Oct. 24, 1967

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3,349,352

SEALED MAGNETIC SNAP SWITCH

Original Filed June 12, 1964

FIG. 1.

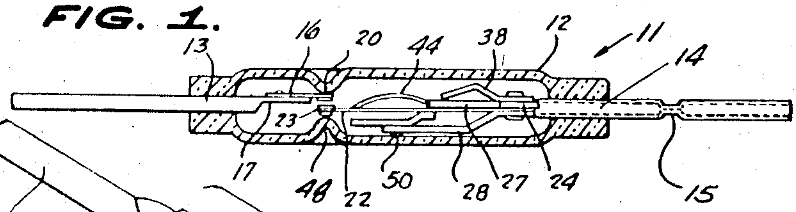


FIG. 2.

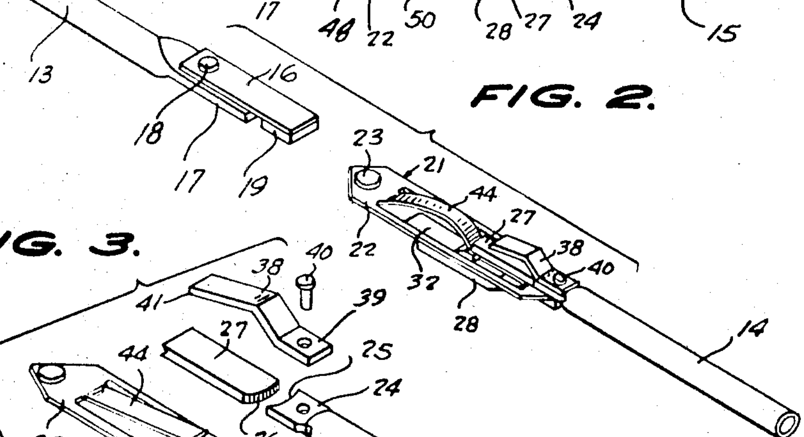


FIG. 3.

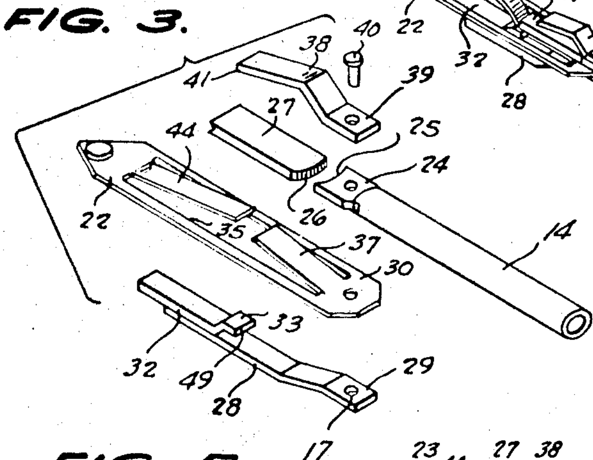


FIG. 4.

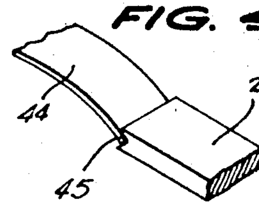


FIG. 5.

