ABSTRACT: A relay controlled alternating current load circuit having a set of relay switch contacts connected in series with the load across the alternating current source is provided with a bilateral thyristor triode connected in parallel with the switch contacts and gated through the relay coil and a control switch connected in series to one side of the alternating current source for arc suppression.
MEANS EFFECTING RELAY CONTACT ARC SUPPRESSION IN RELAY CONTROLLED ALTERNATING LOAD CIRCUITS

This invention relates to means for selective energization of alternating current loads and, more particularly, to an alternating current load circuit and combined electromagnetic and solid state relay means for same, effecting absence switching of loads into the circuit.

Mentional switches are presently made which are capable of conducting relatively high continuous currents, but they are severely limited in their ability to survive the effects of "breaking" such currents. This limitation is particularly severe at voltages above the characteristic arc voltage of any specific contact material used for the contacts. To increase contact life under such adverse conditions had usually involved increasing the mass of the contacts to absorb the arc energy and making them less than completely satisfactory for switching and conducting of high currents. Some of these limitations are relatively low continuous current conducting capability, susceptibility to damage by sustained current and voltage transients, and the need for complex associated circuitry such as biasing networks, triggering networks, and the like.

Accordingly, an object of this invention is to provide an electrical switching apparatus having an improved switch contact protection, which obviates problems heretofore associated with attempts to increase switch contact life.

Another object is to provide a switching apparatus of the type described wherein substantially all arcing resulting from contact disengagement such as resulting from contact bounce is eliminated, thereby increasing contact life.

Another object of this invention is to provide a means for sensing the presence of an arc to be suppressed and effecting suppression of said arc in a switching apparatus of the single-pole, single-toggle type or the like.

Another object is to provide a switching apparatus of the type described which is of rugged and uncomplicated construction, is relatively economical to manufacture, and provides increased reliability of the overall switching circuit.

A further object is to devise such a switching apparatus employing a solid state device and in which no external triggering circuit is needed.

Another object is to provide a switching unit of the type described for connecting an alternating current power source to a load, wherein the magnitude of currents switched is greater than that possible for contacts alone with reliability and long life, and wherein the magnitude of currents continuously conducted is greater than that possible for solid state switch devices alone. A related object is to provide such a switching unit which uses a minimum mass of contact material.

Still another object of this invention is to provide a load switching means comprising a combined electromagnetic relay and bilateral semiconductor triode for switching alternating current loads and suppressing arcing across the contacts of the said relay especially resulting from contact bounce.

Still another object of this invention is to provide a load switching means comprising a combined electromagnetic relay and bilateral semiconductor triode for switching alternating current loads and suppressing arcing across the contacts (when closing or during contact bounce) of the relay; and wherein the coil of the relay is in series with the gate terminal of the bilateral semiconductor triode.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawings wherein several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are for illustration purposes only and are not to be construed as defining the limits of the invention.

The drawing is a schematic diagram of an alternating current load circuit embodying a load switching relay means of the present invention.

Basically, the invention contemplates the provisions of a switching means comprising an alternating current load and a bilateral thyristor triode, the latter having a pair of power terminals in series with a load across an alternating current source and having a gate terminal connected in series with the coil of the alternating current relay and a selector switch to one of the terminals of the source. The bilateral thyristor triode has its power terminals connected in shunt with the make and break circuit and load current path of the said relay. Thus, when the selector switch is closed, the relay coil is energized, the bilateral thyristor triode is substantially instantaneously rendered conductive and the relay contacts will subsequently close without the occurrence of arcing across the said contacts.

Referring in detail to the drawing, the load switching means 10 of the present invention is shown as including first and second power input terminals 12 and 14 and a load terminal 16; and a load L is also shown connected across the second power input terminal 14 and the load terminal 16.

The switching means 10 further includes a bilateral thyristor triode D having first and second power terminals 18 and 20 connected, respectively, to the first power input terminal 12 and the load terminal 16, and a gate terminal 22. The gate terminal 22 is connected to one side of a relay winding RW of an alternating current relay RL which also includes a pair of make and break contacts RK adapted to be actuated in that order upon energization and deenergization, respectively, of the relay winding RW.

The other side of the relay winding RW is connected through a single-pole, single-throw selector switch S and a lead 24 to the second power input terminal 14.

The circuit of the switching means 10 is completed by a first power lead 26 connected from the first power input terminal 12 to one side of the relay contacts RK and a second power lead 28 connected from the other side of the relay contacts RK to the load terminal 16.

Therefore, the power path 12-26-RK-28-16 is in shunt with a power path 12-18-20-16 through the bilateral thyristor triode D.

