

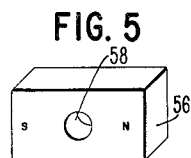
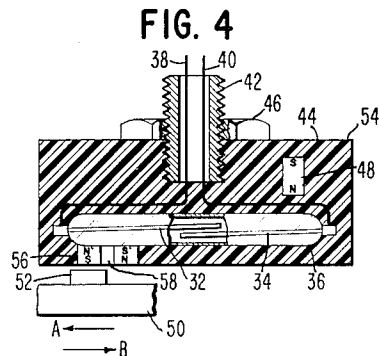
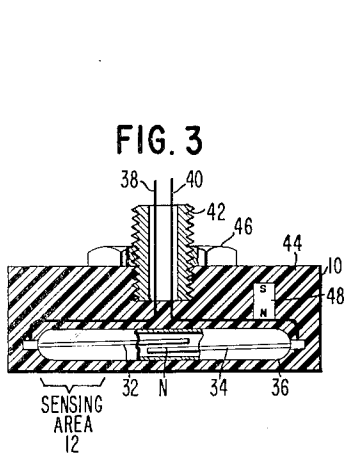
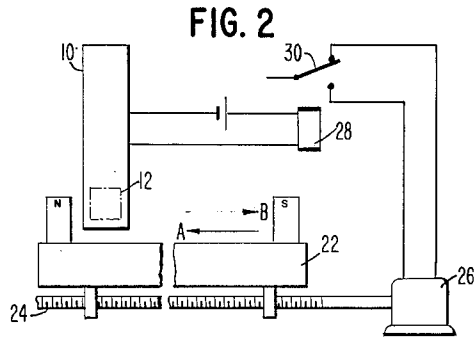
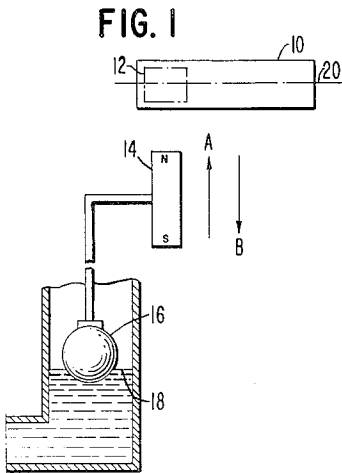
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3,198,902

PROXIMITY MAGNETIC REED SWITCH ASSEMBLY

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PROXIMITY MAGNETIC REED SWITCH ASSEMBLY

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This invention relates to a new and improved switch assembly, and more particularly, to one employing a magnetically biased pair of contacts which can be opened or closed depending upon the polarity of a magnetic field which envelops a portion of one of said contacts.

Industrial applications of limit and analogous switches involve their use for machine control, alarms, signals, and other such functions where the approach or passage of a material body must be detected. Very often the type of function required of a switch is that its contacts open when the material body passes by its sensing area in one direction, and then close when the body returns past the sensing area in the opposite direction. During the time that the body is not adjacent the sensing area, the switch contacts must remain in the state determined by the direction of travel of the body at the last time it traversed the sensing area. This type of function is quite often required of switches associated with floats carried by a rising and falling liquid level, or switches for determining the end limits of travel of machine tool carriages and the like. There are many other environments, too, where a function of this nature is essential.

Therefore, it is one object of the present invention to provide a switch combination wherein the direction of travel of a body past the sensing area determines the state of the contacts.

Another object of the present invention is to provide a switch assembly which incorporates a magnetic pole in one of the switch contacts.

