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Fox et al.

[11] **3,736,466**

[45] **May 29, 1973**

[54] **NON-ARCING SWITCH SYSTEM AND PROCESS**

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[52] **U.S. Cl.** .....**317/11 A**, 307/136, 317/11 C

[51] **Int. Cl.** **H01h 9/30**

[58] **Field of Search**.....317/11 R, 11 A, 11 C; 307/136

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[57] **ABSTRACT**

In order to prevent arcing upon opening a mechanical switch it is proposed to place an electronic signal controlled switch in series with the mechanical switch and to provide a second mechanical switch for opening the signal path to the electronic signal controlled switch before the mechanical switch is opened.

7 Claims, 7 Drawing Figures

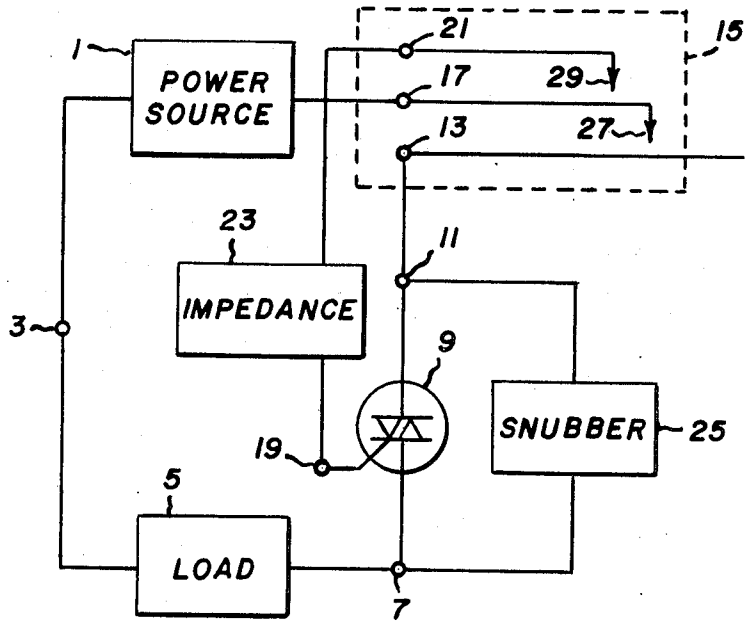


FIG.1.

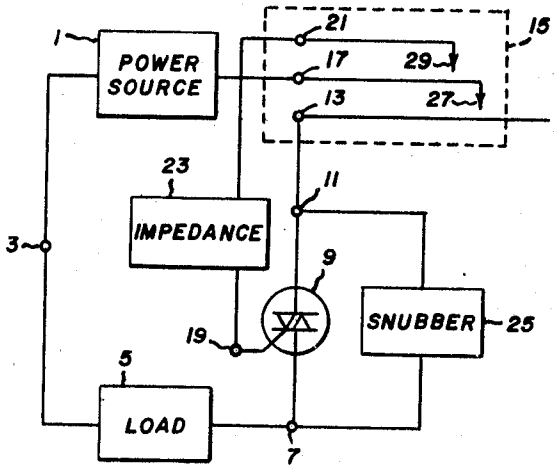


FIG.7.

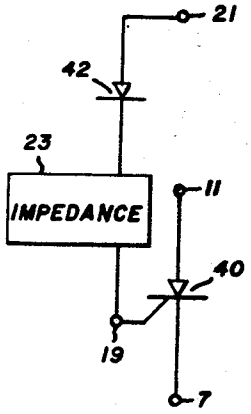


FIG.2.

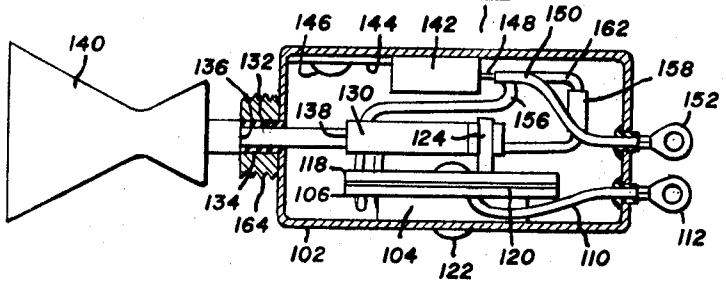


FIG.4.

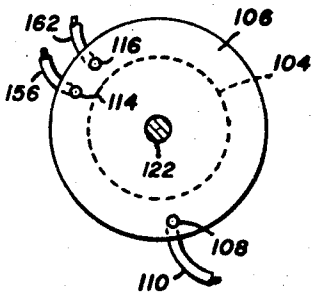


FIG.3.