A bilateral or bidirectional thyristor type semiconductor device is a monostable solid state device which can be triggered or driven from a blocking or nonconducting state when energized, exhibiting a high impedance, to a conducting state, exhibiting a very low impedance. The device turns off or returns to its quiescent or nonconducting state when the current being conducted drops below that required as a holding current if a shunt is provided or when the current approaches the zero crossover. Stated in another way, such devices, hereafter considered as switch devices, are turned on when...
they are triggered from the quiescent nonconducting state to the conducting state which must be maintained by a holding current, and are turned off or return from the conducting state to the nonconducting state when the current conducted thereby drops below the required holding current. Such triggering consumes on the order of a very few microseconds which, for practical purposes, can be considered to be instantaneous, and can be accomplished by an applied voltage of either positive polarity or negative polarity. Once triggered to the conductive state, the device can conduct current in either direction. A thyristor, bidirectional thyristor triode, such as the bilateral thyristor triode D herein, can be selectively gated "ON" (rendered conductive from the "OFF" or nonconductive state) by application of a gating signal to the gate electrode thereof (gate terminal 22 herein) of a magnitude that is relatively small compared to the breakover voltage and which is of either positive or negative polarity.

Therefore, the bilateral semiconductor (thyristor) triode D is, in actuality, a static AC switch of a type generically known in the art as a TRIAC, a gated, bidirectional thyristor device.

The time required to gate or trigger the bilateral thyristor triode D to its "ON" state is relatively short, i.e., on the order of a few microseconds. Further, such gate can be accomplished by an applied voltage of either positive or negative polarity at the gate terminal 22.

Therefore, for the purpose of protecting mechanical switch contacts, such as the relay contacts RK, from the deleterious effects of arcing, the bilateral thyristor triode D acts with such a high relative rate of speed to that of the relay contacts RK as to be substantially an instantaneously responsive device for all practical purposes.

For operation of the switching means 10, an alternating current source 30 is shown connected across the power input terminals 12 and 14.

OPERATION

Assuming that the source 30 is energized; that the selector switch S and relay contacts RK are in the open positions shown; and that the rated breakover voltage between the power terminals 18 and 20 of the bilateral thyristor triode D is greater than that supplied by the source 30, the operation of the present invention will now be described.

Under the above-assumed conditions, the bilateral thyristor triode D is in the "OFF" state and the load L is deenergized.

To energize the load L, the selector switch S is closed completing a gate circuit path 12-18-22-RW-S-24-14 across the source 30. Because of the bipolar response characteristics of the bilateral thyristor triode D to signals applied to the gate terminal 22, the former will be turned "ON" substantially instantaneously to supply power to the load L through the power path 12-18-20-16-L-14 from the source 30.

A short time thereafter, due to the inherently slower response of the relay RL, the gate current flowing in the relay winding RW will cause the relay contacts RK to make, completing a second power path 12-26-RK-28-16-L-14 through the load L which is parallel with that part of the first power path through the bilateral thyristor triode D.

Regardless of the polarity of the immediate half-cycle of the alternating current wave supplied by the source 30, the bilateral thyristor triode D will turn "OFF" as the alternating current from source 30 goes through zero, but will be gated "ON" again by the next half-cycle. Due to the low resistance of the relay coil RW, the bilateral thyristor triode D is gated "ON" short over the alternating current from source 30 has passed through zero. Therefore, the bilateral thyristor triode D may be considered as being in the "ON" condition whenever switch S is closed. Due to the slow release or delay time of the relay, the relay contacts RK remain closed through the zero crossover of the alternating current from source 30, thereby providing the load L with a low resistance path 14-16-RK-26-12 to the alternating current source 30.

Therefore, the bilateral thyristor triode D remains in the "ON" state even upon zero crossover of the applied waveform, which would normally cause the bilateral thyristor triode D to turn "OFF" by lack of minimum holding current thereafter. Further, the load current must remain in the "ON" state regardless of the shunt path 26-RK-28-16 through the relay contacts RK across to power terminals 18 and 20 of the bilateral thyristor triode D during energization of the relay coil RW. However, because of the lower resistance of the closed relay contacts RK and the conductive path 26-RK-28 as compared to the power path 18-20-16 of the bilateral thyristor triode D, the load current, in the absence of arcing at the said contacts RK is carried by the said conductive path 26-RK-28 through the relay contacts RK.

In order to deenergize the load L, however, the selector switch S is caused to open and deenergize the relay winding RW, the bilateral thyristor triode D will turn "OFF" upon the next immediate zero crossover of the applied waveform from the source 30, and the relay contacts RK will open after a brief delay after the deenergization of the relay winding RW. The load L is thus deenergized, since both the first and second power paths supplying same have been broken.

In terms of the arc suppression function of the switching means 10 for arcs tending to form on make of the relay contacts RK, the respective response times of the relay RL and bilateral thyristor triode D together with the time delay of the relay RL all provide the necessary cooperating functions to effect such arc suppression.

When the relay contacts RK are caused to make, the bilateral thyristor triode D has already been gated "ON" and any arc voltage is shunted through the low impedance path 26 (or 28)-18-20-16 through the power terminals 18 and 20 of the bilateral thyristor triode D. However, the present invention, is especially important during conditions of contact bounce upon the initial make of the relay contacts RK since the bilateral thyristor triode D will remain "ON" and suppress any arcind condition at the relay contacts RK.

