MAGNETIC SWITCHING APPARATUS FOR REDUCING CONTACT BOUNCE

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This invention relates generally to electrical relays and more particularly to enclosed reed switches operated by circumferential energizing coils.

The usual magnetic reed switch comprises a pair of spaced, overlapping, magnetic reeds supported in cantilever fashion in the opposite ends of a sealed glass tube about which is provided an exciter or energizing coil. Current flowing through the coil produces a magnetic flux field which attracts the free ends of the reeds toward each other and completes the conduction path from one reed to the other. The reeds are made of thin, relatively flexible magnetic material with an air gap of a few thousandths of an inch between the free ends to permit high speed switch operation. The reed contacts are sealed free of contaminants to provide excellent operational reliability.

These switches, however, are subject to contact bounce, which occurs when the attracted reeds strike each other, resulting in decreased life and a delay in useful time during which the contacts are "made." Because of this difficulty, structural refinements have been made heretofore to provide a switch having reduced bounce. These refinements have included decreasing reed size, adding an auxiliary contact and reed to the principal reeds, providing special collars and changing the gap between the reeds. Such modifications have improved the bounce characteristic but resulted in a reduction of current capacity, increased manufacturing and assembly costs because of additional elements, or a significant increase in operating time due to larger mass.

It is therefore, an object of this invention to provide an improved reed switch which substantially reduces contact bounce without modification to the reeds.

Another object of this invention is to provide a relatively simple and inexpensive reed switch having little or no contact bounce.

Still another object of this invention is to provide a magnetically operated reed switch in which the kinetic energy of approaching reeds is significantly reduced at the instant of impact.

A further object of this invention is to provide a magnetically operated reed switch which includes a fixed limit stop for one of the two approaching reeds operable to arrest or reverse the motion of one of the reeds prior to impact of the reeds.

In accordance with the foregoing objects, this invention provides a fixed stop secured in the switch enclosure adjacent one of the magnetic reed cantilevers and spaced therefrom less than half the gap between the overlapping cantilever contacts when the latter are in a de-energized position. When a magnetic flux field is applied, each reed moves toward the other to minimize reluctance. One reed is arrested by the stop, however, before impact with the remaining reed so that the approaching velocity reaches zero and then becomes a negative value as it rebounds from the stop while being overtaken by the remaining moving reed.

This arrangement eliminates special forming or shaping of the reeds and avoids the addition of auxiliary reeds or electrical contact areas of the principal reeds. Less kinetic energy at impact time also prolongs the life of the contact area.

The foregoing and other objects, features and advan-

tages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings, wherein:

FIG. 1 is a sectional side elevation view of an electromagnetic reed switch constructed in accordance with the invention; and

FIGS. 2a and 2b are comparative oscillograms illustrating the contact action in reed switches which respectively do not and do embody the invention.

Referring to FIG. 1, reeds 10 and 11 of a suitable ferromagnetic material, such as a nickel-iron alloy, are supported in substantially parallel planes as cantilever beams in the opposite ends of a sealed glass enclosure 12 encircled by an energizing electromagnetic coil 13 (shown in phantom). Reeds 10 and 11 each have approximately equal movable lengths from hinge points 14, and their respective free ends 15 and 16 overlap and are spaced from each other a predetermined distance to provide a gap which is usually a few thousandths of an inch. The spacing depends on the current requirement, voltage and operating time of the particular circuit in which the reed switch is used. The reed ends may each be plated with a suitable material at the contact area to improve the electrical connection.

Also secured in the end of enclosure 12 adjacent reed 10 and extending approximately parallel to the reed are a cantilever is a member 17 having an upturned end 18 which serves as a stop to limit the downward movement of reed 10. End 18 is preferably positioned near the contact area to minimize the whipping action upon impact between reed 10 and end 18. The end of the stop member has a substantially flat surface which is spaced from reed 10 at a distance less than half the gap between ends 15 and 16. This spacing will vary according to the distance end 18 is located from the reed gap.

Member 17 has a relatively large mass compared to reed 10 so that it presents a substantially rigid stop for the reed. The stop member 17 is preferably a hardened non-magnetic material to reduce wear and to avoid any effect upon the "make" or "break" time of the reeds.

In operation, coil 13 is supplied with current which establishes magnetic flux lines passing through reeds 10 and 11. The reeds move toward each other with approximately equal acceleration and velocity to decrease the magnetic reluctance of gap. While reed 11 continues moving toward reed 10, reed 10 strikes the stop surface of end 18 so that its movement is arrested. Because of the kinetic energy of reed 10 and relative inflexibility of member 17, the reed rebounds and moves away from approaching reed 11. The latter reed, however, is moving at a higher velocity and overtakes reed 10. The result is that ends 15 and 16 make contact at low relative velocity with a low impact energy because they are traveling in the same direction when impact occurs.

The contact action of the reed switch described above is illustrated by comparing the voltage versus time oscillograms of FIGS. 2a and 2b, obtained in actual comparative tests. These figures show the voltage drop across a load resistor in series with the switch contacts. FIG. 2a represents the reed switch action without a stop, while FIG. 2b represents the switch closure using stop member 17 positioned as shown in FIG. 1. In this comparative example, coil 13 having a winding of 10,000 turns of No. 42 wire and 1600 ohms resistance was energized with twelve volts D.C. Free ends 15 and 16 of the reeds were spaced .003 inch and the stop surface of end 18 was spaced .001 inch from the underside of reed 10.

As seen in FIG. 2a, the switch contacts were closed after approximately 560 microseconds (μs.) after coil energization and then opened again approximately 100 μs. later because of bounce. However, when the stop
member was installed, switch closure occurred approximately 700 μs. after coil energization with no subsequent bounce. Thus, the addition of stop member 17 eliminated contact bounce and prevented the production of extraneous pulses in the switch circuit. This permits the immediate utilization of the switch circuit without the necessity of a delay to let the switch contacts stabilize.

End 18 of the stop member is preferably positioned from reed 10 at less than half the gap between the free ends of the reeds. This assures that, when the coil is energized, reed 10 will start its rebound from the stop before the reeds seal. If the stop is positioned too close to reed 10, the reed will have become stationary before impact by end 16 of reed 11 so that operating time will increase and bounce will occur.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electrical switching device comprising:
   a pair of resilient overlying contact elements formed of magnetic material and cantilever supported at their remote ends and separated by a gap at their adjacent ends;
   means for producing a magnetic field for effecting movement of said elements toward each other; and
   means providing a stop surface engageable by one of said elements upon creation of said magnetic field, said surface being disposed so as to be engaged by said one element before said elements contact each other, whereby at the instant said elements come into mutual contact, both said elements will be moving in substantially the same direction but at different velocities causing the elements to establish electrical connection substantially without contact bounce.

2. An electromagnetically controlled switching device comprising:
   a pair of overlying cantilever supported resilient contact elements formed of magnetic material and separated by a gap;
   a coil energizable to cause both said elements to move toward and into contact with each other; and
   means providing a stop surface engageable by one of said elements during energization of said coil and located from said one element a distance less than half the said gap, such that said one element will strike said stop and be rebounding therefrom at the instant it is overtaken and contacted by said other element, thereby to substantially reduce impact kinetic energy and minimize bounce of the contact-providing elements.

3. A switching device according to claim 2, wherein the stop surface is disposed adjacent the unsupported end of said other element, and both said elements and the stop surface-providing means are sealed within a common enclosure.

4. A switching device according to claim 2, wherein said elements are substantially parallel in the absence of said magnetic field and are supported to have substantially equal movable lengths.

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