Sept. 7, 1965 E. C. DESHAUTREAUX, JR 3,205,323

MAGNETIC REED PROXIMITY SWITCH

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FIG. 1a

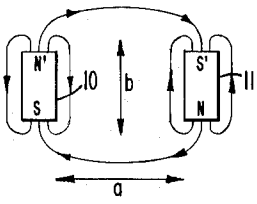


FIG. 1b

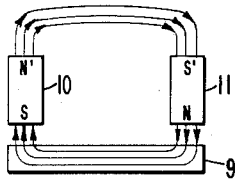


FIG. 2

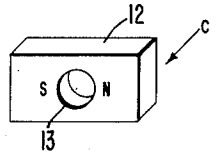


FIG. 3

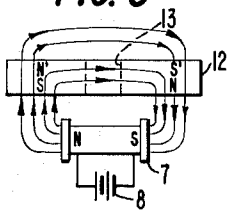


FIG. 4a

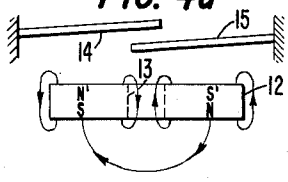


FIG. 4b

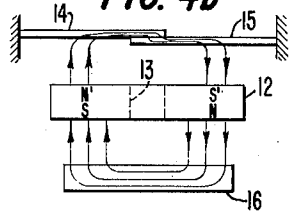


FIG. 5

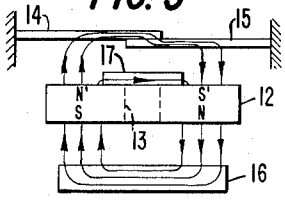


FIG. 6

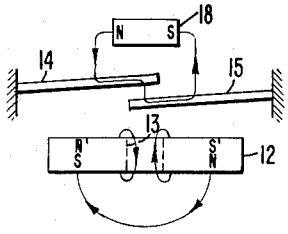


FIG. 8

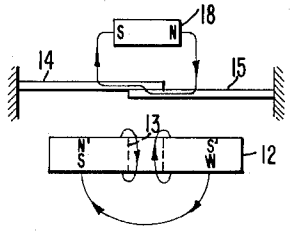


FIG. 7

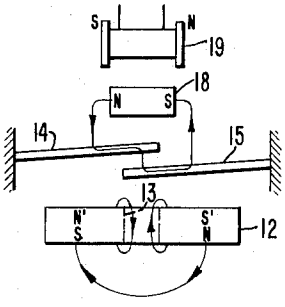


FIG. 9

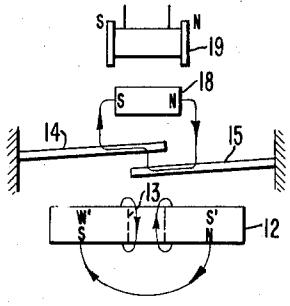
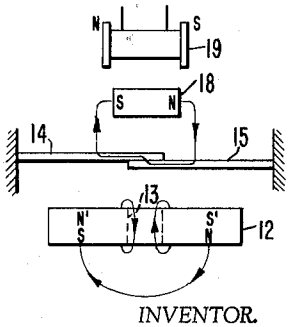


FIG. 10



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FIG. 11

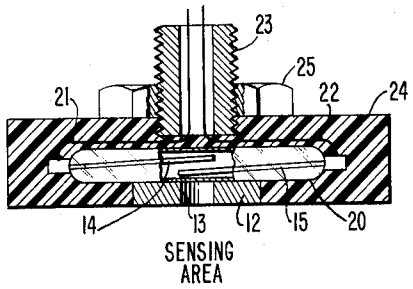
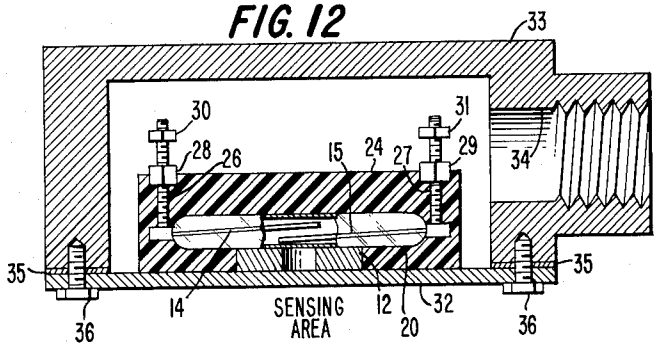


FIG. 12



United States Patent Office

3,205,323

Patented Sept. 7, 1965

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MAGNETIC REED PROXIMITY SWITCH

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Filed Feb. 16, 1962, Ser. No. 173,678

9 Claims. (Cl. 200—87)

This invention relates to a new and improved proximity switch, and more particularly, to one utilizing two pairs of unlike magnetic poles for creating a magnetic field used in actuating switch contacts.

