

United States Patent

Evans et al.

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[54] STATIC SWITCH

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[51] Int. Cl. H03k 17/00

[58] Field of Search 340/258 C; 307/252 C, 252 W, 307/308

[56] References Cited

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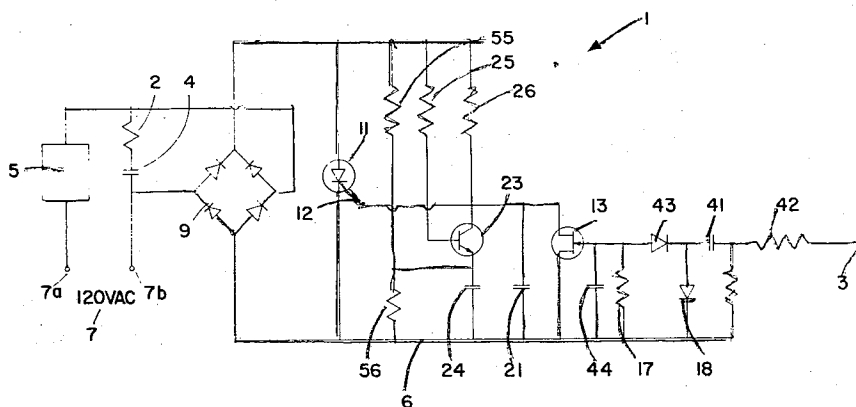
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[57]

ABSTRACT

A touch switch circuit is disclosed for connecting a load to a source of AC potential in response to operator contact with a touch probe. A normally nonconducting SCR is in series connection with a load and source of AC potential. Means are present for clamping the gate of the SCR below its normal turn-on level, and for removing the said clamp in response to operator contact with said touch terminal whereby to fire said SCR and activate said load.