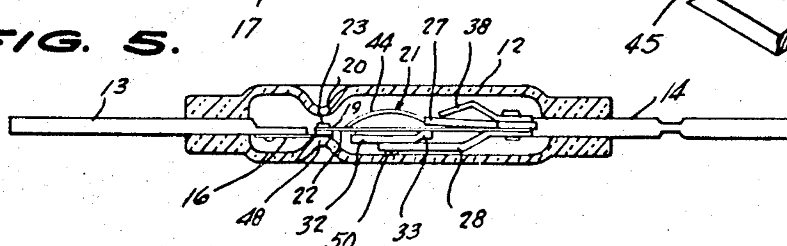
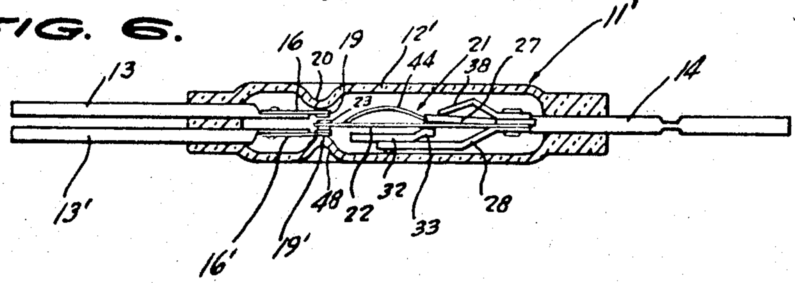


FIG. 6.



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SEALED MAGNETIC SNAP SWITCH

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Substituted for abandoned application Ser. No. 374,610, June 12, 1964. This application May 6, 1966, Ser. No. 548,321

8 Claims. (Cl. 335—154)

This application is a substitute of application Ser. No. 374,610, filed June 12, 1964, now forfeited, and relates to electrical switching devices. More particularly, it has to do with snap-acting switches of the type actuated in response to an externally-applied magnetic field.

There is in current use a form of switch known as a reed switch. Switches of this general type usually consist of a pair of elongated and overlapping contact members sealed within a non-magnetic non-conductive enclosure. These contact members are usually made partly or entirely of a soft magnetic material having contact elements in the gap between the magnetic members which include coatings of noble contact metal. The contact members are resiliently-mounted within a sealed non-magnetic envelope and when subjected to a magnetic field strong enough to overcome the inherent resilience of the members are caused to move by mutual attraction to complete an electrical circuit.

Another configuration of this general type of switch is one having a blade-type contact member resiliently-mounted in one end of a sealed cylindrical envelope overlapping relationship to two fixed contact members mounted in the opposite end. The suspended end of the resiliently-mounted magnetic contact member is positioned between the two fixed members. The fixed contact members, one being of magnetic material, and the other being of non-magnetic material, appropriately coated with a noble contact material, are arranged so that the suspended end of the resiliently-mounted contact member is biased against the non-magnetic member. When this switch configuration is subjected to a magnetic field strong enough to overcome the inherent resilience of the flexible member, the suspended end is attracted away from the non-magnetic contact member toward the magnetic contact member, interrupting one electrical circuit and completing another circuit. This type of reed switch represents a single-pole double-throw switch arrangement.

Among the advantages of switches whose contact members are actuated by mutual attraction in response to a magnetic field is the fact that they may be completely sealed in an enclosure to protect the contacts from the contaminating effects of dirt, moisture, explosive atmospheres, and other incidents of an industrial atmosphere. In addition, such an arrangement eliminates the necessity for additional mechanical moving members in the enclosure.

Although the aforementioned switches are suitable for performing a large variety of switching operations, their application is limited primarily by their low current rating due to limited contact fidelity, and because there is little force available to open the contacts should over-current weld the contacts together. The magnetic contacting surfaces must be in nearly perfect alignment and mate with each other to obtain efficient magnetic actuation conditions. This involves the necessity of very precise adjustments of alignment during the manufacture of such devices. The contact elements of these devices generally comprise ferromagnetic material, usually iron or iron alloy, plated with high conductivity and corrosion-resistant metal, such as gold, or the like. However, such coatings or layers must be very thin, for they also tend to reduce the magnetic efficiency of the switch. Thus,

the ferromagnetic portions of the members must be spaced further apart to allow space for the non-magnetic contact coatings.

