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St. Clair et al.

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[54] **SWITCHING DEVICE**

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[52] **U.S. Cl.** ..... **307/252 B**; 307/252 UA; 315/199; 315/DIG. 7

[51] **Int. Cl.** **H03k 17/72**

[58] **Field of Search** ..... 307/252 B, 252 UA, 308; 315/DIG. 7, 194, 199, 200 R

[56] **References Cited**

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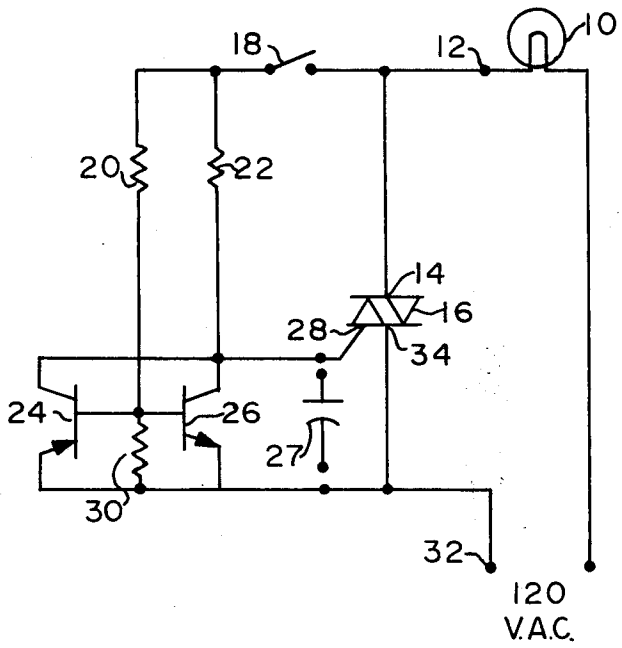
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Primary Examiner—James B. Mullins

[57] **ABSTRACT**

A switching assembly wherein a triac is controlled by a magnetically-operated reed switch. The reed switch is in turn operated by a magnet attached to a slidable button. The circuitry includes a zero crossing detector which operates to interconnect a load through the triac when the switch is operated at an instant when the instantaneous value of A.C. line voltage is less than about 30 volts (in an initial half-cycle) and otherwise limits current flow (if the switch is turned on at a time when the line voltage is above about 30 volts) for the remainder of a first half-cycle, thus in both instances reducing undesired initial abnormal current flow when a typical load is switched "on".

9 Claims, 4 Drawing Figures



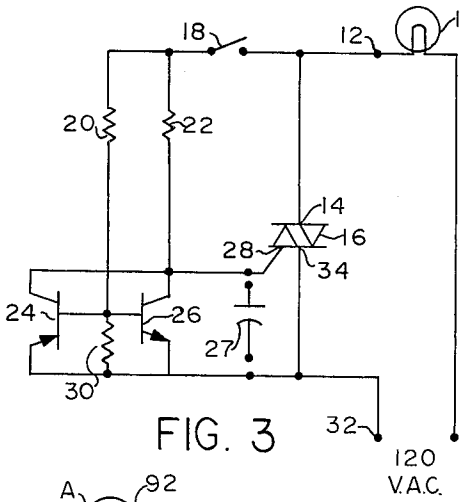


FIG. 3

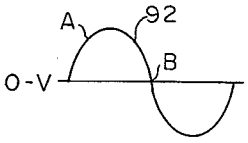


FIG. 4

FIG. 1

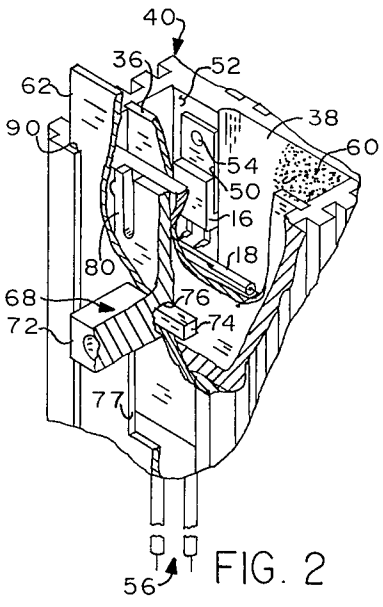


FIG. 2

SWITCHING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to switches, and particularly to a new and improved switch which offers both improved safety and economy.