6 Claims, 8 Drawing Figures



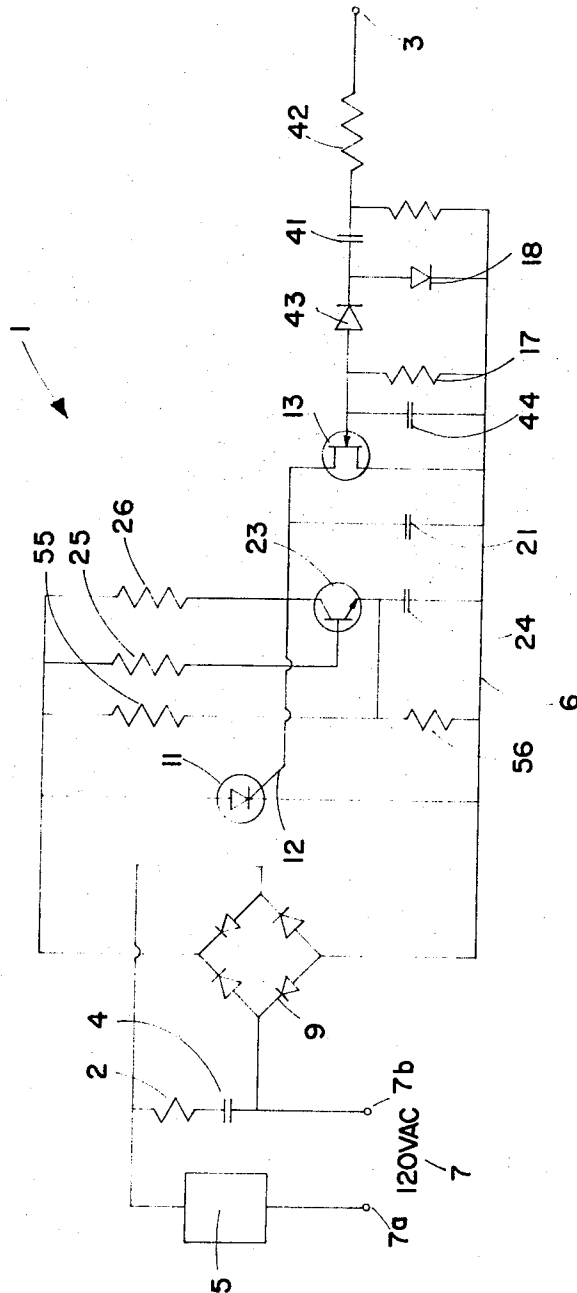


FIG. 1

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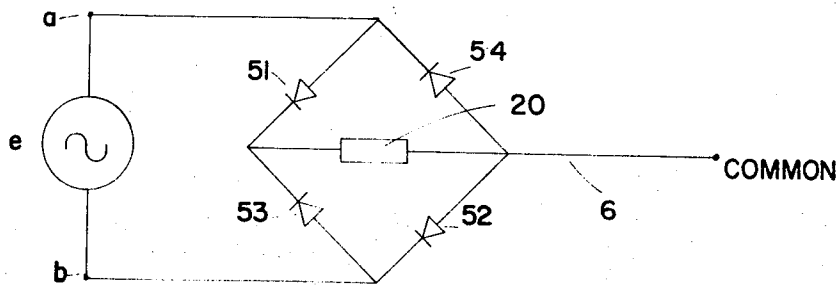
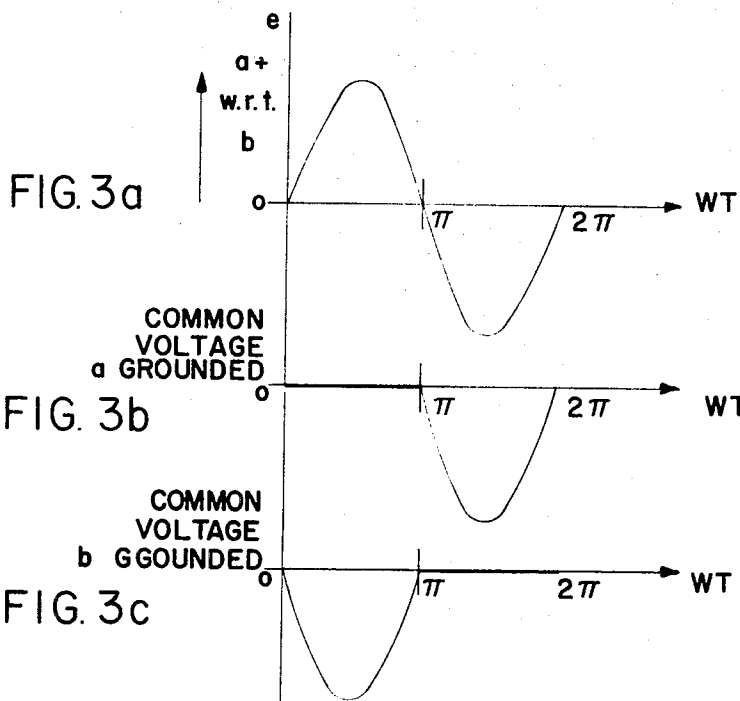


FIG. 2



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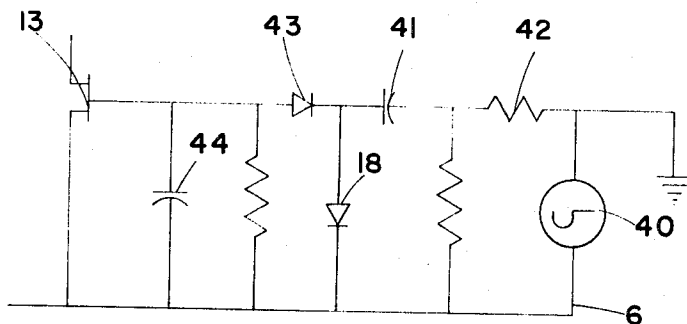


FIG. 4

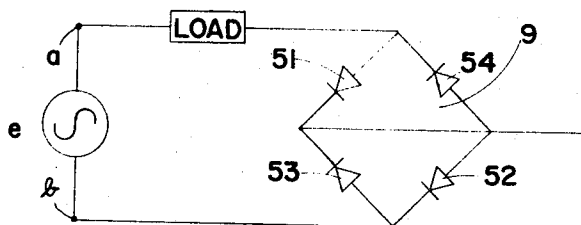


FIG. 5

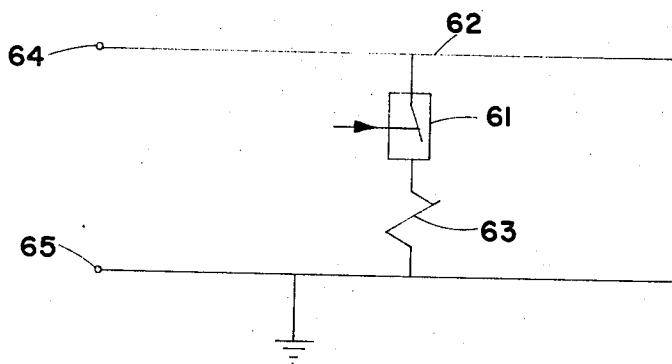


FIG. 6

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STATIC SWITCH

BACKGROUND OF THE INVENTION

This invention relates generally to electrical and more specifically relates to a touch controlled switch, adapted in industrial applications or the like to open or close a load circuit in response to touch by an individual.

