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SWITCHING DEVICE HAVING CURVED CONTACTS ARRANGED FOR END-ON ENGAGEMENT

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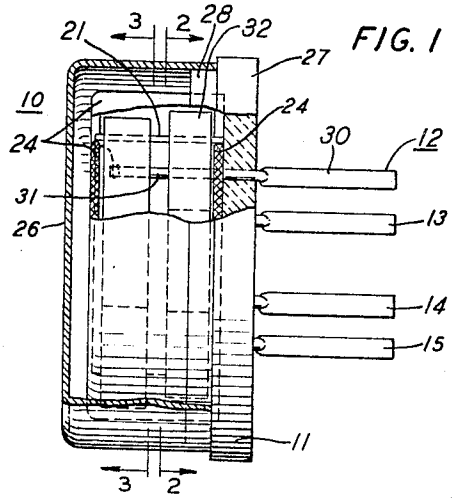


FIG. 1

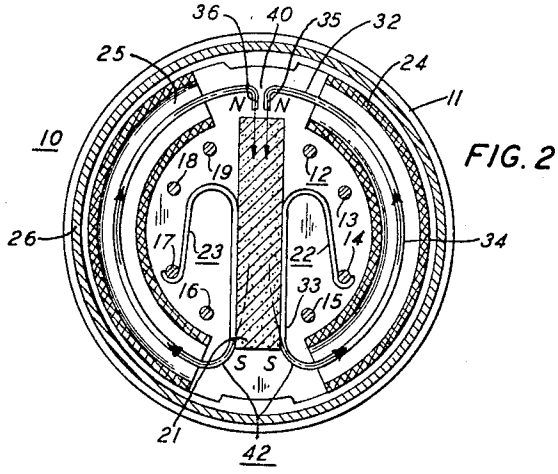


FIG. 2

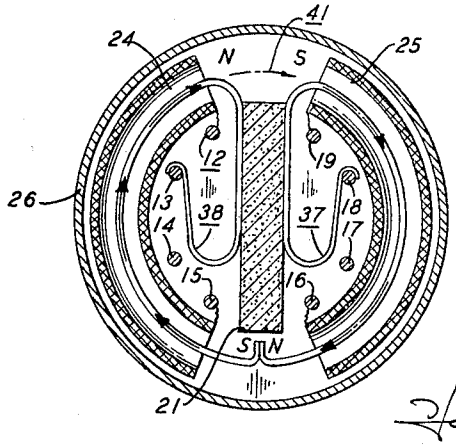


FIG. 3

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SWITCHING DEVICE HAVING CURVED CONTACTS ARRANGED FOR END-ON ENGAGEMENT

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This invention relates to electromatic switching devices and pertains specifically to devices wherein the contacts carry both current and magnetic flux.

Electromagnetic devices wherein current and magnetic flux are conducted in the same contacts are well known. Such devices are referred to generally as reed switches. It is to the reed switch family that this invention belongs.

Reed switches were developed to satisfy a need for switches wherein size and power requirements were reduced without sacrificing reliability of contact operation. Many successful reed switch arrangements are presently available.

In its commonest form, a reed switch comprises a pair of flat contacts, or reeds, sealed in a glass vessel that is surrounded by a source of magnetic flux. The reeds are made of an electrically and magnetically conducting material, and the source of flux is generally a coil of wire. The reeds are arranged with two ends overlapped inside the vessel, two ends extending outside the vessel, and intermediate portions sealed in the vessel walls. The ends overlapping within the vessel are ordinarily separated by an air gap.

In operation, the coil is energized to pass magnetic flux serially through both reeds and the air gap. When the magnetic flux in the air gap becomes sufficiently strong, the overlapping reeds move together and touch, thereby forming a closed path through which electricity can flow. So long as the magnetic flux is sustained, the reeds stay together. When it is removed, the reeds separate and return to their original position, thereby reopening the electrical path.

In general, the reed switches described in the foregoing have proved to be extremely useful, especially where contacts must be opened and closed many times with a high degree of reliability, as, for example, in telephone systems.

Telephone systems, however, require contacts literally by the tens of thousands. Thus, the space required to house the contacts and the power required to operate them are significant considerations. Therefore, even the slightest reduction in the size and power requirements of reed switches is advantageous.

Accordingly, it is an object of this invention to reduce the size and power requirements of reed type switches.

Another object of this invention is to provide a switching device compatible with printed circuit boards.

According to a specific embodiment of this invention, a switch comprises a base; a plurality of electrically conducting contact pins embedded in the base; a spacer mounted on the base and sandwiched between the contact pins; a pair of elongated flexible magnetic reeds or contact springs having free ends and fixed ends, the contact springs being disposed on the base with the fixed ends wedged between the spacer and the contact pins and the free ends extending around the spacer to a position adjacent to each other; and a pair of coils wherein each coil is wound on a contact spring between the fixed end and the free end.

According to one feature of this invention, the reeds or contact springs are long, thin and curved to make end-on

engagement with each other. As a result, the restoring forces acting therein are substantially lessened and the power required to operate the contact springs is reduced.

