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TWO WIRE SWITCH CONTROL CIRCUIT

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(56) Prior Art Documents
US 4745300
US 4328528
US 4097769

(57) Claim

1. A two wire switch for controlling the passage of current between a line and load comprising a solid state alternating current switch circuit means located between said line and load,

a bridge rectifier circuit means,

a trigger circuit means,

a direct current storage circuit means, and

a control circuit, said two wire switch having:

(1) a high impedance "off" state, whereby said control circuit diverts current via said bridge rectifier circuit means to said direct current storage means and controls said solid state alternating current switch means in a non-conducting state,

(2) a low impedance "on" state, whereby said control circuit

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diverts current via said bridge rectifier circuit means to both of said trigger circuit means and said direct current storage circuit means and controls said solid state alternating current switch means in a conducting state,

whereby said direct current storage circuit continuously supplies power to said control circuit.

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Form 10

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COMPLETE SPECIFICATION

(ORIGINAL)

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TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:

"TWO WIRE SWITCH CONTROL CIRCUIT"

The following statement is a full description of this invention, including the best method of performing it known to ~~me~~ us.

This invention relates to a two wire switch which controls the passage of power from a line to a load and concurrently draws sufficient power to provide a direct current source for the control and switching circuitry of the switch and other additional electronic equipment.

Control of a supply of alternating current to a load in its simplest and most convenient form is achieved by the use of a switch placed between the line supply active and the load. A sealed mechanical arrangement is common to the electrical trade and is configured with one wire input, the "active", from the active side of the supply and one wire output, the "switched active", to the load with the neutral of the electric supply system connected to the other side of the load to complete the circuit. This mechanical type of switch and configuration is difficult to remotely or automatically control, and to this end, electronic switch alternatives have been developed to overcome those difficulties.

Commonly a TRIAC or THYRISTOR component is used as the electronic switch alternative, which, allows additional circuit means to control its operation. This type of control can for example time the "on" and "off" periods of the switch, the control sensor or actuators may comprise motion, heat or sunset detectors which then ultimately control the "on" and "off" states of the switch. These and many other variations of control means are possible when an electronic switch alternative is used.

However, the additional circuitry associated with control of the electronic switches must be supplied with a continuous power source and this problem has been approached in a number of ways.

One approach is the use of a direct current battery to supply current to operate the electronic switch alternative, however periodic replacement of the battery is required.

Another approach is the use of a third electrical wire run to the switch means. This third wire would then complete in an alternating current system a path to the A.C. neutral and provide power to an electronic switch circuit or power supply from which could be derived the power to supply an electronic switch and its control circuitry. This method allows current consumption to be as much as required to support the additional circuit/s, within the bounds of space and acceptable heat dissipation. However, the obvious imposition of having to run an extra electrical wire when the switch is installed or installing the wire to a switch in an existing wall is both difficult and an inherently expensive task.

To overcome these problems there do exist switches which require no additional wires and which draw power from the switch circuit while in the "on" state and also to a lesser extent when the switch is in the "off" state.

The current that flows through this type of switch circuit during its "off" state is commonly referred to as a leakage current. Commonly the quantity of leakage current that flows through the load varies in relation to the load and is commonly in the vicinity of 1-3 milliAmperes (mA). However, even the power that is available while the switch is in the "on" state is relatively small since it is preferred that the potential drop across the switch is kept as small as possible.

Further it is common when using this type of switch to use a thyristor as the electronic switch whereby the power to control the switch is derived from the load current during a period in which the thyristor is in an "off" state.

Switches using this approach use a variety of circuit means to effect the power derivation for additional circuitry which might support the timed actuations of the switch. One method is to use the mutual inductance action of a transformer placed on the supply side of the switch to derive electric current, refer AU-A 84714/82. This method has the disadvantage of additional voltage drop during the "on" state and consequent power loss due, to heat dissipation in the transformer/rectification and other circuits which are commonly within the switch housing. Additionally, the load which the electronic switch is controlling must be known so that the "on" state current drawn can also be known and thus the transformer can be designed accordingly.