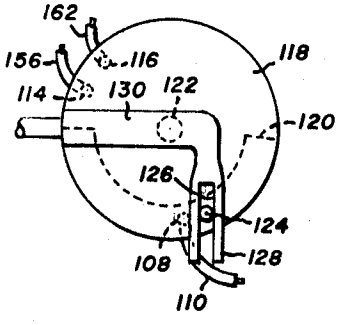


FIG.5.

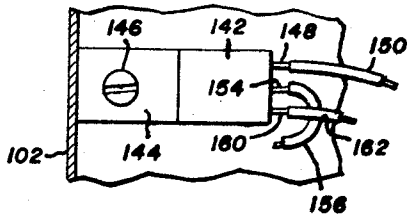
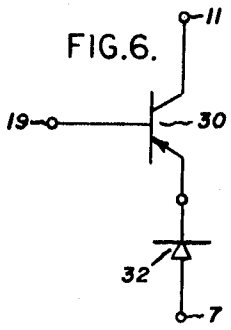


FIG.6.



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NON-ARCING SWITCH SYSTEM AND PROCESS

This invention is directed to a system and process for manually mechanically opening an electrical circuit in a repeatable manner so that electrical arcing across the mechanically separated switch contacts is avoided.

Most common electrical applicances are controlled by a simple mechanical switch which is relied upon to open and close the power supply circuit of the appliance. These simple mechanical switches are of low cost, high reliability, and high effectiveness in opening the electrical circuit. One disadvantage of the simple mechanical power switch, however, is attributable to the fact that electrical arcing occurs across the switch contacts when the switch is actuated from closed to open condition. The arcing causes undesirable radio interference and radiation to be broadcast outwardly from the switch. Since the switches are in most instances manually operable, the appliance user is sufficiently proximate the switch to physically receive a substantial proportion of the broadcast radiation.

It has been known for some time that electronically actuatable switches may be substituted for most common mechanical power on-off switches. These switches can be controlled by varying mechanically, optically, or electrically the electronic signal used to control the switch. Most commonly these switches utilize a very low level electronic signal to permit them to be turned on and are turned off when the current flow therethrough falls below a predetermined latching level. Where the electronic switch is controlling an alternating current power source, switching on and off will normally occur during each half cycle. These electronic switches offer advantages in that they can be readily constructed so that they do not generate either radiation or radio interference upon switching. Further, mechanically controlling the electronic signals supplied to these switches does not present any arcing or radiation disadvantages, since signal current typically flows only during a minute portion of each half cycle and is typically of a very low power level.

The widespread substitution of electronic switches for mechanical switches in electrical appliance power circuit controls has not occurred at least in part because electronic switches permit some level of power conduction even in their high impedance state. Further, they may over a period of time enter a failure mode in which progressively larger power levels are transmitted in their intended high impedance state. Hence something less than the positive on-off actuation of a mechanical switch may be actually achieved in use.

It is an object of our invention to combine the advantages of mechanical and electronic switches in a single switching system. It is a more specific advantage to provide an electrical switching system that is free of electrical arcing and resulting radiation and radio interference disadvantages while at the same time providing positive and reliable on-off switching characteristics normally associated with mechanical switches.

These and other objects of our invention are accomplished in one aspect by a process for mechanically switching an electrical circuit while alleviating electrical arcing comprising initially conducting electrical current through a first switch having manually actuatable separable contacts and a second switch in series therewith which is initially biased from a high impedance state to a low impedance state by an electronic

control signal. The control signal conduction path is manually interrupted to return the second switch to its high impedance state, and, thereafter, the actuatable contacts of the first switch are manually separated so that electrical arcing therebetween is avoided.

In another aspect our invention is directed to a non-arcing switch system adapted to be located in an electrical circuit including an electrical power source and an electrical load. The system is comprised of a controlled electronic valve means including first and second major current carrying terminals and at least one control terminal. The first major current carrying terminal serves as one external connector of the switch system. An impedance is connected to the control terminal. The switch system is also comprised of a switch means including a first terminal conductively associated with the second valve terminal, a second switch terminal serving as a remaining external connector for the switch system, a third switch terminal conductively associated with the impedance and through the impedance with the control terminal, and manually operable means for sequentially electrically interconnecting the first, second, and third switch terminals in that order and for electrically disconnecting the first, second, and third switch terminals in the opposite sequence.

