Jan. 2, 1968 C. R. MARCUM 3,361,995

MAGNETIC PROXIMITY SWITCH

Filed March 24, 1966

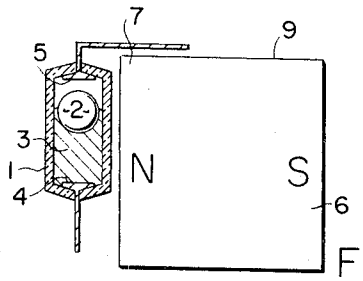


FIG. 1

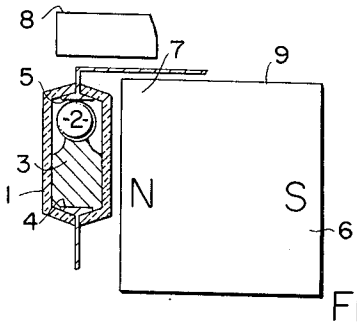


FIG. 2

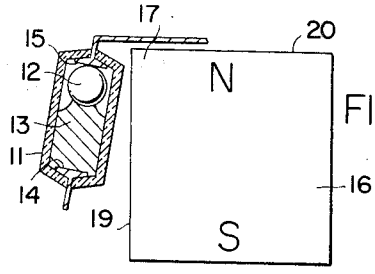


FIG. 4

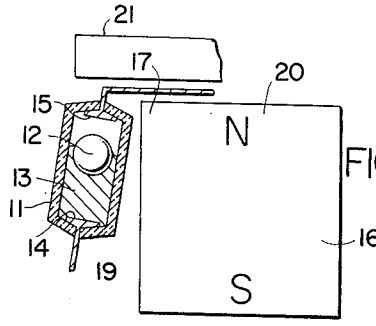


FIG. 5

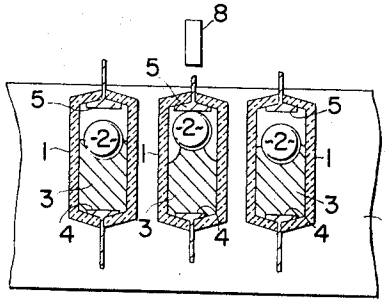


FIG. 3

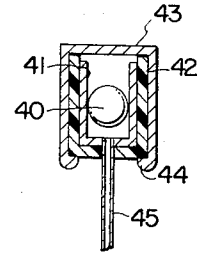


FIG. 7

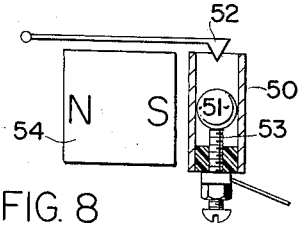


FIG. 8

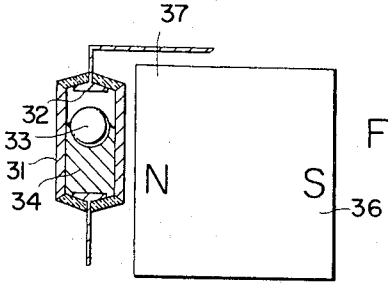


FIG. 6

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MAGNETIC PROXIMITY SWITCH

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ABSTRACT OF THE DISCLOSURE

A ball track containing a magnetizable ball is oriented along a side and adjacent a corner of a generally rectangular permanent magnet. The orientation of the track is such that the approach of a magnetizable object toward such corner causes movement of the ball. The ball is arranged to close a control circuit at one point in its range of movement in the track.

This is a continuation-in-part of application Ser. No. 390,542 filed Aug. 19, 1964 and now abandoned. This invention relates to magnetically actuated switches and more particularly to a switch mounted adjacent a permanent magnet and operated by the movement of a magnetizable operator in the region adjacent the magnet and switch.

Most magnetically operated switches employ moving switch parts that are actuated by varying the strength of the magnetic field produced by an electric coil, or moving a permanent magnet relative to the switch to induce movement of magnetized switch elements. These switches are not suitable for use where the switch is to be operated in response to the presence of a machine element or production line part.

The principal object of this invention is to provide a proximity switch comprising a simple, compact switch contact capsule and permanent magnet arrangement that is operated by movement of a magnetizable member to or from a position adjacent the switch.

Another object of the invention is to provide a simple compact switch and magnet assembly that may be operated as a normally open switch to close upon approach of a magnetizable operator or as a normally closed switch to open upon approach of the operator.