Another prior art switch configuration of this type utilizes separate contact elements, such as buttons, which are attached to the resiliently-mounted overlapping magnetic contact members. These contact elements are generally postioned relatively close to the overlapping portions of the magnetic contacting members to achieve the maximum space between the contact buttons when the switch is de-energized. The relationship of the contact buttons and magnetic overlap is such as to permit the contact buttons and magnetic overlap elements to engage and yet maintain an absolute minimum space between the members at the magnetic overlap, consequently decreasing the magnetic efficiency in accordance with the square of the distance between the elements. By minimizing this space at the magnetic overlap to achieve efficient magnetic performance, the wear allowance of the contact buttons is minimized accordingly, thereby reducing contact life. Although the electrical continuity through the switch is made primarily through the contact buttons, the magnetic and electrical circuits are virtually coincidental.

Due to insufficient clearances, continuity must be made over the magnetic gap. This incidental continuity causes surface erosion and welding at the overlap area, causing premature failure. The electrical continuity through the magnetic gap area becomes considerably more frequent when inductive current loads are interrupted.

The switch configurations aforementioned are further limited to relatively low voltage applications because of the very small electrical clearance between the electrical contact members. These contact members, being in effect solid cantilever beams or blades of soft iron relying on their resilience to provide the movement necessary to make contact with their mating elements, provide an electrical clearance when de-energized of only a few thousands of an inch. This relatively small clearance or space between the overlapping portions of the contact members provides very limited electrical insulation and tends to cause electrical breakdown when relatively high voltages are applied to the device.

Furthermore, difficulties have been encountered with switches of this type by the accumulation of microscopic particles of iron dust which form on the contact surfaces or are accumulated thereon during switch use, Although the contact surfaces are coated with a noble metal or have contact buttons, these ferromagnetic particles accumulating within the small gap tend to form conductive paths between the contact buttons or undesired magnetic flux paths, or both, causing uncontrolled electrical continuity.

A main object of the present invention is to provide a reliable magnetically-actuated sealed switching apparatus which will alleviate the aforementioned shortcomings found in the magnetically-actuated switching devices of the prior art, and which will also be capable of conducting and interrupting relatively large load currents with positive opening and closing operations.

A further object of the invention is to provide an improved magnetic switch configuration which is suitable for fabrication to produce various contact arrangements, such as single-pole, normally open switching devices, single-pole, normally closed switching devices, and single-pole double-throw switching devices.

A still further object of the invention is to provide an improved magnetically-actuated sealed switching apparatus which lends itself readily to modern manufacturing procedures and which inherently provides the degree of precision necessary to repetitively produce a unit having predetermined magnetic as well as electrical values.

A still further object of the invention is to provide an improved magnetically-operated switch device which, although capable of controlling larger currents, may be used in precisely the same combinations as the above-described reed switches of the prior art, namely, may be operated by an externally-applied magnetic field provided by a coil or similar electrically-controlled source of magnetic flux, or by a permanent magnet movable into proximity to the switch.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawing, wherein:

FIGURE 1 is a longitudinal vertical cross-sectional view taken through one form of magnetically-actuated sealed switching apparatus constructed in accordance with the present invention, namely, of the type having contacts which are normally open, the switch being shown in its normal condition.

FIGURE 2 is a perspective view, in separated positions, of the stationary contact member and the movable contact assembly of the switch illustrated in FIGURE 1.

FIGURE 3 is a perspective view, to a somewhat enlarged scale, showing the various components of the movable contact assembly of FIGURE 2 in separated positions.

FIGURE 4 is an enlarged fragmentary perspective view showing the manner in which the free end of the bowed spring element of the main reed member seats in the opposing end edge of the adjacent magnetic armature element of the movable contact assembly of FIGURES 1 to 3.

FIGURE 5 is a longitudinal vertical cross-sectional view, similar to FIGURE 1, showing another form of sealed magnetic switch assembly according to the present invention wherein the contacts are closed under normal conditions.

FIGURE 6 is a longitudinal vertical cross-sectional view taken through still another form of magnetically-operated switch according to the present invention, this switch being of the single-pole double-throw type.

