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ALTERNATING CURRENT SILICON CONTROLLED RECTIFIER SWITCH

Filed July 24, 1961

2 Sheets-Sheet 1

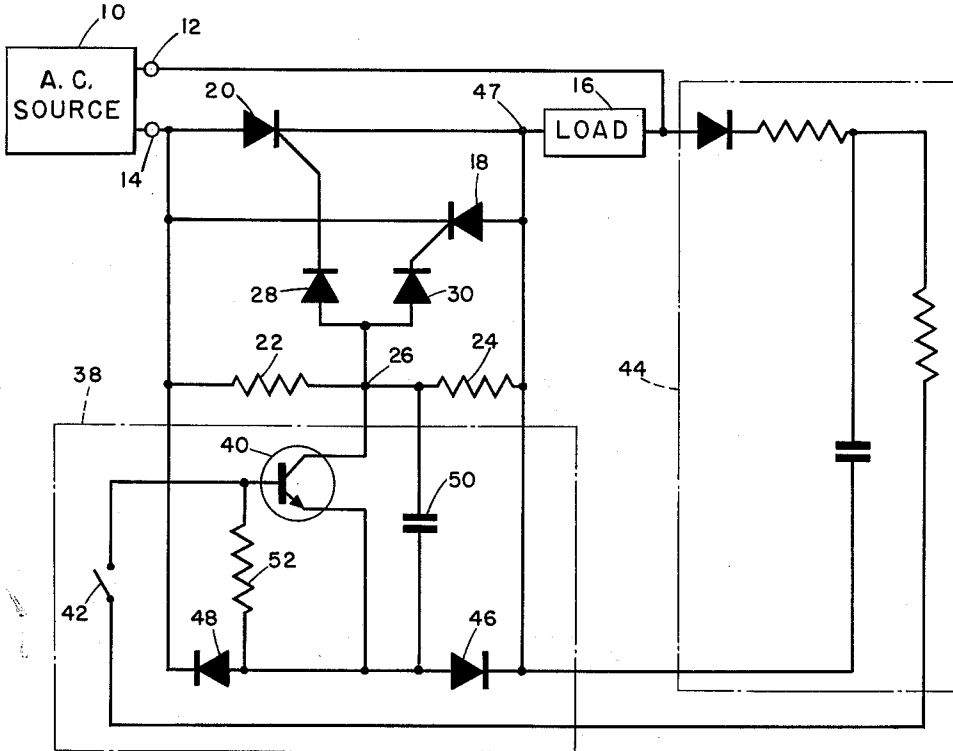


Fig. 1

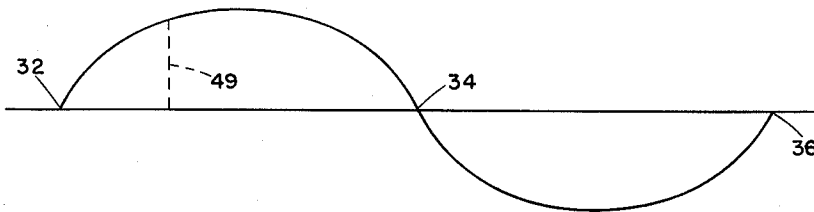


Fig. 2

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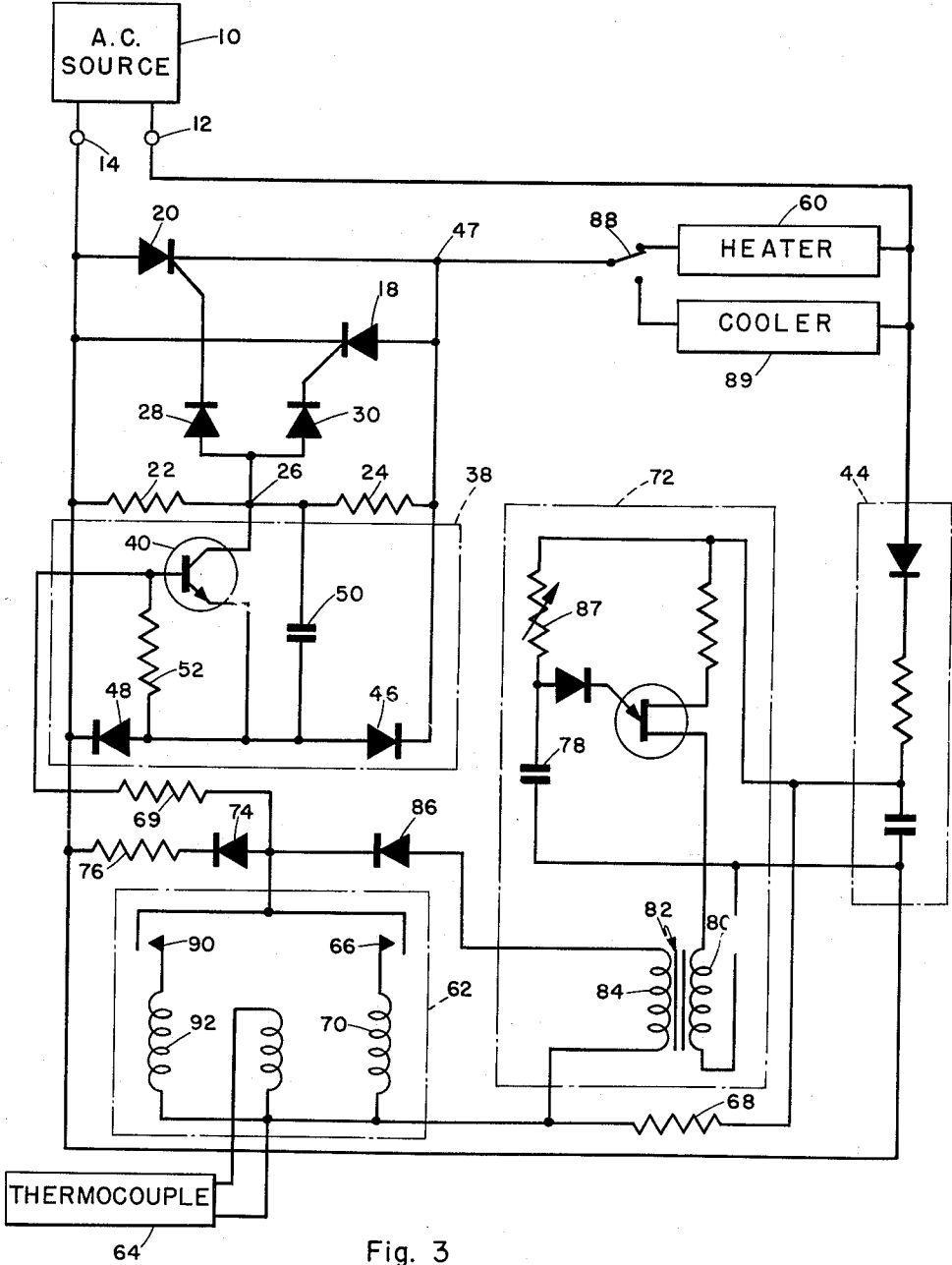


Fig. 3

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ALTERNATING CURRENT SILICON CONTROLLED RECTIFIER SWITCH

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This invention relates to a switch circuit, and more particularly to a switch circuit that may be used to control high-amperage currents with small signals.

Background

Practically everyone is familiar with the sound that is heard from a radio when a light switch is thrown; and in a television set, this action frequently causes a disturbance of the picture.

These disturbances result from the fact that when a switch is thrown, a set of contacts either closes or opens. This results in an arc between the slightly open contacts. The arc produces an amperage surge or produces a radiated signal. Moreover, the arc gradually pits the contacts, and eventually the switch must be replaced.

In industrial uses, the difficulty is more pronounced. The high amperage currents used produce more severe pitting, and greater disturbances. Since adjacent apparatus is often quite sensitive and these greater disturbances are quite objectionable.