A still further object of the invention is to provide an assembly of a plurality of closely spaced, individually operable magnetically actuated switches.

More specific objects and advantages may be obtained from a magnetically operated switch constructed according to the invention.

According to the invention a magnetizable ball is contained in a ball track or container provided with contact elements, electrical, or fluid, that are operated when the ball is urged toward a particular position in its path of travel. The container may, if desired, be partially filled with mercury with the ball and contacts covered or wetted with a film of mercury. The track is positioned along a face or side of a permanent magnet and the ball is moved toward one end or the other of its track by movement of a magnetizable member that alters the flux gradient along the track.

Preferred examples of switches constructed according to the invention are illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a transverse sectional view of the improved switch arranged for normally open operation.

FIGURE 2 is a transverse sectional view of the switch shown in FIGURE 1 in its operated or closed position.

FIGURE 3 is a front view of the improved switch

shown in FIG. 1 or FIG. 2 with the operator in position to operate the switch.

FIGURE 4 is a transverse sectional view of the improved switch arranged to close its circuit during the absence of an operator.

FIGURE 5 is a transverse sectional view of the switch shown in FIGURE 4 in cooperation with an operator arranged to open the circuit upon the approach of the operator.

FIGURE 6 is a transverse sectional view of the improved switch employing a ferrous container for the switch.

FIGURE 7 is a longitudinal cross section of another form of switch that may be employed according to the invention.

FIGURE 8 is a longitudinal cross section of still another form of switch suitable for use according to the invention.

One form of the improved proximity switch, as shown in simple form in FIGURE 1, comprises a glass tubular capsule **1** containing an iron or steel ball floating in a pool or mercury **3**. The ball is of such size and material such as that shown in U.S. Patent No. 2,309,953, that the mercury forms a film over the surface of the ball **2**. Electrical contacts **4** and **5** are provided in the capsule at spaced apart points, here shown as being at the ends of the capsule although they may be inserted from the side of the tube at selected points. The contact **4** is immersed in the globule of mercury **3** while the contact **5** is located above and out of contact with the ball when in its normal position. The capsule **1** forms a ball track as well as an enclosure since it confines the movement of the ball to a particular direction. The capsule **1** or ball track is mounted adjacent the side of a permanent magnet **6**, which is preferably made of a high retentivity ceramic material currently available on the market. Magnets made of a sintered alloy of aluminum, cobalt, nickel and iron may also be used. The magnet **6** is preferably of rectangular cross section in the plane containing the axis of the ball track and for a normally open switch is magnetized to provide a pole of one polarity in the side adjacent the switch. The capsule or ball track is positioned such that the ball is located somewhere between the middle of the pole face and a corner thereof such as a corner **7** shown in FIG. 1. This is considered as having the ball adjacent a corner of the cross section of the magnet.

The switch is oriented in space so that the contact **4** and mercury **3** are below the ball **2** and the parts assume the positions shown in FIGURE 1.

If a magnetizable operator **8**, FIGURE 2, is brought into the region adjacent the corner **7**, either along or toward a side **9** of the magnet adjacent the corner or directly toward the corner, the flux distribution from the pole face is distorted with the flux crowding toward the corner **7**. Since the lines of force are generally normal to the ball track, the allowable path of movement of the ball **2**, the ball attempts to move toward the region of greater flux density. With the operator adjacent the corner **7** or disposed adjacent the side **9** to provide a low reluctance return path for the flux the greater flux density is at the corner **7** and the ball moves toward such corner to close the switch.

In a preferred form the capsule **1** has an outside diameter not greater than three sixteenths of an inch and the switches may be assembled along the length of the magnet **6** on three sixteenths inch centers. The operator **8**, for such spacing, should be quite thin. Suitable proportions are indicated generally in FIG. 3. An operator having a thickness of 20 to 40 thousandths of an inch is suitable.

The size of the switch is such that, for example, it may be mounted under the keyboard of a typewriter to close

a circuit when a key is depressed. The key itself may be the operator, or small magnetizable tabs may be added to the keys to cooperate with the switches.

Various other types of operators may be used. These may be keys of adding machines, key type telephone dialing, or any similar operation initiated by a linear movement of an element. Alternatively the operator may be a rotating disk, as a timer disk or programmer, the disk being notched to leave teeth or projections for operating the switch.