Industrial applications of limit and analogous switches involve their use for machine control, counting of objects, alarms, signals, and other such functions where the approach or passage of a material body must be detected. In wide use today is the mechanical type of switch which requires physical contact between a cam, or other actuating deivce, and a lever arm of push pin which protrudes through the switch case. However, in these type of switches the external levers and push-buttons are very often subject to abuse in all but the simplest environments. Furthermore, the external lever pivots are open to corrosive and abrasive attack at the point where they extend from the case. Since more and more corrosive and abrasive materials are being used in industry, the switch may fail to function properly after but a short period of use.

On the other hand, a proximity type switch requires no physical contact with the material object in order to be actuated. Many of the proximity switches available today employ magnetic sensing such that when an object of magnetic material is brought into the vicinity of the switch sensing area, a change in the flux pattern within the switch causes the contacts to either open or close. Some of these prior art switches, however, require amplifiers using vacuum tubes and/or transistors or other delicate components that are subject to damage due to vibration and shock. This variety also requires a certain amount of external energy in order to make the device operative. Other prior art proximity switches are constructed using permanent magnets, but some of these are too large and heavy for certain applications and others do not have the sensitivity required in many environments.

The primary object of my present invention is to provide an improved proximity switch that can be actuated by the introduction of objects of magnetic material in the vicinity of the sensing area. The main components of the switch are a set of contacts of magnetic material and a magnetic assembly having at least two pairs of magnetic poles. The contacts are placed such that if one is subjected to the field of a north seeking magnetic pole of one pair and the other subjected to the field of the south seeking magnetic pole of the same pair, there will be a magnetic force tending to close the contacts. Alternatively, only one contact may be exposed to the field between the poles. In the magnetic assembly, the preferred arrangement is such that the first pair of unlike poles is weaker than a second pair of unlike poles. The sensing area is in the vicinity of the field of the second pair. Although the magnetic poles of the assembly may be created by electro-magnets, the preferred embodiment utilizes permanent magnets so that no burden load is required. The magnetic assembly and associated switch contacts can be completely encapsulated for maximum ruggedness, and the entire switch can be produced at a reasonable price making it practical for the average control problems found in the normal industrial process.

Therefore, one object of the invention is to provide an improved proximity switch for sensing objects of magnetic material brought into the sensing area.

Another object of the present invention is to provide a switch that can be completely sealed with no moving parts external to the encapsulation.

A further object of the present invention is to provide a switch utilizing two pairs of unlike magnetic poles which is completely independent of any external power source.

Another object of the present invention is to provide a proximity switch that has high reliability and excellent sensitivity, as well as a fast operating speed.

These and other objects of the invention will become apparent during the course of the following description, which is to be read in conjunction with the drawings, in which:

FIGURES 1*a* and 1*b* illustrate the basic theory of operation of the present invention;

FIGURE 2 is a perspective view of a preferred embodiment of the magnetic assembly showing the two pairs of poles;

FIGURE 3 illustrates how the poles may be formed on the assembly of FIGURE 2;

FIGURES 4*a* and 4*b* illustrate the use of the assembly with a pair of switch contacts;

FIGURE 5 shows how the assembly may be modified to obtain the desired operation by placing a magnetic shunt across one pair of the poles;

FIGURE 6 shows the invention with an addition of a biasing magnet used to aid the field from the magnetic assembly;

FIGURE 7 shows an embodiment wherein electro-magnet means is provided for opening the switch contacts when they have once been closed;

FIGURE 8 illustrates a normally closed embodiment of the switch utilizing a biasing magnet;

FIGURE 9 is a different embodiment of the invention similar to FIGURE 8 but utilizing an external signal for initially closing the contacts;

FIGURE 10 shows still another embodiment utilizing an external signal in conjunction with the magnetic assembly of the present invention for opening the switch contacts;

FIGURE 11 shows one way in which the switch might be encapsulated for commercial use; and

FIGURE 12 shows a slightly alternative embodiment for encapsulating the switch.