A particular problem arises in the use of thermostatically controlled heat or cold chambers. Here the temperature control circuitry usually comprises timing motors, mechanical linkages, switches, and the like. As a result, there is a constant clatter and electrical disturbance.

Objects and Drawings

It is therefore the principal object of my invention to provide an improved switch circuit.

It is another object of my invention to provide an improved solid-state electronic switch circuit.

It is a further object of my invention to provide a switch circuit that obviates electrical disturbances.

It is a still further object of my invention to provide a switch circuit that has a practically infinite useful life.

It is a still further object of my invention to provide a switch circuit that is particularly adapted for a controlled temperature chamber.

The attainment of these objects and others will be realized from the following specification, taken in conjunction with the drawings of which:

FIGURE 1 shows a schematic representation of my switch circuit;

FIGURE 2 shows a single cycle of an A.C. signal, and its time relation to the operation of my switch circuit; and

FIGURE 3 shows a schematic representation of my switch circuit as used with a temperature controlled chamber.

Brief Description of the Invention

Broadly stated, my invention uses a pair of oppositely poled silicon controlled rectifiers connected in parallel between the source of energy and the load. Each conducts on alternate halves of a cycle. A disabling circuit, when energized, prevents these rectifiers from conducting current; and thus disables the load circuit. The load circuit is not actually broken, and there is no arcing, pitting, or disturbance. Since the disabling circuit uses an electron discharge device, a small control signal applied thereto will control a large amperage load circuit.

A temperature-indicating meter completes the circuit to the disabling device, the meter incorporating a holding circuit to improve its operation. I use electronic means to periodically break the holding circuit, so that the need for additional load current may be measured. When

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more load current is needed, the meter incapacitates the disabling circuit.

In this way, my invention overcomes the problems, disadvantages as well as mechanical linkages of the prior art, and provides a compact, quiet, improved switch arrangement.

Detailed Description of the Switch Circuit

In FIGURE 1, an A.C. source 10 having output terminals 12 and 14 provides power to a load 16.

When terminal 12 is positive, current flows through load 16 and a silicon controlled rectifier 18 back to source 10. During the other half of the A.C. cycle, current flows from terminal 14 through silicon controlled rectifier 20 and load 16 back to source 10. Thus the individual silicon controlled rectifier conducts for alternate half cycles.

Silicon controlled rectifiers, such as 18 and 20, conduct in one direction and only when the potential at the anode (represented by the triangle) is higher than the potential at the cathode (represented by the transverse line), provided a positive signal is present at the control electrode (represented by the angled line). If all these conditions are met, the SCR will conduct. Conversely, if any one of the conditions is not met, the SCR will not conduct. One other characteristic should be noted; once the SCR begins to conduct, the application of a negative signal to its control electrode will not stop the flow of electrical current therethrough.

When output terminal 14 is positive, the relative potentials on SCR 18 are such that it will not conduct; whereas the potentials on SCR 20 are such that it will conduct as soon as a positive signal is applied to its control electrode.

I apply the positive signal as follows:

Resistors 22 and 24 form a voltage divider whose midpoint 26 is at a relatively high potential. The potential at midpoint 26 is applied through diodes 28 and 30 to the control electrodes of SCR 20 and 18. As previously explained SCR 18 has the wrong potentials, and will not conduct; whereas the positive signal from midpoint 26 causes SCR 20 to become conductive. Thus, during the first half 32—34 of FIGURE 2, SCR 20 will conduct.

When output terminal 12 is positive, SCR 20 will not conduct; whereas the positive potential from midpoint 26 will cause SCR 18 to conduct during the interval 34—36 of FIGURE 2.

Thus, as long as conditions are right, SCR 18 and 20 will alternately supply current to load 16.

Disabling Circuit

In order to stop the flow of current to load 16, a disabling circuit 38 is used. Disabling circuit 38 comprises transistor 40, which has been inoperative during the above explanation. When the load is to be cut off, the disabling circuit 38 operates as follows:

Switch 42 is closed, applying a control potential from rectifier circuit 44 to the base electrode of transistor 40, and causing it to become conductive.