2. General Description of the Prior Art

There are two principal considerations in determining the safety of a switch. One is the safety of the environment with respect to the switch, and the other is the safety of the user of the switch. In the first category is the matter of exposure of an environment to a spark or actual fire which might damage or destroy the environment. In the second category is the matter of possible shock to the user. In the past, switches particularly directed to the matter of safety to an environment have been rather elaborate with substantial coverings, making them both bulky and relatively expensive. Much the same can also be said for switches particularly adapted to provide safety to a user. As an example, switches for use in wet areas or outdoors where there is likely to be conduction between the surface of the switch contacted by the user and an electrical conductor of the switch have required elaborate sealing structures and substantial housings.

In both instances, the resulting switch is both bulky and expensive. In addition to the matter of safety, the present invention attacks the problem of economy, economy from the point of view of the life of electrical devices, particulary incandescent electrical lamps. In the past, the principal approach to extending bulb life has been to use bulbs rated at **100** to **150** volts on **115**-volt lines. While this will extend the life of a bulb somewhat, the problem has been that light output is significantly reduced. While efforts have been made to produce electronically-operated switches to limit initial current flow to a bulb, these devices have been too expensive to enable their general usage.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide an improved switch which provides both safety to an environment and to the user and which may be safely used in most any environment.

It is a further object of this invention to provide an improved switch wherein power provided by the switch to a load is substantially reduced during the first half-cycle of operation, thus substantially improving equipment life.

In accordance with the invention, a switch, or switching assembly, is constructed wherein a triac is controlled by an electronic circuit including a single-pole, single-throw switch. The circuitry includes a unique zero-crossing detector employing a pair of parallel opposite-type transistors connected across the gate circuit of a triac, and wherein the parallel bases of the transistors are powered by a voltage dividing circuit which for low voltage turn ons (instantaneous voltage less than a selected value, say **30** volts) transistors do not operate and the triac is allowed to immediately turn on. However, where the switch is turned on at an instance when the instantaneous voltage is greater than this value, one of the transistors turns on before the triac can turn on, preventing and pulling gate voltage on the transistor down to essentially zero and preventing it from operating during the initial half-cycle. Thus, the triac cannot fire until a zero crossing of the line voltage occurs.

In accordance with the second aspect of the invention, a switching assembly is constructed as described wherein, in addition, the switch is operated by a sliding button. The sliding button houses a small magnet which is moved to and away from a reed switch, which forms the single-pole, single-throw switching function. The components of the circuit are mounted on one side of a printed circuit board with only two terminals (the operating terminals) protruding. Power connections are made by wire to these terminals and then a potting compound is poured into a container surrounding the board and components, totally sealing the switching assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an electrical schematic illustration of an embodiment of the invention.

FIG. **2** is an exploded pictorial view of the mechanical details of the invention.

FIG. **3** is a partial pictorial view of certain of the mechanical details as assembled.

FIG. **4** is a waveform useful in explaining the operation of the circuit of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. **1**, there is shown an electrical schematic diagram of an embodiment of the invention as it would be connected to energize electrical load **10**, such as an incandescent lamp bulb from a **120** volt A.C. source. One switch lead or terminal **12** is connected through load **10** to anode-cathode terminal **14** of triac **16**. It is further connected through normally "open" magnetically-operated reed switch **18** to one lead of resistors **20** and **22**. Resistor **22** is connected to the parallel-connected collectors of PNP transistor **24** and NPN transistor **26** and to gate terminal **28** of triac **16**. The other lead of resistor **20** is connected to the parallel connected bases of transistors **24** and **26** and through resistor **30** to opposite switched terminal **32**. Resistors **20** and **22** are typically of comparable value, e.g. **510** ohms for resistor **20** and **470** ohms for resistor **22**. Actually, a range of values for resistor **20** would typically be from **20** to **5000** ohms, and for resistor **22**, from **50** to **800** ohms. Resistors **20** and **30** form a current divider network with resistor **30** having a typical value on the order of **20** ohms or **1/25** of the value of resistor **20**. It can, with an appropriate transistor, have a range of values from **1** to **200** ohms or a range of ratios of **1/20**th to **1/30**th with respect to resistor **20**. The parallel-connected emitters of the transistors are also connected to switched terminal **32** as is the second anode-cathode terminal **34** of triac **16**. By use of opposite polarity transistors **24** and **26**, a voltage of sufficient amplitude of either polarity will turn on one of them as required. An optional capacitor **27** is connected between gate terminal **28** of triac **16** and switched terminal **32**. It is employed when because of the particularly fast turn "on" of a particular triac that it is necessary to decrease the rise time of the voltage at the gate of the triac OFF an instant longer so that the transistor can fire before the triac does. The voltage will thus be sustained at the gate by capacitor **27** for the finite time that it takes it to be discharged through one of the transistors.