FIGURES 1*a* and 1*b* illustrate the basic theory of operation of the present invention. Two magnets **10** and **11**, each of length *b* and each having north and south poles at the ends thereof, are placed parallel to one another and spaced apart a distance *a*. Magnet **10** is turned 180 degrees with respect to magnet **11** when considering their poles, such that lines of force, or flux lines, link the north pole N of magnet **11** and the south pole S of magnet **10**, and magnetic lines of force link the north pole N′ of magnet **10** with the south pole S′ of magnet **11**. Other flux lines link the north and south poles common to the same magnet, i.e., S and N′ of magnet **10**, as well as N and S′ of magnet **11**.

If the distances *a* and *b* are varied, the relative strength of the various flux linkages changes in the following manner. If the distance *a* is made greater while the distance *b* is made smaller, more of the flux will link with poles of the same magnet. In other words, the flux lines from the north pole N′ of magnet **10** links more with the south pole S of magnet **10** than with the south pole S′ of magnet **11**. Consequently, the magnetic field intensity between N′ and S′ decreases, while that surrounding magnet **10** increases. In similar fashion more flux from the north pole N of magnet **11** links with its south pole S′ than with the south pole S of magnet **10** in event that distance *a* increases. Consequently, the magnetic attraction between north and south poles of different magnets decreases as the distance between the magnets increases and/or the distance between the poles of the same

magnet decreases. This phenomenon is due generally to the change in reluctance of the magnetic circuit, said reluctance being directly proportional to the length of the path between unlike poles, and inversely proportional both to the permeability of the material comprising said path and also to its cross-sectional area.

If there is a decrease in the permeability of the magnetic path between poles S and N, or between poles N' and S', then the flux density between the poles in either of these pairs becomes greater, since the magnetic resistance of the path decreases. Assuming that the magnets **10** and **11** in FIGURE 1*a* are separated by the medium air, the path between poles S and N may be decreased in reluctance by placing a bar **9** of magnetic material close to these poles so that most of the flux therefrom links via the medium of said bar. However, this increased flux linkage between poles S and N consequently reduces the amount of flux available to be linked between unlike poles of the same magnet. For example, since most of the flux from pole S of magnet **10** now links with pole N of magnet **11**, there is very little flux left available to link poles S and N' of magnet **10**, or N and S' of magnet **11**. Therefore, the flux from the N' and S' poles must link said poles together in the manner shown in FIGURE 1*b* so as to increase the magnetic field intensity in the airpath between said primed poles of these magnets. If magnetic bar **9** is removed from the vicinity of poles S and N, then the flux pattern reverts to that shown in FIGURE 1*a*, with there being only few lines of flux linking unlike poles of the different magnets. In essence, then, the distances *a* and *b* between the various poles may be adjusted relative to one another so that in the absence of a magnetic shunt between poles N and S, most of the flux from poles N' and S' is short circuited to poles S and N, respectively.

The phenomenon described in connection with FIGURES 1*a* and 1*b* is the basis for the novel proximity switch of the present invention. The same effect described above can be achieved by using two electro-magnets. However, this would cause a burden load requiring a source of energy to establish magnetic fields. In preference to the use of two separate magnets as shown in FIGURE 1*a*, or two electro-magnets, the preferred means for providing two pairs of unlike poles is shown in FIGURE 2. This comprises a ceramic type wafer magnet formed generally in the shape of a thin bar by pressing ceramic powder material in a fashion well known in the art. Additionally, an aperture **13** is provided in the wafer **12**. 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 or surfaces between which aperture **13** extends. The arrangement for magnetizing the wafer in this manner is shown in FIGURE 3, wherein an electro-magnet **7** provided with a source of energy **8** sets up a flux pattern as indicated which links with the pressed wafer **12** so that the lines of flux enter one surface of wafer **12** on one side of aperture **13** and emerge from the same surface but on the other side of aperture **13** as shown. The flux from the north pole of electro-magnet **7** causes a south pole S to be formed on the portion of the surface entered by said flux lines, whereas a north pole N is formed on the portion of the surface from which said lines exit which in turn return to the south pole of the electro-magnet. The relative positions of these poles S and N are better shown in FIGURE 2, where they are seen to be on the same major surface of the wafer, but on either side of aperture **13**.