Assume now that output terminal 14 is positive. Current flows from it through resistance 22, transistor 40, and diode 46 to the load. Since the forward resistance of transistor 40 and diode 46 are much smaller than the resistance of resistor 24, they effectively shunt resistor 24, and midpoint 26 is effectively connected to point 47, which is at a low potential. Midpoint 26 therefore applies a low potential to the control electrode of SCR 20, and prevents it from becoming conductive; thus disabling the load supplying circuit during the interval 32—34 of FIGURE 2.

When output terminal 12 is positive, a similar analysis will show that transistor 40 and diode 48 shunt resistance 22, and that midpoint 26 is connected to negative terminal

14 and this will prevent SCR 18 from becoming conductive.

Thus, when switch 42 is closed, no current is supplied to the load 16, whereas if switch 42 is opened, current will flow.

Three points of interest should be noted. If switch 42 were closed at an instant 49 indicated by the dash line bearing the numeral 49 in FIGURE 2, SCR 20 would continue to conduct for the rest of interval 32—34. At that time SCR 18 would become non-conductive; and SCR 20 would become non-conductive during interval 34—36.

Thus, at 60 cycles per second, the load circuit would become inoperative at a maximum of $\frac{1}{120}$ of a second after the switch 42 was closed. At higher frequencies, the circuit would become inoperative even sooner.

Another point of interest is that the load circuit is not broken; it is only prevented from becoming conductive on the next half cycle. This means that there is no arcing, pitting of the contacts, or electrical disturbance.

Still another point of interest is that switch 42 carries a very small current, and produces no arcing or electrical disturbance.

I have found that capacitance 50 tends to provide a relatively constant potential for transistor 40, and assures more consistent operation.

Similarly, resistance 52 connects the base and emitter of the transistor, and assures that it will not turn on due to minor transients.

The circuit of FIGURE 1 has many uses. As explained, it can be used to turn a circuit on or off. If the load circuit is highly inductive, there is a minimal inductive "kick," because the shutting off occurs at point 34 of FIGURE 2, where there is no current flow. This obviates the arc, and minimizes electrical disturbance. Furthermore, since there are no contacts to be separated, the contact-pitting problem is also obviated.

It will also be realized that, due to my invention, a high-amperage circuit is readily completed or broken by a small control signal applied to the transistor.

If there are several loads, such as the banks of lights at a stadium, each can be turned on or off remotely by using modulated signals that activate receivers that apply control signals to specific transistors.

Other uses will be apparent to those skilled in the art.

A Temperature Control Circuit

As shown in FIGURE 3, my invention may be advantageously used for controlling the temperature in a chamber. The switch circuit operates as previously described, a control circuit replaces the switch 42, and a heater 60 is now the load.

Many temperature control circuits use a combined meter and control, such as the Sim-Ply-Trol Pyrometer manufactured by Assembly Products Inc., of Chesterland, Ohio. This unit, shown schematically at 62, comprises a pointer that moves over a temperature scale. Two adjustable stops are positioned for the hot and the cold temperature desired.

Assume that the chamber is to be kept hot. The adjustable stop is set at the desired temperature, and the switch circuit supplies current to the heater, which thus warms the chamber. As the thermocouple 64 indicates a progressively higher temperature, the meter pointer moves upward along the scale. When it touches the stop, it closes contacts 66. This has an effect similar to closing switch 42 of FIGURE 1. In FIGURE 3, a control potential from rectifier 44 traverses resistance 68, passes through the closed contact 66, and is applied through base resistance 69 to the base of transistor 40. The operation, as previously described, breaks the heat producing circuit.

When the pointer drops below the desired temperature, contacts 66 open, the heating circuit is re-established, and the chamber is restored up to the desired temperature.

The simple open-and-close operation of contacts 66 has

been found to have some serious shortcomings. Firstly, there is arcing between the contacts, and secondly the contacts are not always as tightly closed as may be desired.