Our invention may be better understood by reference to the following detailed description considered in combination with the drawings, in which

FIG. 1 is a schematic circuit diagram of a switch system formed according to our invention;

FIG. 2 is an elevation of the switch system with housing being shown in section;

FIG. 3 is a plan detail of the moveable switching disc and the control yoke;

FIG. 4 is a plan detail of the fixedly mounted switching disc;

FIG. 5 is a plan detail of the thyristor shown in FIG. 2;

FIG. 6 is a schematic circuit detail of an alternative electronic valve means substitutable for the thyristor shown in the schematic circuit diagram of FIG. 1; and

FIG. 7 is a schematic circuit detail of an alternative electronic valve means and impedance substitutable for the thyristor and impedance shown in the circuit diagram of FIG. 1.

Noting FIG. 1, it can be seen that a power source 1 is connected by a terminal 3 to an electrical load 5. In the circuit shown the power source is preferably an alternating current power source. Typically the power source is the common residential 110 volt, 60 hertz power source. The electrical load is connected to terminal 7, which is a first major current carrying terminal for the triac (or bilateral gate controlled thyristor) 9. The second major current carrying terminal 11 of the triac is connected to a first terminal 13 of a mechanical switch 15 The switch is connected to the power source through a second terminal 17.

The triac also includes a gate terminal 19 which is electrically connected to a third terminal 21 of the switch through an impedance 23. A snubber 25 is connected across the major current carrying terminals of the triac to protect the triac against damage and/or self triggering due to high rates of voltage increase across the terminals. Snubbers are well known in the art and need not be discussed in detail. A simple snubber is provided by a resistance and capacitance in series rela-

tion connected across the major current carrying terminals in parallel with the triac.

The switch is provided with a first set of contacts **27** that selectively interconnect the first and second switch terminals **13** and **17**. The switch is also provided with a second set of contacts **29** that selectively interconnect the second and third switch terminals **17** and **21**. It can be seen that the switch is constructed so that the first contacts are closed before the second contacts can be closed and that the second contacts are opened before the first contacts can be opened.

In use, the load **5** may take the form of an appliance motor or the primary transformer winding of a television set, for example. It is recognized that the load could be any conventional load capable of utilizing an alternating current power source. In the initial circuit condition no power is supplied to the load, since the triac **9**, lacking a gate signal, is in its high impedance state and the mechanical switch **15** is fully open, so that contacts **27** and **29** are open.

To energize the circuit and supply power to the load it is merely necessary to close the first set of contacts **27** and the second set of contacts **29** in that order. When the contacts **27** are closed, the first and second terminals **13** and **17** of the switch are electrically joined to connect the power source to the second terminal **11** of the triac **9**. At this instant, however, the contacts **29** are still not closed. This leaves the triac in a condition in which the full potential of the power source is developed across the major current carrying terminals **7** and **11**, since the triac remains in a high impedance state, the gate terminal **19** being still isolated from the circuit by the open contacts **29**.

Upon closing the contacts **29** a signal is supplied to the gate terminal **19** of the triac to switch it from its high impedance state to a low impedance state. The impedance **23** limits to a low level the current supplied to the gate to prevent the gate signal path from shunting more than a small proportion of current from the major conduction path through the circuit. The impedance placed in the gate signal path between the third switch terminal **21** and the gate terminal **19** of the triac may take any one of a variety of conventional gate impedance forms. Typically the impedance may amount to nothing more than a single resistor. So long as the contacts of the switch **15** remain closed the triac is turned on at the beginning of each half cycle provided by the power source, by a new gate signal being transmitted to the gate terminal of the triac. The triac is turned off automatically each time the polarity of the potential across its major current carrying contacts is reversed. It is to be noted that the gate signal occurs for only a short period at the beginning of each half cycle, since gate current is extinguished once the triac is switched to its low impedance state. The snubber **25** is provided to protect the triac against a high rate of voltage increase. Where the power source does not impinge upon the voltage increase tolerance of the triac, the snubber may, of course, be omitted from the circuit entirely.

When it is desired to interrupt power delivery to the load, the contacts **29** of the switch **15** are first opened before the contacts **27** are opened. In this way the triac is automatically switched to a high impedance state at the completion of the next half cycle and is not provided with an additional gate signal that could trigger it to its low impedance state. Power to the load is thus interrupted at the end of the first half cycle following opening of the contacts **29**.