A variety of power loads cannot always be accommodated by the methods described.

Therefore it can be seen that with the advent of electronic switches and the common need to control them manually and automatically during their "on" and "off" states, there exists the parallel need to derive a power supply sufficient to accommodate the power requirements of the additional control circuitry and concomitantly ensure that the installation of such a switch is simple and cost effective.

Therefore, it is an object of this invention to provide a circuit means which effects electronic switching of loads connected to alternating current power sources and provides a direct current power supply for additional direct current circuitry which can control the switch and power ancilliary devices and circuits.

It is a further object of this invention to provide a circuit means that only requires the use of the existing active and switched active wires and which thus overcomes at least some of the abovementioned problems, and which therefore provides a cost effective alternative to current methods of deriving power for electronic switches and their associated control circuitry.

A still further object of this invention is to provide a circuit means that derives sufficient power during the "off" state whilst keeping to a minimum the leakage current through the load.

Yet a further object of the invention is to provide a circuit means that allows the use of heavy loads while keeping to a minimum the reduction of available power.

Additionally it is also an object of this invention to provide a circuit means that is simple to manufacture and simple to interconnect.

A two wire switch for controlling the passage of current between a line and load comprising a solid state switch circuit means, a bridge rectifier circuit means, a trigger circuit means, a direct current storage circuit means and a control circuit, said two wire switch having an "off" state whereby the control circuit diverts current via the bridge rectifier circuit means to a direct current storage circuit means and maintains in an "off" mode the solid state switch circuit means, an "on" state whereby the control circuit diverts current via the bridge rectifier circuit means to a trigger circuit means and the said direct current storage circuit means and maintains in an "on" mode the solid state switch device, whereby the said direct current storage circuit continuously supplies power to the said control circuit.

In order that the invention may be clearly understood and readily carried into effect, a preferred embodiment will now be described by way of example only, recognising that a person skilled in the art could implement the said invention in a variety of ways. The preferred embodiment is made with reference to the accompanying representations, wherein:

Fig. 1 shows a block diagram of the two wire switch,

Fig. 2 shows a circuit embodiment of the two wire switch,

Fig. 3 shows the current paths for the high impedance "on" state when the two wire switch load terminal is negative with respect to the line terminal,

Fig. 4 shows the current paths for the high impedance "on" state when the two wire switch load terminal is positive with respect to the line terminal.

Fig. 5 shows an alternative trigger circuit and solid state switch circuit; and

Fig. 6 shows an alternative shunt regulator means to trigger the operation of the solid state switch circuit.

In this embodiment a circuit means shown in functional block form in Fig. 1 provides an alternating current switch across the active line terminal and the switched active (load) terminal. These two terminals may in practical use be connected between the active side of A.C. mains and the switched active input to an incandescent light globe which with interconnecting wire completes a circuit to the neutral side of the A.C.

mains. Hence the term two wire i.e. the wires from the line and to the load.

In this embodiment the alternating current switch controls the passage of current that will operate a light globe. The bridge rectifier provides a means to convert alternate cycles of the mains into direct current which is stored in the power supply which thus provides power to the control circuit and additional electronic circuits.

The "on" and "off" switch within the Controlling Device block is shown as a mechanical switch operable by the user, however, this switch could equally be replaced by an electronic equivalent having additional utility namely, timed "on" and "off" periods (preset or programmable), light, heat, sound or movement sensitive and a variety of other control means with power to supply the required circuitry available from the power supply.

This circuit means can also be provided with a known circuit referred to as a snubber circuit, shown in Fig. 2, which is often included to limit the peak rate of change of voltage of the electronic switch operation when the switch controls an inductive load.

Referring to Fig. 2, "on" and "off" control states of the electronic switch are effected by mechanically or electronically controlling the base potential of Q1, although it should be noted that other embodiments could exclude both Q1 and Q2 so that the gate of Q3 is directly controlled.