The aforementioned meter overcomes these shortcomings as follows. When contacts 66 close, a pull-in current passes through coil 70. The action of the coil is such that it closes the contacts with a wiping action that removes any oxidation resulting from arcing; and furthermore holds contacts 66 tightly closed.

I provide a pulling-in action as follows. When contacts 66 close, resistance 68 provides a current that flows "upwards" through coil 70, and out through diode 74 and resistance 76.

It will be realized that this pull-in current remains on, thus providing a holding-in action for the contacts. This holding-in action would prevent the pointer from pulling out if the temperature decreased.

In prior art devices, the pull-out arrangement comprised a motor and cam arrangement that periodically broke the hold-in circuit; but this arrangement introduced other switches, contacts, mechanical linkages, and the like. Moreover, it depended on the temperature of the chamber to pull back the pointer. If the temperature of the chamber dropped only slightly, the contacts didn't open widely, and this introduced more arcing.

To achieve pull-out in my circuit, I use an oscillator 72; which conveniently takes the form of a relaxation oscillator using a unijunction transistor.

Oscillator 72 periodically discharges capacitor 78, so that it discharges through the primary winding 80 of transformer 82. This discharge causes secondary winding 84 to produce a surge of current through diode 86, the current passing "downward" through coil 70. This reversed-direction current drives contacts 66 apart, the action being quick, and minimizing arcing. I have found that a transformer having a 2:1 or a 3:1 step-up ratio provides good results. When the contacts are separated, the heat-supplying circuit is energized as previously explained.

The meter 62 is damped in such a way that it takes about two seconds for the pointer to resume its position; so that a heating interval of about 2 seconds is introduced. For a well-insulated chamber, I have found that if the oscillator fires at 2-second intervals, the temperature easily remains within 2 degrees of the desired temperature. The timing of oscillator 72 is controlled by variable resistance 87. In this way, the thermocouple samples the temperature periodically.

When the chamber door is opened, the temperature, of course, drops. At the next surge from the oscillator, the pointer drops to the temperature indicated by the thermocouple. Since this is below the desired temperature, contacts 66 stay open, and the load circuit provides current to the heater.

When the temperature reaches the desired value, the pointer closes contacts 66, and the heat is shut off.

In those cases where a low temperature is desired, a heat-cool switch 88 closes the circuit to a cooling arrangement 89 that may comprise mechanism that liberates a gas such as carbon dioxide. At this time, contact 90 and coil 92 co-act with the low temperature stop in a manner similar to that previously described.

I have found that my complete circuit, oscillator, rectifier and all, may be built onto a printed wiring board that is approximately 1 inch wide and about 3 inches long.

Advantages

It will now be obvious that my invention provides an improved switch circuit that prevents arcing, pitting, noise, and electrical disturbances. The circuit is compact, lightweight, and has a long life.

The temperature-sampling circuit is also simple, and requires practically no maintenance.

It is understood that minor variation from the form of the invention disclosed herein may be made without departure from the spirit and scope of the invention, and

that the specification and drawing are to be considered as merely illustrative rather than limiting.

I claim:

1. A circuit for controlling whether or not current flows between an A.C. source and a load, comprising:
 a pair of oppositely-poled silicon controlled rectifiers connected in parallel between said source and said load, each of said silicon controlled rectifiers having an anode, a cathode, and a control electrode;
 a voltage divider connected between said anodes, said voltage divider having a midpoint;
 means for applying the potential at said midpoint to said control electrodes of said silicon controlled rectifiers;
 a connection comprising a pair of oppositely-poled front-to-front diodes connected in series between said anodes, said connection having a midpoint;
 an electron discharge device connected between said midpoint of said voltage divider and said midpoint of said connection;
 and means, comprising a switch, for applying a D.C. potential to a control electrode of said electron discharge device.

2. The combination of claim 1 wherein said load is a temperature changing device, and the switch of said last means is activated by the temperature resulting from said temperature changing device.