Referring to the drawing, and more particularly to FIGURES 1 to 4, inclusive, **11** generally designates a typical embodiment of an improved magnetic switch constructed in accordance with the present invention. The switch **11** comprises an elongated, hollow supporting body **12** which may be made of glass, but which can also be made from any other suitable impervious non-magnetic and electrically non-conductive material. Embedded in the opposite ends of the elongated tubular supporting body **12** are respective terminal members **13** and **14** which may be made, for example, from a magnetic nickel-iron alloy, but can be made of any other suitable material having a coefficient of thermal expansion which closely matches that of the glass envelope **12**, permitting a glass to metal seal. Terminal member **14** may be solid, but preferably is a tubular electrode which serves, during the construction of the device, as a means for evacuating the space between the envelope **12** and filling it with any desired type of gas at any desired pressure. This gas may be sealed within the envelope by permanently closing the tube opening in any suitable manner, as by crimping the member **14**, as shown at **15**, or by welding the tube closed. By thus filling the envelope **12** with an inert gas, the operating life of the switch device **11** is greatly extended.

Designated at **16** is a first contact spring arm which is secured to the reduced flattened inner end portion **17** of terminal element **13**, as by a rivet **18**, overlying the flattened portion **17** and being provided at its free end with a depending contact pad or button **19** of suitable conductive material and of proper cross-sectional area from making and breaking the rated circuit current for which the switch is designed. As shown in FIGURE 1, the spring arm **16** is mounted so that it can flex upwardly, the upward flexure thereof being limited by an indentation **20** formed in the top wall of the envelope **12**. The spring arm **16** is made of relatively thin resilient metal having suitable electrical conductivity. The contact element **19** may be suitably fastened to the bottom surface of the free end portion of the spring arm **16**, or alternatively, may be made integral with said spring arm.

Designated generally at **21** is a movable contact assembly which is secured to the inner end of the tubular terminal element **14**. The movable contact assembly **21** comprises an elongated flexible leaf spring member **22** having attached to its inner end a contact button **23** formed of silver or any other suitable contact material. The inner end portion of the tubular electrode **14** is provided with the reduced flat lug element **24** having an arcuately-concave end edge **25** against which is rotatably-engaged the arcuately-curved convex end edge **26** of a moving or floating armature element **27** of magnetic material. Designated at **28** is a supporting arm of non-magnetic material having the upwardly-offset end portion **29** which underlies the right end portion **30** of the leaf spring member **22**, as viewed in FIGURES 1 and 3, and is secured therewith to the flattened inner end portion **24** of the tubular terminal member **14**. Secured on the end portion of arm **28** opposite member **29** is an armature element **32** of magnetic material which is provided with the upwardly-offset end portion **33** which underlies the inner end portion of the floating armature member **27**, the leaf spring member **22** being formed with an elongated longitudinally-extending aperture **35** and the overlapping inner end portions of the armature elements **27** and **32** being normally disposed respectively above and below said aperture adjacent the intermediate portion thereof.

The right end edge of the aperture **35** includes the spring arm **37** which underlies and resiliently-supports the floating armature member **27** and biases said armature upwardly toward a non-magnetic stop arm **38** secured to the inner end lug **24** of terminal member **14**.

As shown in FIGURE 3, the stop arm **38** has an apertured end lug **39** which is fastened to the top surface of the apertured lug **24** of terminal member **14** and likewise to the end portion **30** of leaf spring member **32** and the apertured end portion **29** of arm **28** by a common rivet **40**. As will be readily apparent, the stop arm **38** has an abutment edge **41** which is engaged by the top surface of the floating armature member **27** to limit the upward movement of said floating armature element. The arm **38** is downwardly-concave in shape, and its attaching lug **39** is spaced sufficiently from the attaching lug **29** of arm **28** by the thickness of the supporting lug **24** of terminal member **14** to allow ample clearance for rotation of the floating armature element **27**, with the edge **26** pivoted against the edge **25**, to assure opening and closing of the switch contact elements during the operation of the switch.