In the "off" state the base of Q1 is taken high and hence Q2 is also switched "on" so that current from the source via the line active input, via D5 or D6 and R4 is diverted by Q2 direct to a direct current power supply circuit comprising D1 and C1, with the maximum voltage being regulated via R6 and the zener diode D2. The circuit of this current flow is completed by the switched active output of the two wire switch, via D8 or D7 and therefore, a current value determined by R4 is present on the load side of the switch and requires that the load device be connected at all times to derive the most benefit from the circuit means by charging the direct current storage circuit which comprises the diode D1 and capacitor C1 at all times.

In the "on" state the base of Q1 is taken low and hence Q2 is also switched "off" so that the current from the source is diverted via R4 to the gate of Q3 which conducts, thus, diverting current to the trigger and power supply circuit via Q3. Q3 is a sensitive Gate SCR and is triggered "on" when as little as 5 volts is across R4 which occurs very early in the A.C. voltage switch "on" cycle.

The power supply circuit D1 and C1 is fed therefore from the current flowing via Q3, as is the zener diode

D2 until the zener regulation voltage is reached.

When the zener diode conducts, a voltage drop appears across resistor R6 which is proportional to load current. If load current becomes high enough, this voltage drop can cause a trigger circuit to turn on one or more additional electronic switches to carry the load current. The current at which the additional device (TRIAC or THYRISTOR) is turned on can be set to a value at which the holding current requirements can be guaranteed. The current level can also be selected to ensure that Q3, D2 and the diode bridge are operating within their design limits.

If a triac is used as the solid state alternating current switch on the A.C. side of the bridge rectifier, the trigger circuit current flow is dependant on the polarity of the alternating current, i.e. the load and line terminal potentials with respect to each other.

The first instance as shown in Fig. 3 is where the alternating current source has the switched active terminal negative with respect to the active terminal. The initial current path is via the bridge rectifier diode D5, Q3, R6, zener diode D2 and bridge rectifier diode D8 until the voltage across R6 reaches the Q4 threshold voltage. Once triggerred, Q4 conducts current from Q3 via D3 into the gate of Q6, the main solid state alternating current switch. This switch is a triac having terminals MTI connected to switched active, and MT2 connected to active, and a gate connected to the cathode of diode D3. The current delivered by this path, as determined by Q4 threshold, is always sufficient to latch "on" the triac, Q6, and ensures operation of the triac in its first quadrant.

The second case as shown in Fig. 4 is where the alternating current source cycle has the switched active terminal positive with respect to the active terminal. The initial current path is via the bridge rectifier diode D6, Q3, R6, zener diode D2 and bridge rectifier diode D7 until the voltage across R6 reaches the threshold voltage of Q4. When Q4 conducts, current flows from D6 and Q3 via diode D4, noting that D3 is prevented from carrying any current by main triac Q6, which will then not allow current to flow into its gate and out of MT2. SCR Q5 is turned on since in this state zener diode voltage of D4 is exceeded.

With Q5 "on", the current flow bypasses the circuit path D6, Q3, Q4, D4 and R7 such that the load switched active terminal is connected to the line source active terminal via the Q6 TRIAC gate, into Q5 and D7 to complete the circuit with the TRIAC Q6 operating in its third quadrant.

The function of R5 ensures the cathode of Q3 is pulled down to the circuit common potential after the main TRIAC Q6 has turned "on". This ensures that Q3 will turn "on" much faster following the next current zero.

Furthermore, even small loads may still be used since the "off" state draws very little current through the load via the high impedance "off" state two wire switch circuit.

In the low impedance "on" state, heavy loads cause the alternative load current to build up from zero and reach the trigger threshold early in the cycle, thus zener diode D2 is in the circuit for only a short time until Q6 takes over. This operation causes short periods of approximately 10v drop across the circuit, followed by a longer period with approximately 1v drop. This ensures that the effective reduction in available power is small.

