defined in claim 1 wherein said limit switch housing comprises a casting of nonmagnetic material forming the slot, the top, the bottom, and two sidewalls of said limit switch housing through which said slot passes, one open end of said limit switch housing being closed by a first metal plate, the other open end of said casting being substantially closed by a second metal plate, said heat sink block being mounted on said first metal plate.

8. A vane-operated limit switch as defined in claim 1 wherein said semiconductive bidirectional device is a bidirectional triode thyristor.

9. A limit switch for controlling the energization of a load from a suitable electrical current supply comprising:

a. a housing having a pair of opposed walls, said housing being formed of a nonmagnetic material;
b. at least one magnetic flux-producing device having spaced magnetic poles of opposite polarity mounted in said housing, said magnetic flux-producing device being positioned adjacent one of said pair of opposed walls with said poles of said magnetic flux-producing device facing the other of said pair of opposed walls;
c. an elongated magnetic reed switch having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along the elongated dimension of said magnetic reed switch, said magnetic reed switch being mounted in said housing in spaced relation to said magnetic flux-producing device in a position where the magnetic flux of said magnetic flux-producing device passes through the space between said magnetic reed switch and said magnetic flux-producing device causing said contacts of said magnetic reed switch to close, said contacts of said magnetic

reed switch to close, sand contacts of said magnetic reed switch being opened in response to a decrease in the strength of the magnetic flux directed along said elongated dimension of said magnetic reed switch;
d. a semiconductive device having two main current-carrying terminals and at least one additional gate terminal, said device normally exhibiting a high impedance characteristic between said two main terminals and exhibiting a low impedance characteristic between said two main terminals in response to application of a control signal to said gate terminal, said two main current-carrying terminals being connected to control the energization of a load from a suitable electrical current supply and said contacts of said reed switch being connected to apply a control signal to said gate terminal when said contacts are closed, whereby said load will normally be energized and will be deenergized in response to the opening of said contacts of said reed switch; and
e. electrical transient suppressor means connected to said semiconductive device and said load to prevent said semiconductive device from being falsely fired by electrical transient generated in the circuit.

10. A limit switch as set forth in claim 9 wherein said electrical transient suppressor means includes a series network comprising a capacitor and a resistor connected between said housing and one of said main current-carrying terminals of said semiconductive device.

11. A limit switch for controlling the energization of a load from a suitable electrical current supply comprising:

a. a housing having a pair of opposed walls, said housing being formed of a nonmagnetic material;
b. an elongated magnetic reed switch mounted within said housing, said elongated magnetic reed switch having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along the elongated dimension of said magnetic reed switch;
c. a semiconductive device having two main current-carrying terminals and at least one additional gate terminal, said device normally exhibiting a high impedance characteristic between said two main terminals and exhibiting a low impedance characteristic between said two main terminals in response to application of a control signal to said gate terminal, said two main current-carrying terminals being connected to control the energization of a load from a suitable electrical current supply and said contacts of said magnetic reed switch being connected to apply a control signal to said gate terminal when said contacts are closed, whereby the load will normally be deenergized and will be energized in response to the closing of said contacts of said magnetic reed switch; and
d. electrical transient suppressor means connected to said semiconductive device and said load to prevent said semiconductive device from being falsely fired by electrical transients generated in the circuit.

12. A limit switch as set forth in claim 11 wherein said electrical transient suppressor means comprises an inductor connected to one of said main current-carrying terminals of said semiconductive device and a capacitor connected to said semiconductive device and said inductor, said capacitor bypassing high frequency transient oscillation around said semiconductive device, and said inductor delaying the passage of the transients through said semiconductive device to prevent false gating of said semiconductive device by the transients.

13. A limit switch for controlling the energization of a load from a suitable electrical current supply comprising:

a. a housing having a pair of opposed walls, said housing being formed of a nonmagnetic material;
b. a first magnetic flux-producing device having spaced magnetic poles of opposed polarity mounted in said housing, said first magnetic flux-producing device being positioned adjacent one of said pair of opposed walls with said

poles of said first magnetic flux-producing device facing the other of said pair of opposed walls;

c. a second magnetic flux-producing device having spaced magnetic poles of opposed polarity mounted in said housing, said second magnetic flux-producing device facing said one of said pair of opposed walls such that said first and second magnetic flux-producing devices form a single magnetic circuit having oppositely situated air gaps through which magnetic fluxes established by said first and second magnetic flux-producing devices pass in opposite directions through the space between said first and second magnetic flux-producing devices;

d. an elongated magnetic reed switch having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along the elongated dimension of said magnetic reed switch, said magnetic reed switch being positioned between said first and second magnetic flux-producing devices spanning said oppositely situated air gaps in a region where the resultant of the magnetic fluxes of said first and second magnetic flux-producing devices is normally insufficient to close said contacts of said magnetic reed switch, such contacts being closed by the magnetic flux of said second magnetic flux-producing device in response to shunting of the major portion of the magnetic flux of said first magnetic flux-producing device;

e. a semiconductive device having two main current-carrying terminals and at least one additional gate terminal, said device normally exhibiting a high impedance characteristic between said two main terminals and exhibiting a low impedance characteristic between said two main terminals in response to application of a control signal to said gate terminal, said two main current-carrying terminals being connected to control the energization of a load from a suitable electrical current electrical current supply and said contacts of said magnetic reed switch being connected to apply a control signal to said gate terminal when said contacts are closed, whereby the load will normally be deenergized and will be energized in response to the closing of said contacts of said magnetic reed switch; and

f. an inductor connected to one of said main current-carrying terminals of said semiconductive device and a capacitor connected to said semiconductive device and said inductor, said capacitor bypassing high frequency transient oscillation around said semiconductive device, and said inductor delaying the passage of the transients through said semiconductive device to prevent false gating of said semiconductive device by the transients.

14. A limit switch as set forth in claim **13** wherein a resistor and said contacts of said magnetic reed switch are connected between said gate terminal and the other of said main current-carrying terminals of said semiconductive device, said resistor limiting the gate current flowing through said contacts of said magnetic reed switch.

15. A limit switch as set forth in claim **13** further comprising a series network comprising a capacitor and a resistor connected between said housing and said one of said main current-carrying terminals of said semiconductive device.