The flux pattern set up in wafer **12** by the arrangement of FIGURE 3 also forms two auxiliary poles N' and S' on the other major surface of wafer **12**, said surface being parallel to the surface in which the poles S and N have been formed. The formation of these auxiliary poles is believed to be due to the following reasons. First, the type of ceramic wafer magnet under consideration has a natural tendency to magnetize in the direction of pressing, which may be in the direction of arrow *c* in FIGURE 2. Second, some of the flux lines entering wafer **12** from the north pole of magnet **7** emerge from the opposite major surface and travel through a path in the environment before entering the major surface on the other side of aperture **13** and recombining with those flux lines which remain in wafer **12**. The strength of the auxiliary poles N' and S' is normally less than the strength of the main poles S and N formed on the opposite major surface of the wafer. This is so, since the flux density used to form the main poles is greater than the flux density associated with the auxiliary poles. Consequently, a magnet of this type will show strong magnetic attraction from the major poles, but practically no magnetic attraction from the auxiliary poles. Furthermore, the major portion of the flux from the secondary or auxiliary poles N' and S' is short-circuited to the unlike main poles as shown in FIGURE 4*a*. Thus, most of the flux from auxiliary pole N' links or is short-circuited with the unlike main pole S which is in the corresponding pole area on the opposite major surface. In similar fashion, the flux from main pole N primarily links with the auxiliary pole S'. Very little flux, if any, links main poles N and S, or auxiliary poles N' and S'. However, if a piece of magnetic material is placed close to the major poles N and S of the wafer magnet **12**, the flux linkages between the major poles and the auxiliary poles are broken so that the flux of the auxiliary poles N' and S' is free to attract or link with objects of magnetic material placed sufficiently close to said auxiliary poles.

A pre-magnetized ceramic wafer magnet assembly particularly suitable for use in the present invention 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, 0.187. However, as emphasized above, the novel features of the present invention do not necessarily depend upon the particular magnetic assembly shown and/or described which is but an example of a preferred embodiment.

In FIGURE 4*a*, a pair of reed contacts **14** and **15** are provided each being made of semi-flexible or spring temper magnetic material. In the embodiment of the invention shown in FIGURE 4, contacts **14** and **15** are normally open when there is little or no flux linkage between N' and S' of wafer **12**. However, in FIGURE 4*b* the magnetic material **16** to be detected is shown adjacent to the main poles S and N so that the flux linkages between the unlike auxiliary and main poles is broken because of the phenomenon discussed in connection with FIGURE 1*b*. The increased number of flux lines from pole N' to pole S' will link both contacts **14** and **15** since these contacts provide a magnetic path of lower resistance than the surrounding environment. Consequently, contact **14** actually becomes a north seeking pole whereas contact **15** becomes a south seeking pole. The increased strength of the magnetic field linking contacts **14** and **15** is calculated to provide an attractive force sufficient to overcome the spring biased normally open positions of these contacts which thus draws them together. When the magnetic material **16** is removed from the vicinity of main poles S and N, then the flux pattern of the poles on wafer **12** reverts to that shown in FIGURE 4*a*. Contacts **14** and **15** thereupon open due to their spring-like nature since the strength of poles N' and S' has been reduced, at least as far as regards the effect that these poles have upon the magnetic attraction between contacts **14** and **15**.

It will therefore be appreciated from the above that the novelty of the present invention lies essentially in the provision of two pairs of unlike magnetic poles so arranged that the flux linkages between unlike poles of one pair can only be increased by the increase in flux linkages between unlike poles of the other pair, said latter increase

occurring due to the proximity of magnetic material which lowers the resistance of the magnetic path between the unlike poles of said other pair. By providing magnetic contact material to respond to the increased flux linkages between the unlike poles of said first pair, a switch is provided for making or breaking an electrical circuit according to the proximity of material in the field of the poles of said other pair. Although the preferred basic embodiment of the invention utilizes pairs of poles that have different strengths and which are found on faces of the same body, it is not necessary that such be the case. FIGURE *1a* shows that the invention may be constructed wherein unlike poles of a pair need not physically be on the same magnet. Furthermore, electro-magnetic poles may be utilized if a burden load on a source of energy is deemed satisfactory.