In each of the foregoing cases the complex impedence of the load is not critical to the operation of the circuit means.

In another embodiment of the invention, control of the TRIAC Q6 is achieved via a pulse transformer and thus avoids any direct connection between the trigger circuit and the solid state switching device. This is shown in Fig. 5. This method of switch control allows the TRIAC Q6 to be operated in either the first and fourth or second and third quadrants.

Also apparent from this embodiment is that the circuit comprising R6, D2 and Q4 performs a function which can have many variants but its function is most readily described as being a shunt regulator which provides a means to trigger another switching circuit or circuits.

Alternatively, the solid state alternating current switching means may comprise THYRISTORS Q5 and Q6 as shown in Fig. 6. Thus, as can be seen, the shunt regulator circuit controls via the diode D3a, and resistor R7a one polarity of the A.C. cycle and via D3b and R7b the opposite polarity of the A.C. cycle flowing from line to source.

This invention resides in a circuit means, that, because of the nature of electronic design could be achieved in a number of ways by a person skilled in the art. The essence of this invention is the way in which its functions are achieved, however, this does not limit the scope of the idea and any variants due to the application of skills pertaining to the art.

The claims defining the invention are as follows:

1. A two wire switch for controlling the passage of current between a line and load comprising a solid state alternating current switch circuit means located between said line and load,

a bridge rectifier circuit means,

a trigger circuit means,

a direct current storage circuit means, and

a control circuit, said two wire switch having:

(1) a high impedance "off" state, whereby said control circuit diverts current via said bridge rectifier circuit means to said direct current storage means and controls said solid state alternating current switch means in a non-conducting state,

(2) a low impedance "on" state, whereby said control circuit diverts current via said bridge rectifier circuit means to both of said trigger circuit means and said direct current storage circuit means and controls said solid state alternating current switch means in a conducting state,

whereby said direct current storage circuit continuously supplies power to said control circuit.

2. A two wire switch according to claim 1 wherein said trigger circuit means controls a transition of current flow between line and load either via itself or the said solid state alternating current switch circuit means dependent on the load current magnitude.

3. A two wire switch according to claim 1 wherein said control circuit means comprises a mechanical switch.

4. A two wire switch according to claim 1 wherein said control circuit means comprises an electronic switch device, said switch device deriving power from the said direct current storage circuit means.

5. A two wire switch according to claim 2 wherein said trigger circuit means comprises at least one current switching device arranged to operate such that in the high impedance "on" state of the two wire switch:

(1) the load terminal is negative with respect to the line terminal, the current path is via the bridge rectifier circuit means for a period of time, thereafter the current path is switched to flow from line to load via said solid state alternating switch, and

(2) the load terminal is positive with respect to the line terminal the current path is via the bridge rectifier circuit means for a period of time, thereafter the current path is switched to flow from line to load via said solid alternating current state switch.

6. A two wire switch according to claim 1 wherein said solid state alternating current switch circuit means comprises a TRIAC.

7. A two wire switch according to claim 6 wherein said solid state alternating current switch operates in its first quadrant when the load terminal is negative with respect to the line terminal and operates in its third quadrant when the load terminal is positive with respect to the line terminal.

8. A two wire switch according to claim 1 wherein the trigger circuit means operates the solid state alternating

current switch circuit means comprising a TRIAC in either its first and fourth or second and third quadrants of operation.

9. A two wire switch according to claim 1 wherein the said solid state alternating current switch circuit means comprises at least two thyristors.

10. A two wire switch according to claim 1 wherein said direct current storage circuit means comprises capacitor means having negative and positive terminals.

11. A two wire switch according to claim 10 wherein said trigger circuit further comprises voltage regulator means comprising a zener diode to regulate the maximum voltage of said direct current storage circuit.

12. A two wire switch according to claim 2 wherein said trigger circuit comprises a shunt regulator and circuit means to trigger said solid state switch circuit means.