To provide a positive mechanical open within the power conduction path within the circuit the contacts **27** are then opened. No arcing occurs as the mechanical open is formed, since current flow has already been terminated within the circuit. No arcing occurs when the contacts **29** are opened because of the low current and voltage levels normally utilized in this portion of the circuit and because gate current only flows for a minute fraction of each half cycle.

In FIGS. **2** through **5** inclusive a switch system **100** is illustrated which combines the triac **9**, switch **15**, and impedance **23** together with the electrical interconnections shown in FIG. **1**. While the snubber **25** is not shown as a part of the system, it could be included, if desired.

In the switch system a thermally conductive housing **102** is provided. A mechanical switch is included within the housing made up of a fixed insulative disc **104** provided to separate fixed switching disc **106** from the housing. The disc is formed of an insulative material and is provided with a terminal **108** (corresponding to terminal **17**) which extends between the upper and lower surfaces of the disc and is attached adjacent the lower surface to an electrical lead **110** provided with an insulative coating and extending through an aperture in the housing. Externally of the housing the lead **110** is connected to a first external connector **112**, which may take any conventional form. Angularly spaced from the terminal **108** along the periphery of the disc is a terminal **114** (corresponding to terminal **13**) which is constructed similarly as terminal **108**. A third terminal **116** is similar to terminals **108** and **114** and is angularly positioned so that it is separated from the terminal **108** by the terminal **114** in a clockwise direction when viewed as in FIG. **4**.

A moveable switching disc **118** is formed of an insulative material and carries a conductive area **120** on its lower major face adjacent its periphery. The conductive area does not extend entirely around the periphery of the disc. The moveable switching disc is rotatably mounted over the fixed switching disc by a central pin **122**. The pin may be spread at opposite ends to hold the discs in the desired stacked relation.

Extending upwardly from the upper major surface of the movable disc is an actuator pin **124**. The pin may be formed integrally with the moveable disc or may be attached thereto in any convenient conventional manner. The pin is slidably fitted within a slot **126** in a yoke **128** extending laterally outwardly from the end of the actuator arm **130**.

The actuator arm extends through an aperture **132** in the housing. An insulative bushing **134** is shown fitted within the aperture. The actuator arm is provided with a first shoulder **136** which limits the extent to which the actuator arm may be slid into the housing and a second shoulder **138** which limits the extent to which the actuator arm may be retracted from the housing. The shoulders abut the busing located within the aperture **132**. A knob **140** is threadedly or otherwise removably attached to the outer end of the actuator arm. An externally threaded mounting bushing **164** is attached to the exterior surface of the housing and mounts a portion of the insulative bushing. The housing may be mounted to an electrical appliance or at any other convenient loca-

tion using the threaded bushing or any other conventional mounting connector.

The triac **142** is shown provided with a heat dissipating mounting **144** which is attached to the housing by a bolt **146.** A first terminal **148** of the triac is soldered to an insulated lead **150** that extends through an aperture in the housing and is attached at its opposite end to a connector **152** which may be identical to connector **112.** The connector **152** serves as a second external connector for the switch system. The terminal **154** of the triac is connected to switch terminal **114** by lead **156.** The gate terminal **160** of the triac is connected through impedance **158** to the gate switch terminal **116** by electrical lead **162.**

In the position shown the mechanical switch is in a full open condition. The switching system **100** may be connected in an electrical circuit including a load and a power source utilizing electrical connectors **112** and **152.** To apply electrical power to the load it is then merely necessary to pull the knob **140** outwardly from the housing **102** so that shoulder **138** abuts the bushing **134.** This causes the yoke **128** to pull the pin **124** to the left and to rotate the moveable switch disc **118** clockwise in FIG. **3.** The conductive area **120** associated with the bottom major surface of the moveable disc is then moved from a position in which it contacts only terminal **108** of the fixed switch disc to a position in which it overlies and interconnects terminals **114** and **108.** This places the potential supplied by the power source across the terminals **148** and **154** of the triac. The triac is not gated from its initial high impedance state to a low impedance state, however, until the conductive area **120** is rotated still further to overlie the gate terminal **116.** The triac then switches to its low impedance state.

To utilize the switch system to de-energize the load it is merely necessary to push the knob **140** inwardly until the shoulder **136** abuts the bushing. The conductive area and moveable disc are then rotated counterclockwise in FIG. **3.** This results in the gate terminal **116** being first disconnected from the conductive area with the result that the triac reverts to its high impedance state with the next following half cycle supplied by the power source. At this point in time then the triac **142** is effectively preventing current flow through the switch system. Continued counterclockwise rotation disengages the conductive area from the switch terminal **114** and provides the positive mechanical open desired in the circuit for maximum reliability and elimination of leakage currents. There is no arcing as the conductive area disengages from the terminal **114,** since the triac has already reverted to its high impedance state.