As can be seen from the foregoing description, the present invention provides a switching means 10 which can readily be packaged in a modular structure having only three external terminals (power input terminals 12 and 14 and load terminal 16) and an externally engageable switch actuator to effect make and break of the selector switch S.

Further, the provision of a substantially arced switching means for selective energization of alternating current loads substantially increases the power and life expectancy ratings of the relay contacts over the maximum rating currently applied to similar equipment.

Although a single embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes may be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

I claim:
1. Switching means effectively energizing loads in alternating current load circuits, comprising:
   a. first and second input terminal means adapted to be connected with an alternating current source;
   b. load terminal means adapted to interconnect a load with at least one of said input terminal means;
   c. bilateral semiconductor triode means having gate terminal means and first and second power terminal means, the latter being connected, respectively, with the other of said input terminal means and said load terminal means;
   d. electromagnetic relay means having relay winding means, relay contact means adapted to make and break upon energization and deenergization, respectively, of said relay winding means, and selector switch means effecting selective energization of said relay winding means;
   e. said selector switch means and said relay winding means being connected in series between one of said input ter-
5 minals means and said gate terminal means; and said relay contact means being connected in and effecting the establishment of a shunt circuit path from said other of said input terminal means to said load terminal means.

2. The invention defined in claim 1, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

3. The invention defined in claim 1, wherein upon the application of an alternating current input to said input terminal means, and selective energization of said relay winding means by said selector switch means, said bilateral semiconductor triode means is rendered substantially instantaneously conductive between the said power terminal means thereof and, subsequently, said relay contact means are caused to make, whereby said bilateral semiconductor triode means substantially precludes arcing at said relay contact means.

4. The invention defined in claim 3, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

5. The invention defined in claim 1, wherein, upon application of an alternating current waveform to said input terminal means, said bilateral semiconductor triode means is gated into a conductive state by energization of said relay winding means, said winding means having a sufficiently low resistance after energization thereof such that said bilateral semiconductor triode means is maintained gated into said conductive state regardless of the polarity of an alternating current waveform applied to said input terminal means.

6. The invention defined in claim 5, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

7. An alternating current load circuit, comprising:
   first and second input terminal means adapted to be connected with an alternating current source;
   load terminal means;
   load means connected between said load terminal means and one of said input terminal means;
   bilateral semiconductor triode means having gate terminal means and first and second power terminal means, the latter being connected, respectively, with the other of said input terminal means and said load terminal means;
   electromagnetic relay means having relay winding means, relay contact means adapted to make and break upon energization and deenergization, respectively, of said relay winding means, and selector switch means effecting selective energization of said relay winding means;
   said selector switch means and said relay winding means being connected in series between said one of said input terminal means and said gate terminal means; and
   said relay contact means being connected in and effecting the establishment of a shunt circuit path from said other of said input terminal means to said load terminal means.

8. The invention defined in claim 7, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

9. The invention defined in claim 7, wherein upon the application of an alternating current input to said input terminal means, and selective energization of said relay winding means by said selector switch means, said bilateral semiconductor triode means is rendered substantially instantaneously conductive between the said power terminal means thereof, and, subsequently, said relay contact means are caused to make, whereby said bilateral semiconductor triode means substantially precludes arcing at said relay contact means, and said load means is energized through said shunt path and said bilateral semiconductor triode means.

10. The invention defined in claim 9, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

11. The invention defined in claim 7, wherein, upon application of an alternating current waveform to said input terminal means, said bilateral semiconductor triode means is gated into a conductive state by energization of said relay winding means, said winding means having a sufficiently low resistance after energization thereof such that said bilateral semiconductor triode means is maintained gated into said conductive state regardless of the polarity of an alternating current waveform applied to said input terminal means.

12. The invention defined in claim 11, wherein said bilateral semiconductor triode means comprises a bilateral thyristor triode.

13. Switching means effecting selective energization of loads in alternating current load circuits, comprising:
   first and second input terminal means adapted to be connected with an alternating current source;
   load terminal means adapted to interconnect a load with at least one of said input terminal means;
   electromagnetic relay means including relay winding means and relay contact means, the latter being included in and effecting the establishment of a first circuit from one of said input terminal means to said load terminal means upon the energization of said relay winding means;
   bilateral thyristor means having a gate electrode connected to one end of the relay winding means, and first and second power terminal means connected, respectively, with said one of said input terminal means and said load terminal means, in shunt with said relay contact means; and
   circuit means selectively interconnecting the other end of said relay winding means and the other of said input terminal means and selectively effecting a substantially instantaneous conductive state in said bilateral thyristor means upon energization of said relay winding means to thereby establish a second circuit through said power terminal means in shunt with and suppress arcing at said relay contact means.