According to another feature of this invention, the coils for enabling magnetic circuits for operating contact springs are wound directly around the contact springs. As a result, space required for switch components is reduced and efficiency in the use of available flux is improved.

Other objects and features of this invention will become readily apparent from the following detailed description when taken in conjunction with the drawing, in which:

FIG. 1 is an elevation view of an illustrative embodiment of the invention;

FIG. 2 is a plan view taken in section and showing the lower portion of the embodiment illustrated in FIG. 1 in the unoperated state; and

FIG. 3 is a plan view taken in section and showing the upper portion of the embodiment illustrated in FIG. 1 in the operated state.

Referring now to FIG. 2, the switch **10** illustrated therein comprises a base **11**, a plurality of contact pins **12**, **13**, **14**, **15**, **16**, **17**, **18**, and **19**, a spacer **21**, a pair of contact springs **22** and **23**, and a pair of coils **24** and **25**. All of the foregoing are assembled to form a unitary switch which is encapsulated by a cap **26**, as shown in FIG. 1.

The base **11** supports the working components of the switch **10**. In the embodiment illustrated herein, the base **11** is formed from a ceramic material and comprises a lower portion **27** and a shoulder portion **28** adapted to accept the cap **26**. While a ceramic material is illustrated, any electrically nonconducting material will serve as well.

The contact pins **12**, **13**, **14**, **15**, **16**, **17**, **18**, and **19** provide a path for conducting electricity into and out of the switch **10**. They are embedded in the base **11** with a portion protruding from each side thereof as illustrated, for example in FIG. 1, by the portions **30** and **31** on the contact pin **12**.

The portion **30** may be flattened, as illustrated, or may take any other shape that will make electrical connection more convenient. In addition, the portion **30** can be used to mount the switch **10**, as for example, on a printed circuit board. The portion **31** serves as a terminal for the contacts and may conveniently be cylindrical.

The spacer **21** serves as an insulating anchor for the contact springs and if desired, as a preferred magnetic return path. As illustrated in FIG. 2, the spacer **21** rests on the base **11** in a position between the contact pins **12**, **13**, **14** and **15** and the contact pins **16**, **17**, **18** and **19**. In the embodiment shown, the spacer **21** is made of an electrically nonconducting but magnetically conducting material which is characterized by a high remanence. For the practice of this invention, however, it is necessary only that the spacer **21** be electrically nonconducting.

The contact springs **22** and **23** make and break, or, in other words, open and close, an electrically conducting path through the switch. In the embodiment shown, the contact springs **22** and **23** are made from a material which is both electrically conducting and magnetically conducting.

Each of the contact springs has a fixed end, a free end, and an intermediate portion connecting the fixed and free ends as illustrated, for example, in FIG. 2 by the free end **32**, the fixed end **33**, and the intermediate portion **34** of the contact **22**.

The free end **32** has a contact face **35** arranged to make electrical contact with a corresponding contact face **36** on the contact spring **23**. The fixed portion **33** is con-

veniently U-shaped with one side thereof wedged against the contact pin **14** in electrically conducting relationship and the other side thereof wedged against the spacer **21**. The intermediate portion **34** is curved to extend around the spacer **21** in the form of a crescent. As illustrated in FIGS. 2 and 3, the curvature of the intermediate portions of the contact springs hold the free ends thereof in end-on relationship.

In cross section, the contact springs are thin in one dimension and wide in the other dimension. Moreover, each contact spring is disposed so that the thin dimension flexes when the free end is moved.

As shown in FIG. 1, two sets of contact springs are used in this embodiment. The contact springs **22** and **23**, which have just been described and which are illustrated in FIG. 2, comprise one set. Contact springs **37** and **38**, which are illustrated in FIG. 3, comprise the other set. Except for the manner in which they are oriented, the contact springs **37** and **38** are identical to the contacts **22** and **23**.

The coils **24** and **25** supply electromotive force for opening and closing the contact faces on the contact springs. As illustrated in FIGS. 2 and 3, the coil **24** is wound around the intermediate portions of the contact springs **22** and **37**, and the coil **25** is wound around the intermediate portions of the contact springs **23** and **38**. The coils are so wound that the intermediate portions of all of the contact springs reciprocate the free ends back and forth along a path. As illustrated in FIG. 2, the intermediate portions of the contact springs **22** and **23** are arranged to move within the coils **24** and **25** to reciprocate the free ends thereon back and forth along a short operating path **40** whereby the contact faces thereon engage and disengage each other.

The coils are connected to external circuits through the contact pins. As shown in FIG. 3, the coil **24** terminates on the contact pins **12** and **15**, while the coil **25** terminates on the contact pins **16** and **19**.

In operation, the coils **24** and **25** induce either opposing or aiding magnetic fluxes. FIG. 2 shows opposing fluxes acting in a magnetic circuit **42**, while FIG. 3 shows aiding fluxes acting in a magnetic circuit **41**.