Opposite the resilient tongue element **37** the end edge of aperture **35** is formed with another resilient tongue element **44** whose end edge is pivotally-engaged in a generally V-shaped groove **45** formed in the inner end edge of the floating armature member **27**, as is clearly shown in FIGURE 4. The resilient tongue **44** is normally bowed upwardly and is placed under tension by its pivotal engagement with the grooved end of armature element **27**, providing a biasing action which urges the armature element **27** upwardly against the edge **41** of a stop arm **38** and which consequently exerts a downward biasing force on the inner end portion of leaf spring **22**, biasing the contact button **23** downwardly into engagement with an indentation **48** formed in the bottom wall of the tubular envelope **12**. As shown in FIGURE 1, the contact button **23** is thus biased to an open-circuit position relative to the opposing contact element **19** carried by arm **16**. When the floating armature member **27** is urged downwardly toward the upwardly-offset end portion **33** of the bottom armature member **32** by a magnetic field, the downward movement of the pivoted edge of finger **44** flexes the leaf spring member **22** past a dead-center configuration, causing the free end portion of member **22** carrying contact button **23** to snap upwardly and to cause the button **23** to rapidly engage the bottom surface of the contact element **19** on arm **16**. This provides rapid closure of the switch with snap action. When the magnetic field is removed, whereby armature element **27** is free to move away from the cooperating magnetic armature portion **33** by the biasing force of resilient finger **37**, the pivoted edge of finger **44** is moved upwardly past the dead-center configuration of the leaf spring member **22**, causing said leaf spring member to rapidly assume its normal configuration, namely, that shown in FIGURE 1, wherein the bottom of button **23** engages the indentation **48**.

Armature member **32** is preferably secured to the non-magnetic arm **28** in a permanent manner, for example, by a weld. Similarly, the flat lug member **24**, which is preferably of magnetic material, is secured to the inner end of the tubular terminal member **14** in a permanent manner, for example, by means of a weld.

The elongated reed member **22** is preferably made of relatively thin non-magnetic conductive material, such as copper or an alloy thereof, and serves not only as a snap-acting leaf spring element to cooperate with floating armature member **27** to provide toggle action, but also serves to provide a current-conducting path from the contact button member **23** to the terminal member **14**. The center tongue elements **44** and **37** serve as the control means for regulating the movement of the floating armature element **27**. In the normal position of the switch, shown in FIGURE 1, the finger **37** acts as a resilient support for the armature element **27**, opposing the downward force exerted thereon by the bowed resilient arm **44**. The spring arm **37** thus serves as a means to maintain a small air gap between the overlapping inner end portions of the armature members **32** and **27**. It will be seen from FIGURES 1 and 2 that the spring **37** terminates short of the inner end of the floating armature member **27** and also short of the transverse edge **49** of the upwardly-offset stationary armature element **33** so as not to interfere with the air gap between element **33** and the overlying end portion of armature **27** which overlaps it.

It will be noted that the armature **27** automatically aligns itself longitudinally under the biasing force exerted thereon by the arcuately-curved spring arm **44** because of the arcuate seat **25** provided therefor on stationary element **24** which receives the convexly-curved end edge **26** of the floating armature element **27**. The arcuate seat **25** permits any necessary self-adjustment of the armature **27** to properly align its inner end portion with the cooperating stationary armature element **33**, providing a substantially articulated joint with respect to its supporting bearing member **24** and allowing free movement of the floating armature element **27** except as restrained by the cooperation therewith of the resilient finger elements **44** and **37**. As above-mentioned, the resilient finger member **37** provides a cushioned limiting action with respect to downward movement of the armature element **27** under the spring force exerted thereon by the bowed finger **44**, whereas the resistance of the finger **37** is overcome responsive to the application of a magnetic field to the switch, causing the armature element **27** to be magnetically attracted toward the stationary armature element **33**, moving the recessed edge **45** thereof downwardly past the dead-center position of the leaf spring member **22**, causing said leaf spring member to snap in the manner above-described and move button **23** suddenly into engagement with contact member **19**.