One species of the present invention requires that the body, whose direction of travel is to be sensed, actually carry magnetic poles of unlike polarity whose fields selectively determine the open or closed state of the switch contacts. In this type of switch, the switch contacts may be actuated and closed by placing one pole on the body close to the switch sensing area. After removal of this one pole the contacts remain closed until an unlike pole on the body is placed close to the sensing area for the purpose of opening the switch contacts. Thereafter the switch contacts remain open until said one pole of the body is again placed adjacent the sensing area. The unlike poles on the body are so positioned that both are carried past the switch sensing area for each direction of travel, with the last pole to pass the sensing area determining the state of the switch contacts. In another species of the invention, the switch sensing area itself contains means responsive to the passage of a ferro-magnetic body in order to generate a field of one polarity or the other for changing the switch contact state. In this alternative embodiment, two pairs of unlike magnetic poles are employed adjacent the sensing area and are positioned such that the flux field of one or the other pair is increased due to the proximity thereto of magnetic material comprising or carried by the moving body. The contact state is therefore determined by the polarity of the last strong field produced during the passage of the external body adjacent to the switch sensing area.

It is therefore another object of the invention to provide a switch assembly of the type disclosed wherein magnetic means are employed to generate a field of one or the other polarity in accordance with the position of magnetic material in the switch sensing area.

These and other objects of the present invention will become apparent during the course of the following de-

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scription, which is to be read in conjunction with the drawings, in which:

FIGURE 1 shows the first embodiment of the switch assembly being used in the environment of liquid level indication;

FIGURE 2 illustrates said first switch assembly being used to indicate the end limit travel of a machine tool component;

FIGURE 3 shows details of the contacts of said first switch embodiment;

FIGURE 4 shows a second embodiment of the invention which includes magnetic field generating means internal of the sensing area; and

FIGURE 5 shows the preferred magnetic field generating means of said second embodiment.

Referring first to FIGURE 1, there is shown one typical environment in which the novel switch assembly may be utilized, but to which it is not restricted. Reference numeral 10 generally indicates a contact housing which includes a sensing area 12 at one end thereof. Cooperatively associated with sensing area 12 is a magnet 14 carried by a float member 16 which in turn rests upon the surface of a liquid body 18 whose level may vary. Magnet 14 is held so that its direction of travel across sensing area 12 is substantially transverse to the longitudinal axis 20 of the switch contact housing 10. The unlike north and south poles of magnet 14 will thereupon be carried successively across sensing area 12, but the size of sensing area 12 and the distance between poles N and S of magnet 14 should be such that only one of these poles is adjacent the sensing area for any position of float 16.

In operation, assume first that the liquid 18 is low so that the north pole N of magnet 14 is positioned below sensing area 12. At this time, it is assumed that the switch contacts inside of housing 10 are open. If the liquid 18 begins to rise, float member 16 is carried upward in the direction of arrow A such that the north pole N is eventually carried adjacent the sensing area 12. The contacts inside of housing 10 are so biased that they remain open when a north pole is adjacent the sensing area. If the liquid 18 now rises slightly more, north pole N of magnet 14 is carried upward and out of proximity with the sensing area, while the south pole S of the magnet 14 is brought adjacent to sensing area 12. At this time, the contacts inside of housing 10 close and will thereafter remain closed even through liquid 18 rises to a higher level and carries south pole S upwards and out of proximity with the sensing area.

Upon return of the surface of liquid 18 to its original level, magnet 14 is carried downward in the direction of arrow B and past sensing area 12. During this downward direction of travel, the south pole S of magnet 14 first passes sensing area 12, but does not affect the closed state of the contacts. Upon further lowering of the liquid surface, the north pole of magnet 14 is now brought adjacent sensing area 12 and in turn causes the contacts in housing 10 to open. If the liquid level retreats even more, thus carrying float member 16 down further so that magnet 14 is completely beneath sensing area 12, the contacts remain open even though the north pole N of magnet 14 is no longer in proximity thereto. Thus, it is seen that when magnet 14 moves in the direction of arrow A completely across sensing area 12, the contacts are forced closed, whereas upon return of magnet 14 completely across sensing area 12 in the direction of arrow B, the switch contacts are open. Furthermore, the contacts in housing 10 remain in either the open or closed state as determined by the last direction of travel of float member 16. The closing of the switch contacts and housing 10 may close a circuit leading to an indicator for showing that the liquid level has risen above a certain

point, or the contacts may energize a circuit for automatically controlling the liquid level.