The electrical components of the invention are mounted on one side of printed circuit board or card **36** and are installed as shown in FIGS. **2** and **3.** Printed card **36** is then placed in an essentially rectilinear opening **38** formed through housing **40.** Printed card **36** is supported within guide slots **42** formed in opposite walls **44** and **46** of opening **38** and is inserted within the opening so that upper edge **48** of card **36** is just below the upper surface of the housing. Triac **16** is attached to circuit card **36** in a position so that heat dissipating tab **50** mates with raised longitudinal surface **52** within opening **38** and to which it is secured through matching holes in tab **50** and housing **40** by rivet **54.** This is more clearly shown in FIG. **2.** Connections are made to the switch by externally connecting leads **56** which are internally connected to the anode-cathode junction of triac **16** and extend out lower end **58** of housing **40.** Once the switch is assembled as shown in FIG. **2,** opening **38** is completely filled with heat conductive potting compound **60.** Cover plate **62** of nonferrous material contains usual mounting holes **64** and **66,** adapting it to be employed in place of existing-type wall switches. Slide button assembly **68** consists of resilient slider portion **70** and button **72** with magnet **74** positioned in opening **76** of button **72.** Slide button assembly **68** is held to a selected operating range of movement by rectangular opening **77** through which button **72** extends when assembled. Slider portion **70** of button assembly **68** is dimensioned to freely slide within slot **78** provided in housing **40** and is provided with flexible prong **80,** which frictionally engages one side **82** of slot **70** when in a position other than "on". When in the "on" position, it is more substantially supported by detent **84,** which engages semi-circular notch **86** formed near upper end **88** of slot **78.** This condition is illustrated in in FIG. **2** which shows button **68** positioned in the "on" position. When assembled, cover plate **62** is supported by notches **90** formed in housing **40.** It is typically positioned permanently by pins (not shown) which are inserted through cover plate **62** and housing **40.** Finally, when the switch is mounted, an outer cover plate (not shown) would be connected by conventional means to cover plate **62.**

The function and operation of the invention is as follows. When button **72** is pushed upward (as shown in FIG. **2**), magnet **74** in slider **70** is essentially positioned over reed switch **18.** This causes this switch to close and a circuit is completed through load **10.** Now, depending upon whether the instantaneous voltage of the applied **120** volt A.C. source is above or below approximately **30** volts, power would be applied to load **10** in either one or the other of two modes. First, assume initially that switch **18** would be closed at a time when the instantaneous value of the applied source is at **100** volts (point A), as illustrated on curve **92** of FIG. **4** showing **120** volts (R.M.S.) A.C. input voltage. In such case, the current flow through resistor **20** and the base emitter path of transistor **26** is such as to turn transistor **26** "on" before triac **16** can fire. (If the polarity of input had been negative, transistor **24** would have turned on). This effectively shorts out any significant voltage to gate **28** of triac **16.** Thus, triac **16** does not switch " on" at this instant to provide power to load **10.** Instead, there exists relatively high impedence paths through resistors **20** and **22,** which limit peak current flow during the balance of the positive half-cycle of curve **92** to between **600** and **700** milliamperes. Thus, current flow through load **10** which would otherwise typically be several amperes (e.g. an incandescent **100**-watt bulb would draw a peak current during the first half-cycle of approximately **10** amperes) would be initially substantially limited. The condition of limited current flow or preheat current through load **10** continues until the voltage drops at point B (FIG. **4**) to zero at the end of the first half-cycle. At this point, the voltage is removed from transistor **26** and it would open.

As the supply voltage increases in a negative direction, the posture of the circuit is as follows. Initially, both transistors are "off" and triac **16** is "off", and thus the voltage at the gate of triac **16** rises with little delay. Capacitor **27** having a value of, for example **0.1** Mfd, does not significantly slow the rise time of the **60** cycle current which is applied. This voltage corresponds closely to the full source voltage until there is significant current flow through one of the current paths, a transistor or through gate **28** of triac **16.** On the other hand, the voltage on the base of transistor **24** initially rises at a slower rate because of the voltage divider input circuit, wherein the voltage input on a transistor is essentially **1/25** of the source input voltage. The result is that triac **16** is fired before the transistor (in this case transistor **24**) can significantly turn "on" and before it can saturate. When this occurs, the voltage across triac **16** and transistors **24** and **26** drops to less then one volt, and transistor "turn on" cannot occur. Actually, triac **16** fires when the supply voltage has risen to about **30** volts and stays on until the supply voltage goes through zero again, at which point the operation just described repeats. With this mode of "turn on", the peak current is limited, being limited to about one-half normal peak for the "turn on" half-cycle.