The switch shown in FIGURES 1 to 3 is a normally open switch requiring the approach of an operator into proximity to the corner of the magnet to close the switch. FIGURES 4 and 5 show a similar switch and magnet arranged for normally closed operation, i.e. the switch opens upon the approach of the operator. In this switch a capsule 11 forms the enclosure and ball track for a magnetizable ball 12 that floats in a globule of mercury 13 and is covered with a film of mercury from the globule 13. Electrical terminals or contacts 14, 15 are provided, the terminal 14 being immersed in the mercury 13 and the terminal 15 being at the far end of the path of movement of the ball 12.

The capsule 11, forming the ball track, is mounted adjacent a side 19 of the magnet 16 that has a corner 17 between the side 19 and a pole face 20. The capsule 11 is positioned along the side 19 with its axis in the plane of the cross section of the magnet 16 and with the ball 12 located adjacent the corner 17, i.e., somewhere between the middle of the face 19 and the corner 17. Preferably the ball track is mounted at a small angle such that the ball 12 approaches the face 19 as it moves toward the corner 17. With no operator adjacent the corner 17 the ball 12 moves to the limit of its travel toward the corner thus closing the switch.

When an operator 21, FIG. 5, similar to the operator 8 is brought near the corner 17 corresponding magnetic poles are induced in the operator with the result that the ball 12, which itself contains induced magnetic poles, is repelled from the corner 17 and driven into the mercury. This opens the circuit between the contacts 14 and 15.

The repelling action of the operator 21 is believed to be caused by reduction in flux gradient on the ball side of the corner 17 from a steep gradient without the operator that occurs at the corner 17 by the crowding of the external lines of forces toward the corners on the pole faces and thence through the air to the opposite pole face. Thus the external field has its maximum density just above the position of the ball as shown in FIGURE 4. The presence of the operator 21 concentrates the flux from the pole face 20 to the operator 21 and the flux return is through the air from the end of the operator to the far side of the magnet. This leaves the ball on the lower side of the minimum flux density region along the side of a composite magnet (magnet 16 and operator 21) so that the ball is now attracted toward the opposite pole of the magnet.

It has also been observed that some types of ceramic magnets, called "unoriented" by the manufacturers, can be magnetized so that one cross section has poles on one pair of faces while an adjacent cross section, at the next switch, has poles on the other pair of faces. Thus a pair of adjacent switches responding to a pair of operators or a thick operator may provide the equivalent of a single-pole, double-throw switch.

It has also been discovered that the ball track or enclosure may be made of thin stainless steel without rendering the switch and magnet arrangement inoperative. Such an arrangement is shown in FIGURE 6. In this arrangement a capsule 31 made with thin steel side walls and an insulated cap 32 serves as a track for a magnetic ball 13 supported in a mercury pool 34. The ball 33 is of a size and surface material that it is covered and wet by a mercury film. In its normal position the ball is supported in the mercury and does not contact the insulated cap 32

serving as one terminal of the switch. The capsule 31 serves as the other terminal.

The capsule 31 is mounted along a pole face of a magnet 36 with the ball 33 adjacent a corner 37 as previously defined. However, in this embodiment the capsule is preferably moved down away from the corner 37 so that the ball is somewhat nearer the center of the pole face than the corner.

This switch is operated by bringing an operator, similar to the operators 8 or 21, into the region adjacent the corner 37, either along the pole face or along the adjacent side.

In each of the foregoing examples, the ball floats on a mercury pool and is pulled upwardly to make contact with a fixed contact element without breaking contact with the mercury pool. It is often desirable that the switch be operated in other than an upright position. For such applications a different form of capsule and contact arrangement such as those illustrated in FIGURES 7 and 8 may be used.

In the capsule arrangement shown in FIGURE 7 a metallic ball 40 is a loose fit in a metallic inner liner 41, preferably made of stainless steel. The inner liner 41 is inserted into and is a gas tight fit in a plastic cup 42. The plastic cup 42 is preferably constructed of a plastic material known as Teflon. The assembly of the ball 40, inner liner 41, and insulating plastic cup 42 is fitted into an outer metallic cup 43, with the open end of the liner 41 and plastic cup 42 seated in the bottom of the outer cup 43 and sealed by a rim 44 of the outer cup spun or curled inwardly against the closed end of the plastic cup 42.

The inner metallic liner 41 is provided with an exhaust tube 45 so that the interior of the assembly may be evacuated and thus filled with gas, preferably hydrogen. After filling, the tube 45 is sealed. A substantial portion, of the tube 45 extending beyond the lip 44 of the outer cup 43, is left attached to serve as one terminal of the switch.