The invention may also be employed in the environment of FIGURE 2. Here, a machine tool carriage 22 is moved in either direction by a conventional rotating lead screw 24 driven by a motor 26. Unlike magnetic poles N and S are positioned at the ends of the carriage as shown. The contact housing 10 is located on the bed so that its sensing area 12 will be traversed by each of the poles N and S during each complete travel of the carriage in either direction A or B. The opening or closing of the contacts in housing 10 can be utilized to determine the end limits of travel of the machine tool carriage in order to reverse direction of screw thread 24 when an end limit has been reached. For example, assume that when the contacts in housing 10 are open, a relay 28 is de-energized so that armature 30 is in the position shown to thereby supply power to motor 26 in order to drive machine tool carriage 22 in the direction of arrow A. The south pole S at the right end of 22 will eventually come into proximity with sensing area 12 so as to close the contacts, which in turn remain closed even though south pole S is carried a bit beyond to the left of sensing area 12. The closing of contacts in housing 10 energizes relay 28 which in turn allows armature 30 to apply power for reversing the rotation of motor 26 and thus carry machine tool carriage 22 back in the direction of arrow B. The south pole S is first carried across sensing area 12 in this return direction but does not affect the closed position of the contacts in housing 10. Eventually, carriage 22 moves all the way to the right so that the north pole N is brought adjacent to sensing area 12. At this time, the contacts in housing 10 are opened by the proximity of north pole N in order to again de-energize relay 28 and thus cause machine tool carriage 22 to commence again its travel to the left. It will be seen that, in reality, the environment of FIGURE 2 is analogous to the environment of FIGURE 1, except for the fact that the unlike magnetic poles N and S are spaced apart much further in FIGURE 2 than in FIGURE 1.

FIGURE 3 illustrates the preferred construction of the switch utilized in the environments of FIGURE 1 and FIGURE 2. A pair of reed contacts 32 and 34 made of spring magnetic material are located in a glass enclosure 36 which is hermetically sealed with glass-to-metal seals at the points where the contacts emerge from the glass wall. The glass enclosure itself may be filled with a non-conducting gas so that no current flows when the contacts open and an E.M.F. impressed across the contacts. Conductors 38 and 40 are mechanically and electrically connected to their respective contacts 32 and 34 and extend through the hollow interior of a mounting conduit 42 in order to provide access to the external electrical circuit that they are controlling. Conduit 42 has external threads and is placed in a plastic potting compound 44 prior to the setting of the compound but after it has been poured. The plastic compound 44 actually provides a case or housing 10 for the glass enclosure 36 with the latter being potted therein. Other kinds of housings may be provided. A lock nut 45 is also shown having internal threads that are engaged to the external threads of conduit 42. This lock nut may have flats to accommodate a wrench to facilitate the connection of conduit 42 to an external supporting object. The lower face of lock nut 45 is in contact with the plastic potting material 44, which greatly improves the mechanical bond between conduit 42 and compound 44.

The sensing area 12 is located or delineated on housing 10 at a position nearest the fixed end of contact 32. The free end of contact 32 is used for engaging the free end of contact 34. A magnetic pole of some polarity is physically placed or otherwise induced in the free end of contact 34. In FIGURE 2, this pole in the engaging end of contact 34 is a north pole N, but could as well be a south pole. If reed contacts 32 and 34 are of a standard

unmagnetized type which are purchased already enclosed in container 36, then this north pole N may be conveniently established by incorporating a small biasing magnet 48 into the housing 10. Biasing magnet 48 is positioned so that its north pole N is adjacent to the fixed end of contact 34, and it is securely held in place by the surrounding potting compound 44. The flux from north pole N of biasing magnet 48 traverses a part of contact 34 before returning to the south pole S of magnet 48. This causes a north pole N to be induced in the free end of contact 34 due to the orientation of the magnetic dipoles caused by the biasing magnetic field.