13. A two wire switch substantially as hereinbefore claimed and described with reference to the accompanying figures.

Dated this 19th day of December 1990

GERARD INDUSTRIES PTY LTD

By its Patent Attorneys,
<u>R K MADDERN & ASSOCIATES</u>

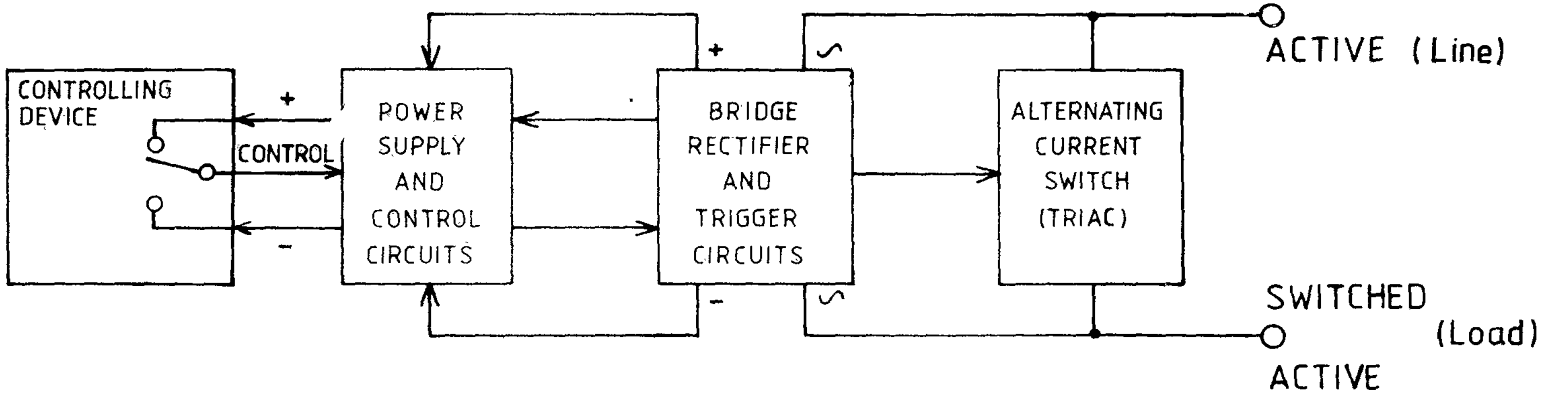