3. A circuit for controlling whether or not current flows between on A.C. source and a load, comprising:
 a pair of oppositely-poled silicon controlled rectifiers connected in parallel between said source and said load, each of said silicon controlled rectifiers having an anode, a cathode, and a control electrode;
 a voltage divider connected between said anodes, said voltage divider having a midpoint;
 means, comprising a pair of similarly poled diodes for applying the potential at said midpoint to said control electrodes of said silicon controlled rectifiers;
 a connection comprising a pair of oppositely-poled front-to-front diodes connected in series between said anodes, said connection having a midpoint;
 a transistor having its collector-emitter circuit connected between said midpoint of said voltage divider and said midpoint of said connection;
 and means, comprising a switch, for applying a D.C. potential to the base electrode of said transistor.

4. The combination of claim 3 wherein said last means comprises a meter whose pointer acts to close a circuit, thus acting as said switch.

5. In combination with a meter wherein the pointer closes a contact and completes a circuit through a holding coil, the combination comprising:
 means for causing a holding current to flow in a given direction through said coil; and
 means, comprising an oscillator, for causing a releasing current to flow through said coil in the opposite direction.

6. In combination with a meter wherein the pointer closes a contact and completes a circuit through a holding coil, the combination comprising:
 means whereby said contact is closed under given conditions;
 means for causing a holding current to flow in a given direction through said coil, to provide a holding action;

an oscillator;
 a transformer having a primary and a secondary;
 means for causing said oscillator to periodically send a surge of current through said primary; and
 means for causing the resultant surge of current in said secondary to flow through said coil in the opposite direction to break said holding action.

7. A circuit for controlling whether current flows between an A.C. source and a load, comprising:
 a pair of oppositely-poled silicon controlled rectifiers connected in parallel between said source and said

load, each of said silicon controlled rectifiers having an anode, a cathode, and a control electrode;

a voltage divider connected between said anodes, said voltage divider having a midpoint;

means for applying the potential at said midpoint to said control electrodes of said silicon controlled rectifiers;

a connection comprising a pair of oppositely-poled front-to-front diodes connected in series between said anodes, said connection having a midpoint;

an electron discharge device connected between said midpoint of said voltage divider and said midpoint of said connection;

disabling means for applying a D.C. potential control electrode of said electron discharge device, said means comprising;

a meter wherein the pointer closes a contact and completes a circuit through a holding coil;

means for causing a holding current to flow in a given direction through said coil; and

means, comprising an oscillator, for causing a releasing current to flow through said coil in the opposite direction.

8. A circuit for controlling whether current flows between an A.C. source and a temperature changing device, comprising:

a pair of oppositely-poled silicon controlled rectifiers connected in parallel between said source and said device, each of said silicon controlled rectifiers having an anode, a cathode, and a control electrode;

a voltage divider connected between said anodes, said voltage divider having a midpoint;

means, comprising a pair of similarly poled diodes for applying the potential at said midpoint to said control electrodes of said silicon controlled rectifiers;

a connection comprising a pair of oppositely-poled front-to-front diodes connected in series between said anodes, said connection having a midpoint;

a transistor having its collector-emitter circuit between said midpoint of said voltage divider and said midpoint of said connection;

disabling means, for applying a D.C. potential to the base electrode of said transistor, said means comprising;

a meter wherein the pointer closes a contact and completes a circuit through a holding coil;

means whereby said contact is closed under given conditions of temperature;

means for causing said D.C. potential to cause a holding current to flow in a given direction through said coil, to provide a holding action;

an oscillator;

a transformer having a primary and a secondary;

means for causing said oscillator to periodically send a surge of current through said primary; and

means for causing the resultant surge of current in said secondary to flow through said coil in the opposite direction to break said holding action.

9. The combination of claim 8 wherein said temperature changing device has a heating action.

10. The combination of claim 8 wherein said temperature changing device has a cooling action.

11. The combination of claim 8 wherein said meter has an additional contact and holding coil, whereby one contact and coil may be used for heating and the other contact and coil may be used for cooling.

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