In numerous and varying electrical environments it is desirable to incorporate switching circuits that are capable of opening or closing a load circuit in direct response to mere touching by a human operator. In some instances switching devices of this type are mere conveniences—as, for example, in modernistic lighting schemes. In other instances such a circuit serves a more vital purpose: specifically such circuits are commonly used in industrial environments to provide a simple means whereby an operator can quickly activate or inactivate machinery or the like by touching a wire button or similar “-probe” element forming part of the load controlling circuit. It should be clear that such simple and direct control of machinery provides an enormous safety factor to the said operator in that under emergency conditions the operator has only to contact the probe element to effect desired electrical switching.

In general, circuits of the foregoing type have in the past been constructed with an unduly large number of elements and have tended for this and other reasons to be relatively unreliable. Such circuits have, moreover, commonly employed high frequency oscillatory circuits, which not only create radio interference, but which moreover require relatively high standby power. Because of the factors mentioned such circuits have tended to be hazardous—not only to the operator, but by virtue of possible sparking therein to the industrial environment as well.

In accordance with the foregoing, it may be regarded as an object of the present invention to provide a touch controlled switching circuit which is simple in construction, contains relatively few parts, and is correspondingly dependable in operation.

It is a further object of the invention to provide a touch controlled switching circuit with low power requirements, and which introduces no hazard to the operator or the environment in which the circuit is employed.

It is another object of the invention to provide a touch controlled switching circuit utilizing only low frequency energy, whereby problems of radio interference are eliminated or minimized.

It is still a further object of the invention to provide a touch controlled switching circuit wherein touch activation is accomplished by means rendering the circuit highly sensitive and dependable.

SUMMARY OF THE INVENTION

Now in accordance with the present invention, the foregoing objects, and other as will become apparent in the course of the ensuing specification, are achieved in a touch switch circuit utilizing a normally nonconducting SCR in series connection with a load and source of AC potential. Means are present for providing full wave rectified unipolar drive to said SCR. The gate of said SCR is clamped below its normal turn-on level by an FET. To remove the clamp and allow the SCR to turn on, the FET is biased by a potential supplied via rectified 60 Hz voltage picked up by the touch-probe and applied to a capacitor across the said FET.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the appended drawings, in which:

FIG. 1 is a schematic electrical diagram depicting a touch switch in accordance with the invention;

FIG. 2 schematically depicts the equivalent circuit for the sense circuit before the probe is grounded;

FIGS. 3a, 3b, and 3c illustrate respectively the waveform of supply potential e of FIG. 2, the voltage at the common head with point a (FIG. 2) grounded, and the voltage at the common lead with point b (FIG. 2) grounded;

FIG. 4 depicts an equivalent circuit providing a waveform as shown in FIGS. 3b and 3c;

FIG. 5 depicts the equivalent circuit of FIG. 2 just after the thyristor has been turned on; and,

FIG. 6 schematically depicts installation of the switch of the present invention in a typical operating environment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a schematic electric diagram appears, depicting a touch switch in accordance with the invention. In connection with the ensuing description thereof, certain parameters such as potentials, currents, time delays, capacitances, or so forth may be specified. It will, however, be appreciated that the use of such data is intended merely to concretely illustrate operation of the circuit, and not to provide limitations upon the invention otherwise set forth.

As seen in FIG. 1 a circuit 1 is provided which in response to touch by an individual at touch probe 3 will activate an electrical load. The load circuit does not per se form part of the present invention; the load relay 5 and 120 volt AC potential source 7 may be regarded as part of such circuit. It may be presumed that relay 5 when activated by application of source 7 through the circuit 1 will in turn activate the load—such as machinery, lighting fixtures, or the like.

It is seen that the AC line potential source 7 is in series with a thyristor 11, which may for example comprise a silicon-controlled rectifier (SCR). In the present environment thyristor 11 may thus be a type such as that available from Radio Corporation of America under the designation number 40655. Such thyristor 11 will be operated in a normally nonconducting mode, contact with probe terminal 3 serving in accordance with the invention to render the device conductive and thus in turn to activate load relay 5.