When the device is subjected to an adequate magnetic field, as above-described, so as to bring the contacts into engagement, the resilient contact arm **16**, having substantial resilience, is displaced from the top surface of portion **17**, as viewed in FIGURE 1, and is elevated until further upward movement thereof is prevented by its engagement with indentation **20**.

During the displacement of arm **16**, the accelerated contact button **23** is retarded before converging with the surface of indentation **20**, resulting in a cushioning effect reducing contact bounce. This displacement also achieves a desirable sliding action between the contacts.

Consequently, in its return movement, the contact arm **16** acquires a certain momentum before colliding with its normal supporting surface of portion **17**. The impact between these members, in effect, hammers the contacts apart. This hammering action on contact separation, along with the sliding action on contact engagement, provides a means of breaking the bond of welds which incidentally occur and insures increased contact fidelity.

As above-mentioned, the self-aligning feature provided by the arcuate seat **25** which receives the convex arcuate edge **26** of floating armature element **27** provides a substantial amount of manufacturing tolerance latitude while assuring dependable and repetitive performance of the switch and also increasing the magnetic efficiency thereof so that a minimum amount of magnetic energy is required to actuate the device.

As above-described, the snap action of the reed member **22** is caused by the movement of the grooved end **45** of armature **27** past the dead-center position of the reed member **22**, namely, by the movement of said grooved end past the plane of the reed member. The snap action of the reed member **22** achieves the desired quick-make and quick-break contact action to minimize electrical arcing at the contacts. Also, electrical arcing across the magnetic gap is prevented inasmuch as the magnetic actuating mechanism is isolated from the electrical contacts of the device.

It will be further noted that by locating the contact button **23** at the end of the reed member **22**, its movement is multiplied with respect to the movement of the grooved end **45** of armature element **27**. This factor permits maintaining a relatively small magnetic gap, whereby to achieve a high degree of magnetic efficiency, while permitting a relatively large electrical gap between the contact button **23** and the cooperating contact element **19** under open-circuit conditions, without interfering with the ability of the switch to handle relatively high load currents.

It will be further noted that since the magnetic actuating mechanism is integral with the contact assembly, adjustment of the magnetic elements may be made, with regard to magnetic actuation values and contact performance, prior to sealing the assembly within the envelope **12**.

It will be noted that the support member **28** is provided at its bottom surface with an abutment lug **50** which bears against the bottom wall of the envelope **12**, supporting the member **28** and increasing its resistance to vibration.

Referring now to FIGURE 5, the magnetic switch therein illustrated is similar to that shown in FIGURES 1 to 4, except that the switch is arranged as a normally closed switch which opens responsive to the application of a magnetic field to the spaced armature elements **27** and **32**. In the arrangement of FIGURE 5 the spring arm **16** is secured to the bottom surface of the lug **17** with the bottom surface of the inner end of the spring arm bearing normally against the indentation **48**, and being urged thereagainst by the contact button **23** which normally engages same under the biasing force exerted thereon by the arcuately-bowed finger **44**. The configuration and arrangement of the movable contact assembly **21** is the same as described previously and as illustrated in FIGURES 1 to 4, except that the switch is biased normally to a closed position. When a magnetic field is applied to the switch, whereby to cause floating armature member **27** to move toward fixed armature element **33**, the reed member **22** snaps in the manner above-described, rapidly disengaging contact button **23** from contact element **19**.