If the auxiliary poles N' and S' have strengths great enough to normally force contacts **14** and **15** closed even in the absence of material **16**, then it may be necessary to provide a magnetic shunt **17** between said poles in order that the flux actually linking contacts **14** and **15** be reduced to a point where these contacts normally remain open. This shunt **17** in FIGURE 5 is made of magnetic material of such cross-sectional area that it is substantially saturated by the flux linking N' and S' even during the absence of material **16**. In this case, little or no flux will link contacts **14** and **15** since the environment path between the auxiliary poles and these contacts is of greater resistance than the path provided by shunt **17**. However, upon material **16** being moved in proximity with the main poles S and N, the increased flux linkages between N' and S' must take the environment path via contacts **14** and **15** due to the saturation of shunt **17**. Consequently, this modification of the basic circuit of FIGURE **4** may be necessary in the event of magnets of large size or those that have been magnetized in a stronger field than is necessary to get proper action of the switch. Hence, the incorporation of shunt **17** provides a very convenient way to get proper operation of the switch without requiring a high degree of precision in the formation of the auxiliary poles N' and S'. This shunt arrangement may also be utilized with success when two different magnets, such as shown in FIGURE *1a*, are employed, since very often in this case the poles all have the same strengths.

If the auxiliary poles N' and S' have insufficient strength to close contacts **14** and **15** even during the presence of material **16**, then it may be necessary to provide a biasing arrangement as shown in FIGURE 6. In this modification of the basic switch arrangement, a biasing permanent magnet **18** is placed in such a manner that the flux from its north seeking pole N links with contact **14**, while the flux from the south pole S of the magnet links with contact **15**. The flux field of magnet **18** by itself is insufficient to provide an attracting force between contacts **14** and **15** large enough to overcome the spring tension exerted to keep these contacts open. However, upon bringing a piece of material into proximity with the main piles S and N of wafer **12**, the flux contributed by auxiliary poles N' and S' and added to the flux from magnet **18** is sufficient to set up a force closing the contacts **14** and **15**. It will be appreciated that the flux pattern contributed by auxiliary poles N' and S' in FIGURE 6 is the same flux pattern shown in FIGURE *4b*, so that summation of the lines of force from magnet **18** and wafer **12** occurs within the material comprising contacts **14** and **15**. However, it should be appreciated that the field strength necessary to keep contacts **14** and **15** closed after they have once been forced together is normally less than the value necessary to move them from their normally open position to their closed position. Therefore, if the switch operation is to be such that contacts **14** and **15** are forced open whenever there is no material in proximity with main poles S and N, the strength of the field contributed by magnet **18** should be less than the field necessary to maintain contact.

The provision of a biasing magnet **18** provides a simple way for changing the mode of operation of the basic switch in a manner illustrated in FIGURE 7. In FIGURE 7, the field strength provided by the poles of magnet **18** is by itself insufficient to initiate closing of contacts **14** and **15**. However, magnet **18** field strength is sufficient by itself to maintain contacts **14** and **15** in their closed position until a reset electro-magnet **19** is energized. The energization of magnet **19** causes the formation of north and south poles in the position shown which set up flux lines within contacts **14** and **15** in a direction calculated to cancel the effect of the flux from magnet **18**. Consequently, the operation of FIGURE 7 is as follows: Assuming that contacts **14** and **15** are normally biased to an open position due to the spring-like nature of the contact material, a bar **16** must be placed in proximity with main poles S and N of wafer **12** in order that these contacts can be closed in the manner described in connection with FIGURE 6. When once the material **16** has been withdrawn from the sensing area adjacent main poles S and N, the field contributed by magnet **18** is sufficient to maintain contacts **14** and **15** closed until the subsequent energization of magnet **19**. It may be noted in connection with both FIGURES 6 and 7 that the field strength of biasing magnet **18** can be controlled by changing the size of said magnet and/or by changing the distance between the magnet and the positions of contacts **14** and **15**.