A diode bridge rectifier 9 supplies fullwave rectified 60 Hz potential to thyristor 11 to provide switching on both half-cycles of the AC line when touch probe 3 is contacted by an operator. A series RC network 2-4 is placed across input terminals 7a-7b to provide noise suppression to prevent line transients from triggering thyristor 11 on. The gate 12 of thyristor 11 is clamped below its normal turn-on level by transistor 13. The latter is exemplarily shown as an FET “N” channel device, such as Amelco type 2N5163. The device in question conducts with zero bias.

To remove this clamp and allow thyristor 11 to turn on the transistor 13 must be biased with a negative potential on its gate. Such negative potential is supplied by rectified 60 Hz voltage picked up by touch-probe 3 when it is contacted by an operator. In particular the voltage doubler rectifier circuit consisting of 17, 18, 41, 42, 43, and 44 charges capacitor 44 to provide a negative potential from gate to source of transistor 13. Capacitor 44 filters the half-wave rectified voltage to provide a continuous negative voltage to the gate of transistor 13 between half-cycles to keep the clamp removed. This allows thyristor 11 to switch on each half-cycle of the line voltage. Capacitor 21 between the gate and cathode of thyristor 11 provides a slight lag of the thyristor 11 firing voltage and prevents transients from the input circuitry from firing the thyristor. A transistor 23, together with capacitor 24 and resistors 25 and 26 is also connected across thyristor 11; these elements function to clamp the thyristor gate potential at the cathode potential for a brief period after transistor 13 is rendered nonconductive, whereby to provide a start-up delay for said thyristor. Resistors 55 and 56 provide biasing for the emitter of transistors; the former is part of the base-emitter circuit.

When contact with touch probe 3 is broken, the resistor 17 across transistor 13 gate capacitor 44 discharges the capacitor. Transistor 13 then conducts to provide a clamp across the thyristor gate to prevent it from firing.

For purposes of analysis the circuit 1 can be considered as divided into three parts: the “power circuits;” the “sense circuit;” and the “start-up” circuit. Comprising the power circuit are the bridge rectifier 9 and the thyristor 11, together with

the resistance-capacitance line transient suppressor, consisting of resistance 2 and capacitance 4. When no gate current flows in thyristor 11, it is in the open state. Thus, the rectified line voltage appears between its anode and cathode since no drop occurs in the relay 5.

The thyristor 11 is turned on by causing current to flow between gate and cathode. Under this condition the thyristor is in the "on" state and may be considered, to the first approximation, a short circuit. Thus, neglecting diode drop in the bridge 9, no line voltage appears across the bridge. Full line voltage appears across the load (relay 5 in the diagram).

The transient suppression resistor 2 and capacitor 4 are selected in coordination with the thyristor rating. In a typical case, approximately 20 amperes must flow in the suppression resistor before the voltage across the thyristor reaches its noted value under the poorest instantaneous line voltage condition. This represents a transient of 400 volts peak value capable of supplying the 20 amperes.

In order to understand the sense circuit, it is necessary to examine the potential of the common lead 6 with respect to earth ground before and after the probe is touched. Since the transistor 13 has a very high impedance input, we may neglect it together with its load (the gate circuit of thyristor 11). Note, however, that the thyristor 11 will "fire" (go from open to closed state) when the input to transistor 13 goes negative with respect to the common. Also note, that touching the probe is essentially the same as grounding the probe to the earth ground because of the extremely high impedance of the circuit "looking in" at the probe.

If the probe is not grounded, thyristor 11 is not conducting and no voltage drop appears across the load. The common potential may be simply seen by referring to the equivalent circuit of FIG. 2 under this condition, where resistance 20 is finite but very large. With point *a* positive with respect to point *b* and *b* grounded, diodes 51 and 52 conduct. Since point *b* is grounded and there is essentially no voltage across diode 52, the common lead 6 is at ground potential for this condition and in this half-cycle. With point *a* negative with respect to point *b* and point *b* grounded, diodes 53 and 54 conduct. The common lead 6 then assumes essentially the same potential as point *a*. This is shown in FIG. 3b.

Now if we ground point *a*, then in the first half-cycle of the supply potential, *e*, shown in FIG. 3a, diodes 51 and 52 conduct. The common lead 6 assumes the potential of point *b*. In the next half-cycle of the supply potential, *e*, diodes 53 and 54 conduct, causing the common lead 6 to be essentially tied to ground.