FIG 1

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20 2 89 30790

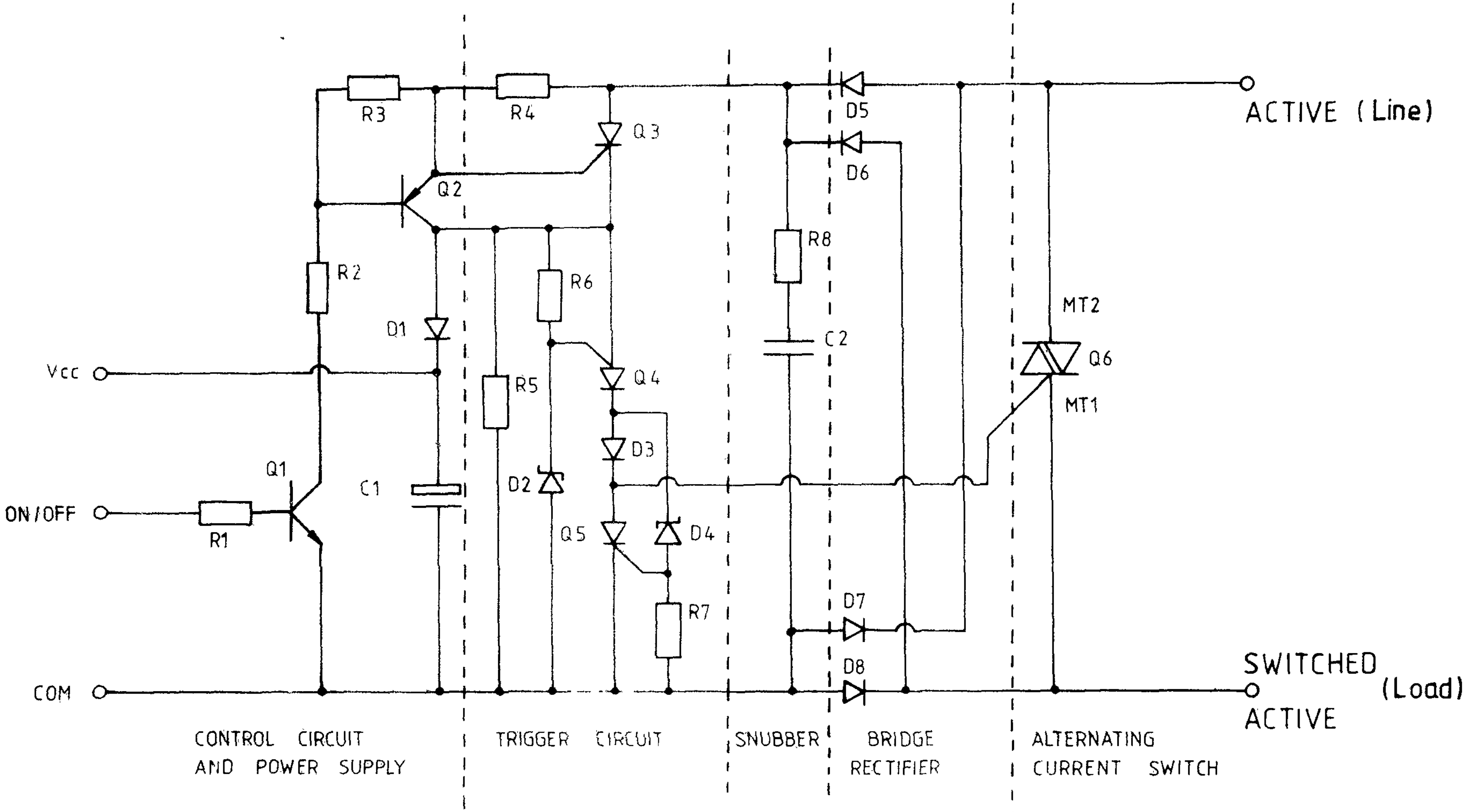

FIG 2

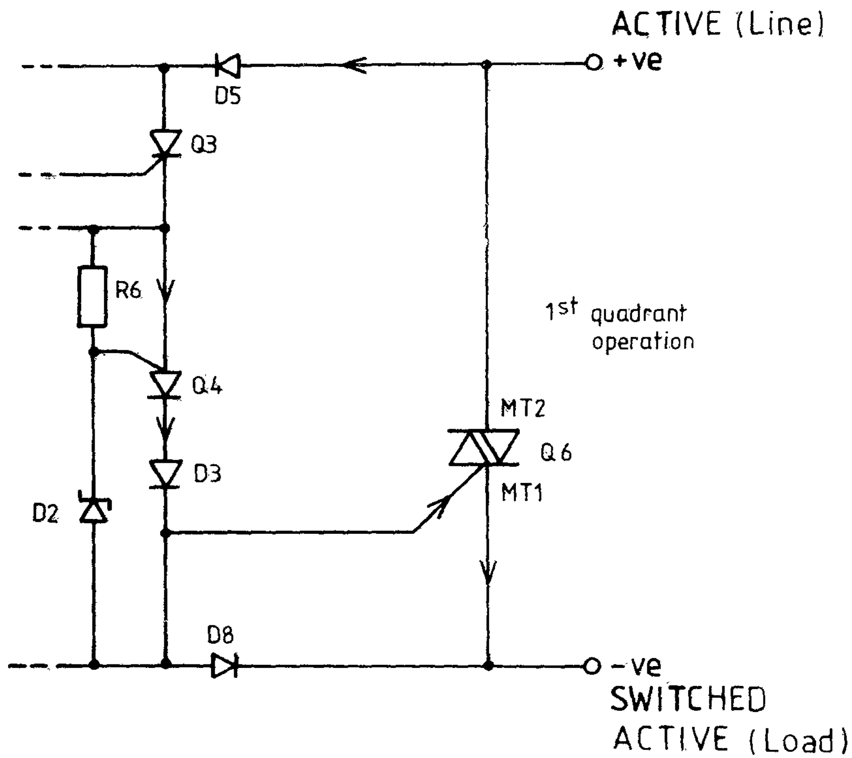
ACTIVE (Line)
+ve
D5
Q3
R6
Q4
D3
D2
1st quadrant operation
MT2
Q6
MT1
D8
-ve
SWITCHED ACTIVE (Load)