It is recognized that a variety of electronically controllable electronic valve means may be substituted for the triac which has been discussed in connection with the embodiments of FIGS. **1** through **5** inclusive. In FIG. **6** a transistor **30** and diode **32** are shown attached to terminals **7, 11,** and **19** of the circuit of FIG. **1** in place of the triac **9.** It is to be noted that the anode of the diode is connected to terminal **7** while its cathode is connected to the transistor emitter, since in this instance the transistor is a PNP transistor. Where an NPN transistor is substituted the sense of the diode is reversed so that its anode is connected to the transistor emitter. The base and collector of the transistor are in each instance connected to the terminals **19** and **11,** respectively.

In FIG. **7** another alternative embodiment is disclosed in which the silicon controlled rectifier **40** is substituted for the triac **9.** The cathode of the SCR is connected to the terminal **7** while its anode is connected to terminal **11.** In order to avoid shunting of the SCR when it is reverse biased a diode **42** is connected in series with the impedance **23** so that its anode is attached to terminal **21** of the switch. The SCR performs similarly as the triac, but permits only unidirectional current flow to the load. In this instance the power source could as well be a pulsating direct current source as an alternating current source. In the former instance no diode **42** would be required. It is also anticipated that the triac **9** could also be used with a pulsating direct current source instead of an alternating current source.

It is anticipated that a number of variations could be introduced into the embodiments shown without departing from our teachings. For example, the relative locations of the power source and load in the circuit are immaterial, so long as they are serially related. It is also anticipated that still other elements may be added to the circuit disclosed without effectively changing its character. It is anticipated that the impedance **23** may take a form permitting control of the phase angle of firing of the thyristors. In the switch system **100** it is anticipated that the housing might serve as one connector to the power source. In this instance the electrical connection of the triac to the housing could be through the heat dissipation tab **144.** While a specific mechanical switch has been illustrated, it is recognized that other equivalent mechanical switches are known to the art and could be substituted. Accordingly, it is intended that the scope of our invention be determined by reference to the following claims.

What we claim and desire to secure by Letters Patent of the United States is:

1. A non-arcing switch system adapted to be located in an electrical circuit including an electrical power source and an electrical load comprising

controlled electronic valve means including first and second major current carrying terminals and at least one control terminal, said first major current carrying terminal serving as one external connector for said switch system,

an impedance having one end connected to said control terminal, and

mechanical switch means including a first terminal conductively associated with said second major current carrying terminal of said valve means a second switch terminal serving as a remaining external connector for said switch system, a third switch terminal connected to the other end of said impedance and through said impedance to said control terminal, and mechanically operable means for connecting the terminals of said switch means to apply power to an electrical load and for disconnecting the terminals of said switch means for removing power from an electrical load, said manually operable means effecting connection of said first and second terminals of the switch means before connection of the second and third terminals of the switch means during application of power and effecting disconnection of said second and third terminals of the switch means before discon-

nection of the first and second terminals of the switch means during removal of power.

2. A non-arcing switch system according to claim 1 in which said electronic valve means is an electronic switch.

3. A non-arcing switch system according to claim 1 in which said electronic valve means is a gate controlled bilateral thyristor.

4. A non-arcing switch system according to claim 1 in which said electronic valve means is a silicon controlled rectifier having a cathode, an anode, and a gate, said anode and cathode constituting said first and second terminals of said electronic valve means, respectively, said gate constitutes said control terminal, and said impedance includes a diode oriented to permit current flow from said third switch terminal to said gate and to substantially impede current flow in the opposite direction.

5. A non-arcing switch system according to claim 1 in which said electronic valve means is a transistor having an emitter, base, collector, emitter junction, and collector junction and a diode having a rectifying junction therein, said diode being interposed between said first terminal and said emitter of said transistor and oriented so that said rectifying and emitter junctions are both forwardly biased in the same direction of current flow, said collector serving as said second terminal of said electronic valve means and said base serve as said control terminal of said electronic valve means.

6. A non-arcing switch system according to claim 1 in which said switch means includes a thermally conductive housing and said electronic valve means is mounted in low thermal impedance relation thereto.

7. A non-arcing switch system according to claim 1 additionally including means for reducing the rate of rise of voltage within said electronic valve means when closing said switch means to apply an electrical potential across said first and second major current carrying terminals.

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