To complete the picture, we must now look at the relationship of the common potential to ground and its effect on the input voltage to transistor 13. The equivalent circuit of FIG. 4 shows a generator 40, providing a waveform as shown in FIGS. 3b and 3c.

When the generator 40 forces the common lead 6 negative with respect to earth ground, current flows through diode 18 charging capacitor 41 as shown. In the next half-cycle when generator 40 provides zero voltage, capacitor 41 discharges through resistor 42 and diode 43 charging up capacitor 44 as shown. Note the potential across capacitor 44 is in a direction to turn the thyristor 11 on.

FIG. 5 shows the equivalent circuit of FIG. 2 just after thyristor 11 has been turned on. If, in this case, point *a* is tied to earth ground, the common lead assumes the potential of point *b* because of the essentially full line voltage drop across the load. On the other hand, if point *b* is tied to earth ground, the common lead is also.

By referring to FIG. 4, it is seen that after turning the thyristor 11 on if point *a* is grounded, the generator 40 is identical in waveform to the source *e*. Thus capacitor 44 increases in potential in the direction to keep thyristor 11 turned on. But, if point *b* is tied to earth ground, the common lead 6 goes to zero throughout the cycle and the charge on capacitor 44 eventually "leaks" off allowing the thyristor 11 to again open. Naturally, if the probe is still grounded, waveform from

generator 40 appears in the off condition and the thyristor 11 turns on again. This causes cycling of the switch.

The start up circuit consists of resistors 25 and 26, capacitor 24, and transistor 23 (FIG. 1). When the switch is energized by applying 120 volts rms, bridge 9 rectifies the source and provides a direct voltage input to resistor 25 and capacitor 24. Current flows (to charge up capacitor 24) through the base-emitter circuit of transistor 23, thereby turning it on. The low impedance across transistor 23 "shorts" the thyristor 11 gate to its cathode making it impossible to turn on. This condition continues until capacitor 24 is completely charged (to approximately the rectified supply voltage peak value). At this point transistor 23 opens, effectively removing it from the circuit. Resistor 26 limits current to transistor 23. Note that if the supply source is removed, the charged capacitor 24 discharges slowly. Some time is required with the power source removed before the capacitor is fully discharged and again capable of "locking out" the thyristor gate circuit on re-energization.

FIG. 6 schematically depicts installation of the switch of the present invention in a typical operating environment. It is thus seen that the switch 61 is installed on the ungrounded (or non-common) side 62 of the line. The load controlled by the switch appears at 63, and the line power is applied at terminals 64-65.

While the present invention has been set forth in terms of specific embodiments thereof, it will be understood in view of the present disclosure, that numerous variations upon the invention are now enabled to those skilled in the art, which variations will not in propriety depart from the scope of the instant teaching. Accordingly the invention is to be broadly construed, and limited only by the scope and spirit of the claims now appended hereto.

What is claimed is:

1. A touch switch circuit for connecting a load to a source of AC potential, comprising:

a normally nonconducting thyristor in series connection with said load and said source of AC potential;

means to provide full wave rectified unipolar drive to said thyristor;

a field effect transistor (FET);

means to clamp the gate of said thyristor below its normal turn-on level, said field effect transistor (FET) conducting with zero bias connected across the gate and cathode of said thyristor; and

sensing circuit means including a touch terminal electrically connected to said thyristor to remove said clamp in response to operator contact with said touch terminal whereby to fire said thyristor and activate said load, said sensing circuit means being connected to the gate of said FET to render said FET conductive after contact with said touch terminal is established, whereby to remove said clamp.

2. Apparatus in accordance with claim 1 wherein said thyristor is an SCR.

3. Apparatus in accordance with claim 1 wherein said sensing circuit means includes means to rectify 60 Hz voltage picked up by said touch terminal when it is touched, and apply said voltage to a capacitor across said field effect transistor gate, said voltage across said capacitor acting to render said FET nonconductive to remove said SCR clamp.

4. Apparatus in accordance with claim 3 wherein a diode bridge connected to said source of AC potential provides said unipolar drive for said SCR and said sensing circuit means.

5. Apparatus in accordance with claim 4 further including transistor means connected across said SCR, adapted for clamping said gate potential at said cathode potential for a period after said FET is rendered nonconductive whereby to provide a start-up delay for said SCR.

6. Apparatus in accordance with claim 5 further including a series RC network across said load and AC potential source for providing noise suppression to prevent line transients from triggering said SCR.

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