The contacts 32 and 34 are made of spring material which normally maintains their free ends out of contact with one another in the absence of a sufficiently strong threading magnetic field. The strength of the magnetic pole N in the free end of contact 34 should be insufficient to, by itself, overcome this spring bias. However, once contacts 32 and 34 close by the action of some external field, then the strength of pole N in the preferred embodiment should be sufficient to maintain closure until some positive step is taken to cancel its effect.

By bringing a south pole into proximity with sensing area 12 of housing 10, in a manner typically shown in either FIGURE 1 or 2, the magnetic dipoles in contact 32 are oriented so that its free end becomes effectively a south pole S. The field between the free ends of contacts 32 and 34 now increases to overcome the spring bias, thus forcing or attracting the free ends of contacts 32 and 34 together. When the external south pole is removed from the proximity of sensing area 12, the strength of the north pole N in contact 34 is sufficient to maintain the contacts closed. If an external north pole is now brought into proximity with sensing area 12, then the dipole orientation in contact 32 is reversed, thus establishing a north pole in the free end of contact 32 which thereupon forces apart said ends. As a slight modification of FIGURE 3, the normal field of the north pole N in contact 34 can be reduced to a value less than that necessary to even hold the contacts closed. Thus, the contacts close only when a south pole is maintained in proximity to the sensing area.

FIGURE 4 shows an alternative embodiment of the present invention in which a moving body 50 carries a body of magnetic material 52 which of and by itself does not produce a magnetic field. Instead, switch contact housing 54 has included therein magnetic field generating means 56, in addition to the other elements already described in connection with FIGURE 3. Corresponding numerals in FIGURES 3 and 4 identify corresponding parts. Magnetic field generating means 56 comprises, in its preferred form, a ceramic material magnet formed generally in the shape of a thin bar or wafer by pressing ceramic powder in a fashion well known in the art. The rectangular shape of this wafer is shown best in FIGURE 5. An aperture 58 is provided in wafer 56. A ceramic wafer magnet of the type disclosed may be permanently magnetized so as to form a pair of unlike poles on each of its two major parallel faces, which are those faces between which aperture 58 extends. As shown in FIGURE 4, a pair of unlike poles S and N is formed on either side of aperture 58 at the major face of the wafer which is adjacent or closest to the housing sensing area 12. In addition, a pair of auxiliary poles N' and S' is formed on either side of aperture 58 on the opposite major face of wafer 56, which is that surface adjacent or closest to the fixed end of contact 32. The strength of the auxiliary poles N' and S' is normally less than the strength of the main poles S and N. A magnet of this type shows a strong magnetic attraction from the major poles, but practically no magnetic attraction from the auxiliary poles. However, if the piece of ferro-magnetic material 52 is brought into proximity to the main south pole S, the field from the auxiliary north pole N' increases due to the decrease in reluctance of the magnetic circuit be-

tween poles S and N'. In similar fashion, if the magnetic material 52 is brought into proximity with the main north pole N, the field from the auxiliary south pole S' increases because of the decrease in reluctance of the magnetic path between poles N and S'. Thus, a strong field of one polarity or the other can be selectively generated, according to the position of material 52, to envelop the fixed end of contact 32. This field in turn generates a similar pole at the free end of contact 32 in order to either close or open contacts 32 and 34. The arrangement of FIGURE 4 thereby eliminates the need for a moving body 50 to carry magnetic poles thereon. Instead, only the external magnetic material 52 is required to selectively vary the reluctance of the paths between the unlike poles in each of the pairs S-N' or N-S'. It should also be noted that the length of material 52 may even be of a size so that it is, for some position, in proximity substantially with both of the main poles S or N. For this case, when magnetic material 52 is moving from left to right, the contacts will not close until its trailing edge is in proximity with main pole N. When once the switch closes, it remains locked in until the material 52 reverses direction, with the contacts opening at least by the time that its trailing edge moves into proximity with main pole S. If the switch contacts are open and the material is moved from right to left, they will first close and then open.