FIG 3

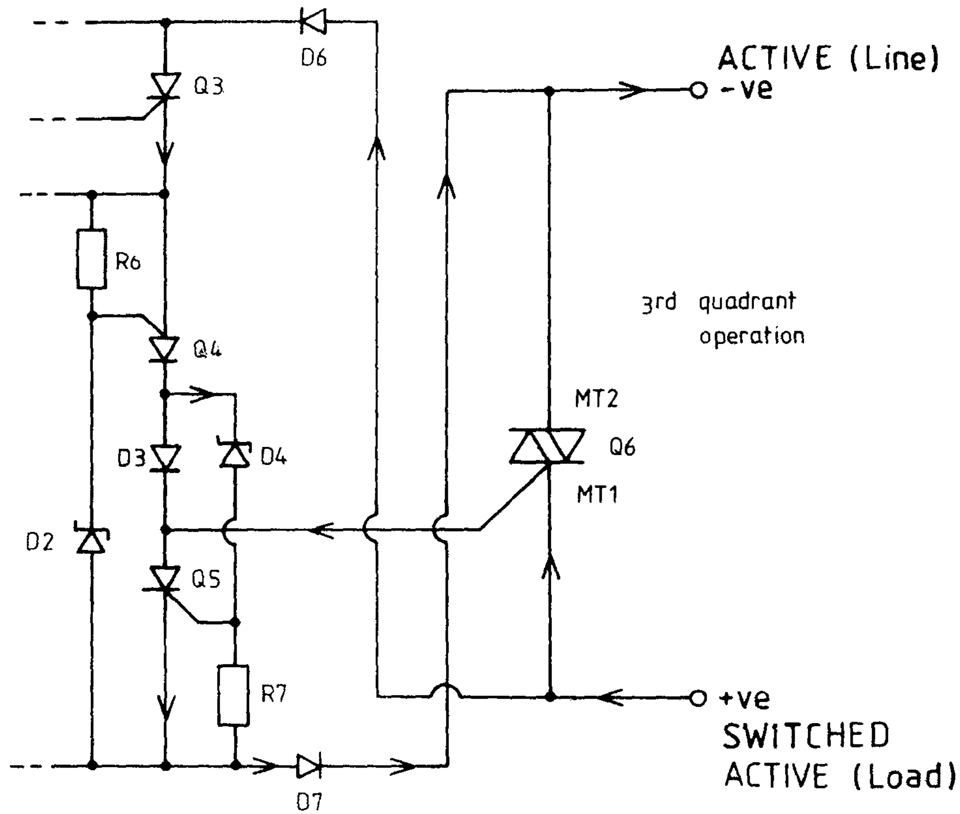
D6
ACTIVE (Line)
-ve
Q3
R6
Q4
3rd quadrant operation
MT2
Q6
MT1
D3
D4
D2
Q5
R7
+ve
SWITCHED ACTIVE (Load)
D7