If, however, switch **18** is turned "on" at a time when the source voltage is less than **30** volts, we have the same posture as described above following source voltage passing through zero and rising in either a positive or negative direction. In such case, triac **16** will fire first because the gate voltage reaches a triac firing potential before base voltage on one of the transistors can cause the transistor to saturate.

It will be thus appreciated from the foregoing description that the present invention provides a simple and inexpensive electronic structure wherein power can be applied to a load gradually. Typically, the inrush current during the first half-cycle of power applied to an incandescent light bulb rises to approximately **100** milliseconds of operation. In the applicants' device, tests have shown that it rises to no greater than five times the normal operating value. The result is that by limiting the initial application of current in this manner, it has been found that the life of electrical devices in general can be extended. With respect to incandescent lamp bulbs, bulb life can be extended from a minimum of about five times to a maximum of about **10** times. It is thus obvious that the potential savings from the applicants' device are enormous. While other current limiting devices have been devised in the past, in view of their complexity and expense, it does not appear that they have enjoyed any significant acceptance. The applicants' device, on the other hand, reduces the circuitry substantially, and thereby has made possible substantial net savings to a user.

What is claimed is:

1. An electrical switching assembly comprising:

first and second electrical terminals to be selectively opened and closed;

a solid state A.C. switch having a gate lead and first and second controlled leads;

a PNP transistor and NPN transistor with emitters and collectors commonly connected in parallel between said gate lead and said first controlled lead, respectively;

a control switch having an input terminal connected to said second controlled lead and an output terminal;

a current-limiting resistor connected between said switch output terminal and said gate lead and collector leads of said transistors;

a voltage divider comprising a first resistor and second resistor, wherein said first resistor has a resistance value substantially greater than said second resistor;

a first terminal of said first resistor being connected to said output terminal of said control switch, a second terminal of said first resistor being connected to a first terminal of said second resistor and to the bases of said transistors, and a second terminal of said second resistor being connected to said emitters to said transistors and to said first controlled lead and to said second electrical terminal;

whereby upon the application of an A.C. potential through a load across said first and second electrical terminals, switching operation occurs upon the closing of said control switch with said solid state A.C. switch providing a closed circuit in the event that closure of said control switch occurs when a source switching potential is below a selected discrete voltage, and when said control switch is closed when said source voltage is above a selected discrete voltage, one of said transistors turns on before said solid state A.C. switch can turn on, applying initially a reduced current flow through a said load.

2. A switching assembly as set forth in claim **1** wherein said selected discrete voltage is **30** volts.

3. A switching assembly as set forth in claim **1** wherein said control switch is a magnetically-controllable reed switch.

4. A switching assembly as set forth in claim **1** wherein said solid state A.C. switch is a triac.

5. A switching assembly as set forth in claim **4** further comprising:

a metal enclosure having exterior heat emitting ribs;

a printed circuit card and said triac, control switch, resistors and transistors being mounted on said printed circuit card; and

said enclosure includes a slot for mounting therein said printed circuit card with said triac in heat conductive contact with said enclosure.

6. A switching assembly as set forth in claim **5** comprising switch operating means including a slide button assembly comprising:

an operating slidable button;

a magnet attached to said button; and

a supporting sliding surface adapted to enable said button and magnet to be moved on the outer face of said enclosure, whereby said magnet is moved toward and away from said magnetically-controlled switch, and thereby said switching assembly selectively operated.

7. A switching assembly as set forth in claim **6** wherein said slide button assembly comprises a non-metallic plastic material and wherein there is included a contractable arm having a notch thereon, and a notch in said housing and adapted to receive and latch said button assembly when it is positioned in an "on" position.

8. A switching assembly as set forth in claim **7** wherein said magnet is positioned within said plastic material.

9. A switching assembly as set forth in claim **8** wherein the range of ratios of ohmage values for the resistance of said second resistor divided by the resistance of said first resistor is in the range of **1/20** to **1/30.**

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