A premagnetized ceramic wafer magnet assembly particularly suitable for use in the embodiment of FIGURE 4 is termed Index 1 and is made from a non-oriented barium ferrite material which is pressed into the shape of a thin wafer having a center hole. The dimensions in inches of this wafer are: length 1.00; width 0.75; thickness 0.177; hole diameter 0.137. However, instead of forming the poles S, N, S' and N' on the same physical body, it would also be possible to fabricate the housing of FIGURE 4 using two separate but parallel bar magnets, one with poles S and N', and the other with poles N and S'.

While preferred embodiments of the present invention have been shown and described in detail, it is obvious that many modifications thereto may be made by persons skilled in the art without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. A switch assembly which comprises:

(a) a pair of cooperating electrical contacts, at least one of which is made of magnetic material having spaced apart first and second portions, said second portion being adapted to either make or break electrically with at least a portion of the other contact of said pair;

(b) first means to normally bias open said contacts;

(c) second means establishing a magnetic pole of one polarity in said other contact at its said portion, said pole having a field strength which, by itself, is insufficient to overcome said bias and close said contacts, but which is sufficient to maintain said contacts closed after said bias has been overcome; and

(d) control mechanism for selectively enveloping said one contact first portion with either a like or an unlike magnetic field of sufficient strength so that said second portion thereby is either repelled from or attracted to close with said other contact portion, respectively, where said control mechanism comprises a first pair of spaced apart unlike magnetic poles each permanently located adjacent to said one contact first portion so as to envelop same with a magnetic field, a second pair of spaced apart unlike magnetic poles each permanently located opposite an unlike pole of said first pair so that a flux path is created therebetween whose normal reluctance is such as to cause the field from the associated pole of said first pair to be of a strength insufficient to affect the state of said contact pair, and a body of magnetic material relatively physically movable with respect to said one contact first portion which can be selectively

moved into the field of either one of the poles of said second pair so that the reluctance of its associated flux path decreases which in turn increases the field strength of the associated pole of said first pair of poles to thereby make or break said contacts.

2. A switch assembly which comprises:

(a) a housing;

(b) a pair of first and second cooperating electrical contacts internally placed in said housing, each of which is made of spring magnetic material in the shape of a reed having spaced apart first and second portions with said first portion being fixed and said second portion being adapted to move so as to make or break with the second portion of the other contact, where said spring nature of each contact normally biases open said contacts;

(c) means establishing a magnetic pole of one polarity in said second contact at its said second portion, said pole having a field strength which, by itself, is insufficient to overcome said spring bias and close said contacts, but which is sufficient to maintain said contacts closed after said spring bias has been overcome;

(d) a sensing area delineated on said housing at a position which is nearest said first contact first portion; and

(e) control mechanism for selectively enveloping said first contact first portion with either a like or an unlike magnetic field of sufficient strength so that said first contact second portion thereby is either repelled from or attracted to close with said second contact second portion, where said control mechanism comprises a first pair of spaced apart unlike magnetic poles each permanently located within said housing at its sensing area position and adjacent to said first contact first portion so as to envelop same with a magnetic field, a second pair of spaced apart unlike magnetic poles each permanently located within said housing adjacent to said sensing area and opposite the unlike pole of said first pair so that a flux path is created therebetween whose normal reluctance is such as to cause the field from the associated pole of said first pair to be of strength insufficient to affect the state of said contact pair, and a magnetic material body external to said housing and relatively physically movable with respect to said sensing area which can be selectively moved exclusively into the field of said sensing area of either one of the poles of said second pair so as to decrease the reluctance of its flux path associated with the unlike pole of the first pair to thereby increase the field of the unlike first pair pole to a strength sufficient to affect the state of said contact pair.

3. A combination according to claim 2 wherein said first pair of poles is permanently formed on one face of a wafer of ceramic magnetic material and said second pair of poles is permanently formed on an opposite parallel face of the same said wafer.

4. A switch assembly according to claim 2 wherein said external magnetic material body is relatively movable, with respect to said sensing area, in a path which in turn is substantially parallel in the vicinity of said sensing area to the length of the reed comprising said first contact.

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