FIGURE 6 illustrates a magnetic switch according to this invention in the form of a double-throw, single-pole switch. The switch, designated generally at **11'** has elongated supporting envelope **12'** in one end of which is secured the tubular electrode **14** and a movable contact assembly **21**, similar to that above-described in connection with FIGURES 1 to 5. Embedded in the opposite end of the envelope **12'** are respective terminals **13** and **13'**, the terminal **13** being provided with a contact arm **16** having a contact element **19** on the bottom surface of its free end, as in the form of the invention illustrated in FIGURES 1 to 4. The terminal member **13'** is provided at its inner end with a contact configuration similar to that illustrated in FIGURE 5, including a resilient contact arm **16'** provided with a contact element **19'** on the top surface of its inner end. The contact element **19'** is normally engaged by the contact button **23** on the inner end of the flexible reed member **22** of the movable contact assembly **21**. Thus, the terminal member **14** is normally electrically-connected to the terminal elements **13'**, but in response to the application of a magnetic field to the switch, as in the case of the previously-described embodiments of the invention, the floating armature **27** is urged toward the magnetic stationary armature element **33**, causing the reed member **22** to snap. This disengages the contact button **23** from the bottom contact **19'** and moves said button rapidly into engagement with the upper contact element **19**, thus disconnecting terminal member **14** from terminal member **13'** and connecting said terminal member **14** to terminal member **13**. When the magnetic field is removed the parts snap back to their normal positions shown in FIGURE 6.

While certain specific embodiments of an improved snap-acting magnetic switch have been disclosed in the foregoing description, it will be undertsood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore, it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. A snap-acting magnetic switch comprising a hollow elongated support, terminal members secured in each end of the support, a first contact element secured to one of the terminal members inside said support, a flexible conductive non-magnetic reed member secured to the other said first contact element, said reed member being pro-terminal member inside said support and extending toward vided at its free end with a second contact element engageable with said first contact element, a first magnetic armature element fixedly-mounted in said support subjacent said reed member, a second magnetic armature element pivotally-mounted in said support above said reed member, said armature elements having overlapping spaced inner end portions, and a bowed resilient longitudinal tongue element on the reed member pivotally-engaged with the inner end portion of said second magnetic armature element and cooperating therewith to exert biasing force on the free end of the reed member.

2. The switch according to claim **1**, wherein said reed member is provided at its free end with a second contact

element engageable with said first contact element, and wherein said second magnetic armature element is movable toward said first magnetic armature element responsive to a magnetic field whereby to cause flexure of said reed member.

3. The switch according to claim **2**, wherein the inner end of the second armature element is provided with a groove pivotally-receiving the end of said tongue element.

4. A snap-acting magnetic switch comprising an elongated support, respective terminal members at opposite ends of the support, a first contact element secured to one of the terminal members, a flexible conductive reed member secured to the other terminal member and having a free end portion extending adjacent said first contact element, said free end portion being provided with a second contact element conductively-engageable with said first contact element, a fixed magnetic armature mounted below the intermediate portion of said reed member, abutment means adjacent said other terminal member, a movable magnetic armature engaging said abutment means and overlapping said fixed magnetic armature, toggle spring means extending between the free end portion of the reed member and the movable magnetic armature and exerting endwise biasing force on the movable armature, and means limiting upward movement of said movable armature, said movable armature being movable downwardly toward said fixed magnetic armature in response to a magnetic field to flex the reed member past a dead-center configuration and to thereby produce rapid movement of said second contact element relative to said first contact element.

5. The switch according to claim **4** which includes in addition a resilient tongue element on the reed member which extends from the end portion of the reed member, the end edge of the resilient tongue element being pivotally-received in a recess formed in the end of the movable armature and exerting endwise biasing force on the movable armature.

6. The switch according to claim **5** which includes in addition means limiting upward movement of said movable armature.

7. The switch according to claim **4**, wherein said abutment means is formed with an arcuate concave seat, and wherein said movable armature is formed with an arcuate convex end edge which is received in and engages said concave seat.

8. The switch according to claim **4**, wherein one of said terminal members comprises a metal tube adapted to be employed for filling the hollow support with inert gas and to be subsequently sealed.

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