Preferably, the ball 40 is made of or plated with a mercury wettable metal and enough mercury is included with the ball 40 to form a thin film on the ball. The liner 41 and outer cup 43 are preferably made of a non-wettable metal so that there is no surface tension exerted between the ball and the other metal surfaces to affect the motion of the ball in response to external magnetic fields.

In use, this switch assembly is mounted adjacent a magnet and operated in the same manner as the switches shown in FIGURES 1–6. It has the additional advantage that it, because there is no mercury pool, may be operated in any position, rather than being limited to an upright position.

The sealed switch assembly, just described, has good life because the contacts are maintained in a neutral or non-oxidizing atmosphere and a small amount of mercury adheres to the ball so that electrical circuits through the switch are made or broken through the mercury, thus protecting the contact surfaces. The film of mercury on the ball is maintained because any vaporized mercury tends to collect on the wettable surfaces rather than on the other surfaces in the switch.

If the service demands do not require enclosure of the contacts, as where small currents at ordinary voltage levels are being switched or where fluid circuits such as fluid amplifiers are being controlled, an open type construction may be used. Such a construction is shown in FIGURE 8.

In this construction the switch, which may be operated in any position since the magnetic forces exceed the force of gravity, comprises a non-magnetic, metallic tube 50, preferably made of stainless steel, a ball 51 positioned in and movable along the axis of the tube, a fixed contact member 52 located at one end of the tube 50 and insulated therefrom, and a screw 53 serving as a

second contact mounted in and insulated from the other end of the tube **50**. The tube **50** is mounted alongside a pole or side of a magnet **54**, either parallel to the side or at an angle similar to the mountings shown in FIGURES 1–6.

As may be seen in FIGURE 8, the second contact **53** is screw threaded through an insulator **55** closing the lower end of the tube **50**.

If the switch is used to control fluid circuits, such as fluid amplifiers or similar control systems using fluid pressure and flow, the electrical contact members **52, 53** are replaced with orifices or nozzles with which the ball **51** cooperates to control the flow of fluid through the orifice or nozzle.

This switch assembly provides, when positioned as shown relative to the magnet **54**, a single pole double throw contact arrangement, the tube **50** being the common contact, the fixed contact **52** being the normally open contact and the screw **53** being the normally closed contact.

The normal position of the ball may be shifted to the contact **52** if the tube **50** is mounted at an angle adjacent a side of the magnet as in the switch illustrated in FIGURE 4.

These particular configurations made it possible to mount a large plurality of switch capsules on a single magnet when used with multi-key devices such as typewriters, adding machines, cross bar switches, etc. without interference between adjacent switches. The switches may also be mounted on opposite sides of a single magnet thus doubling the number of switches per unit of length.

Various modifications may be made in the specific details of construction without departing from the scope of the invention.

Having described the invention, I claim:

1. A magnetically actuated switch comprising, in combination, a magnetizable ball, means forming a ball track for guiding the ball, switch elements including an element at a selected point along the track to be engaged by the ball to control a circuit, a permanent magnet having a generally rectangular cross section and magnetized with lines of force lying in the plane of the cross section, said ball track being positioned along a side of the magnet with its axis in the plane of the cross section and with the ball adjacent a corner of the cross section, whereby a magnetizable object to be detected movable into proximity to said corner varies the flux gradient along the track to move the ball.

2. A magnetically actuated switch according to claim **1** in which the ball track is mounted along a pole face side of the magnet whereby the switch closes upon the approach of an operator.

3. A magnetically actuated switch according to claim **1** in which the ball track is mounted along a side of the magnet separated from a pole face by a corner of the magnet from which corner the ball is repelled as an operator moves into proximity to such corner.

4. A magnetically actuated switch according to claim **3** in which the ball track is mounted at an angle to the side of the magnet, the ball end of the track being closest to the magnet.

5. A magnetically actuated switch assembly according to claim **1** have a plurality of switches spaced along the side of a single magnet with each switch individually responsive to an operator.

6. A magnetically actuated switch according to claim **1** in which the ball track is partially filled with mercury.

7. A magnetically actuated switch according to claim **1** in which a film of mercury covers the ball.

8. A magnetically actuated switch according to claim **6** in which the mercury completes a circuit through the switch.

References Cited

UNITED STATES PATENTS

2,309,953	2/1943	Harrison	335—56
2,995,635	8/1961	Ovshinsky et al.	335—196
3,164,696	1/1965	Pusch	335—205
3,261,942	7/1966	Wessel	335—154

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