FIG 4

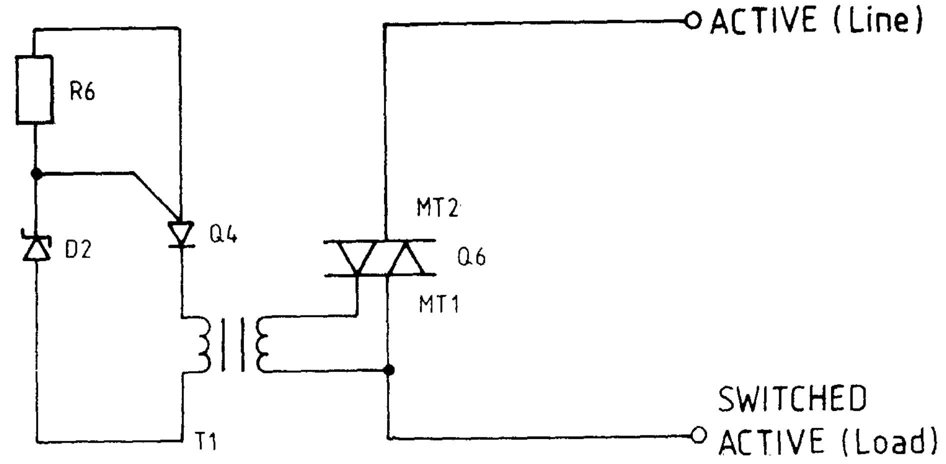
ACTIVE (Line)
R6
MT2
Q4
D2
Q6
MT1
SWITCHED
ACTIVE (Load)
T1

FIG 5

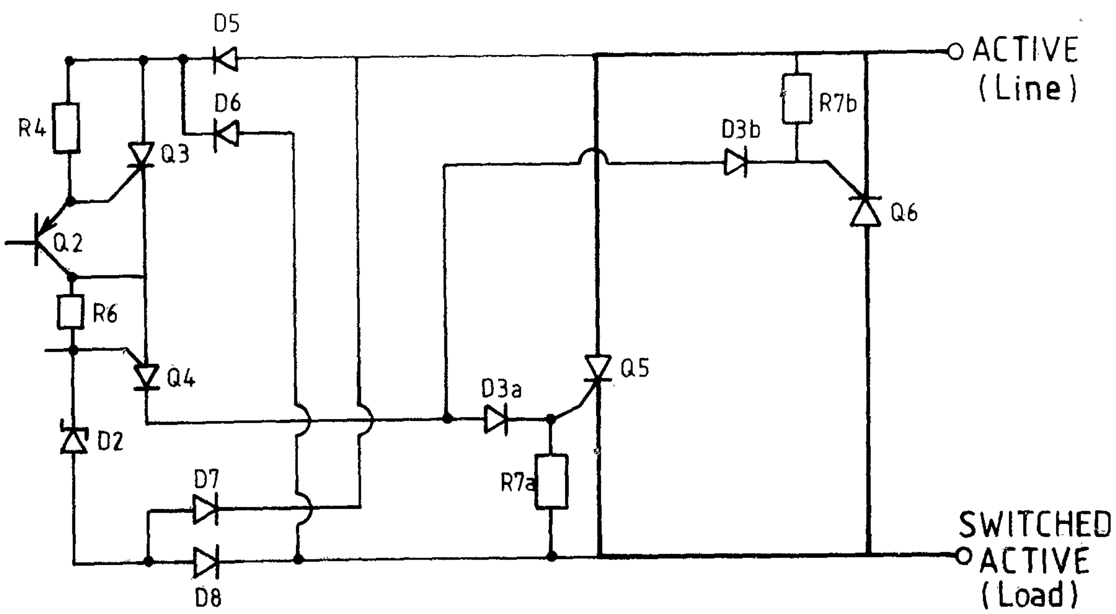
D5
ACTIVE
(Line)
D6
R7b
R4
D3b
Q3
Q6
Q2
R6
Q4
Q5
D3a
D2
D7
R7a
SWITCHED
ACTIVE
(Load)
D8

FIG 6