The magnetic circuit **41** comprises a pair of contact springs and a pair of air gaps, one air gap separating the free ends and the other air gap separating the fixed ends of said contact springs. When the magnetic circuit **41** is enabled, flux flows serially through the contact springs and the air gaps. In the condition illustrated in FIG. 3 the fluxes are shown circulating serially through the contact springs **37** and **38** in aiding relationship and opposite polarities have been developed on the contact faces. As a result, the contact faces have moved together and touched, thereby closing an electrical path between the contact pin **13** and the contact pin **18**.

Reversing the energization of either coil **24** or **25** causes the fluxes to oppose each other and flow through the magnetic circuit **42**. The magnetic circuit **42** comprises a set of contact springs and the space common to all of the ends thereof. When the magnetic circuit **42** is enabled, flux flows in opposing relationship in the contact springs and in aiding relationship in the space between the ends.

In the condition illustrated in FIG. 2, the magnetic circuit **42** has been enabled, and flux is flowing in opposing relationship through the contact springs **22** and **23** and in aiding relationship through the spacer **21**. As a result, the contact faces **35** and **36** have been magnetized with like polarities. Therefore, they have repelled each other, moved apart and thereby interrupted the electrical path between the contact pin **14** and the contact pin **17**.

The amount of energy required to operate reed switches depends upon the mechanical restoring forces which must be overcome in order to move the reeds or contact springs. These restoring forces are determined principally by the stiffness of the contact springs.

In the embodiment disclosed herein, the contact faces are mounted on the free ends of long, thin contact springs which are disposed so that only the thin dimension flexes during bending. As a result, the contact springs have relatively little stiffness. Consequently, the restoring forces, and thereby the power required to operate the contact springs, is reduced.

Further, the contact springs are curved so that the free ends reciprocate with each other in head-on or end-on relationship when they carry the contact faces into engagement with each other. It has been found that the end-on movement of the free ends requires less force to operate the contact springs than does "face-on" movement found in typical reed switches.

Curving the contact springs provides other advantages. When they are curved, the intermediate portions of adjacent contact springs are separated from each other. The space so created allows the coils to be wound directly on the contact springs in such a manner that they do not interfere with each other. As a result, excellent magnetic coupling is obtained between the contact springs and the coils.

Furthermore, curving the contact spring shortens the magnetic path between the free end and the fixed end of each. Consequently, reluctance in the magnetic path is reduced and more efficient use of available flux is obtained.

Finally, curving the contact springs improves the magnetic geometry of the switch.

According to this invention, therefore, power requirements for operating the switch are reduced by using long, thin contact springs arranged to reciprocate free ends thereon in a head-on relationship. Moreover, space requirements are reduced by curving the contact springs and winding the coils directly thereon.

A particularly desirable advantage is obtained when portions of the contacts in the switch are made from a magnetically remanent material, as for example, a material such as Remendur. When the contacts contain such a material, the magnetic circuit selected through the operation of the coils will be maintained after the coils are de-energized. As a result, the switch becomes essentially a pulse-operated bistable device.

It is to be understood that the above-described arrangements are but illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A switching device comprising:
a base;
a source of magnetic flux; and
a plurality of contact springs arranged to cooperate with each other in an electrical crosspoint, said plurality of contact springs having fixed ends attached to said base, free ends adapted to reciprocate along a common path, crescent-shaped members interconnecting said ends for reciprocating said free ends in end-on relationship along said path in response to magnetic flux from said source, and contact faces on said free ends for opening and closing a crosspoint in response to the reciprocal movement of said free ends.

2. A switching device as defined in claim **1**, wherein said crescent-shaped members are thin, wide, and flexible.

3. A switching device as defined in claim **1**, wherein said base, source of magnetic flux and contact springs are sealed in a vessel, and said source of magnetic flux comprises a plurality of coils wherein each coil is located within said vessel and wound directly around a contact spring.

4. A switching device as defined in claim **1**, wherein each of said contact springs is made from a magnetically remanent material.

5. A switching device comprising:
a source of magnetic flux; and

a pair of semicircular contact springs arranged to engage each other in end-on relationship when flux from said source flows in series through said contact springs and for disengaging each other when flux from said source flows in parallel through said contact springs, said contact springs being arranged to operate in a first magnetic circuit for directing flux from said source through said contact springs in series and a second magnetic circuit for directing flux from said source through said contact springs in parallel.

6. A switching device comprising:

a base;

a plurality of electrically conducting contact pins embedded in said base;

a spacer mounted on said base and disposed between said contact pins;

a pair of flexible magnetic contacts having free ends and fixed ends, said contacts disposed on said base with said fixed ends wedged between said spacer and said contact pins and said free ends extending around said spacer to a position adjacent to each other; and

a pair of coils wherein each coil is wound around a contact between the fixed end and the free end thereof.

7. A switching device as defined in claim **6**, wherein said contacts are shaped substantially in the form of a flattened G.

8. A switching device as defined in claim **6**, wherein said spacer is made from a magnetic material.

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