A further modification of the basic switch is that shown in FIGURE 8 wherein the biasing magnet **18** is reversed so that its north pole N links with contact **15** and its south pole S links with contact **14**. Wafer magnet **12** is still retained in the position shown in the preceding figures, in that its auxiliary north pole N' links with contact **14** while its auxiliary south pole S' links with contact **15**. In this embodiment, the field strength of magnet **18** by itself is sufficient to overcome the normally open tendency of the spring contact members **14** and **15** and so maintains them closed in the absence of material **16**. However, upon such material **16** being sensed by poles S and N, the lines of force now contributed by auxiliary poles S' and N' is such as to oppose and effectually cancel the lines of force from magnet **18**. In this case, the net amount of flux linking contacts **14** and **15** is reduced below the level necessary to provide the minimum attracting force necessary to keep them closed. Consequently, contacts **14** and **15** are forced open as long as material **16** remains in the sensing area of magnet **12**. Upon removal of this material, the flux from the auxiliary poles N' and S' is once again short-circuited to their main poles so as to again allow the field from magnet **18** to attract and hold closed contacts **14** and **15**. FIGURE 8 therefore discloses a normally closed switch which is only opened by the proximity of material in the sensing area adjacent to main poles S and N.

Reference is now made to FIGURE 9 which shows a slight modification of the embodiment in FIGURE 8. If the flux from the biasing magnet **18** by itself is not sufficient to attract contacts **14** and **15**, but is only sufficient to maintain them closed when once attracted, then the provision of a magnet **19** with north and south poles as shown accomplishes the following. If contacts **14** and **15** are open, then current of correct polarity into magnet **19** forms north and south poles which generate flux to aid the flux from magnet **18** in linking contacts **14** and **15**. This additional flux from magnet **19** thereupon provides sufficient force between contacts **14** and **15** so that they close. If magnet **19** is now de-energized, the field contributed by magnet **18** is sufficient by itself to maintain contacts **14** and **15** in their closed position until material **16** is brought within the sensing area of magnet **12** so that the flux from auxiliary poles N' and S' now cancels the magnet **18** flux in the manner described in connection with FIGURE 8. Thereupon, contacts **14** and **15** open. After

the material **16** has been removed from the sensing area of magnet **12**, a subsequent energization of magnet **19** is required before contacts **14** and **15** can again be closed.

FIGURE 10 is still another embodiment of the invention which utilizes a biasing magnet **18** having its poles in the position shown, as well as an electro-magnet **19** which, when energized, forms poles as illustrated. In this embodiment, which is similar to that shown in FIGURE 8, the field contributed by magnet **18** is by itself sufficient to force contacts **14** and **15** into their closed position and maintain them there until its field is cancelled. Cancellation of the field from magnet **18** is caused by the concurrent energization of magnet **19** as well as the proximity of magnetic material **16** in the sensing area of magnet **12** adjacent main poles N and S. Unless both of these latter conditions occur at the same time, there is insufficient cancellation of the magnet **18** field to cause contacts **14** and **15** to open. For example, assume that magnet **19** is de-energized at the time that material **16** is brought into the sensing area of magnet **12**. Although the flux from the auxiliary poles N′ and S′ increases and effectually cancels a portion of the magnet **18** flux, this cancellation is not sufficient to allow contacts **14** and **15** to spring open. On the other hand, if only magnet **19** is energized and without magnet **12** sensing the proximity of material **16**, then the magnet **19** field strength is again insufficient to cancel enough of the magnet **18** field intensity so as to allow contacts **14** and **15** to open. However, when both magnet **19** and the auxiliary poles of magnet **12** contribute flux, then the addition of said flux in a direction opposing the flux from magnet **18** is sufficient to reduce the attractive force between contacts **14** and **15** below that necessary to maintain them in a closed position. In effect then, the switch arrangement of FIGURE 10 requires that a conditioning signal be applied to electro-magnet **19** of proper polarity in order that proximity of magnet material in the sensing area of magnet **12** will cause the contacts to open. Upon cessation of one or both of the fields from magnets **19** and magnets **12**, magnet **18** again forces contacts **14** and **15** to close in the manner shown.

In all of the preceding FIGURES 6 through 10, biasing magnet **18** can just as well be electro-magnetic in nature instead of permanent. Furthermore, electro-magnet **19** in FIGURES 7, 9, and 10 might well be replaced with a magnetic assembly similar to unit **12** so that the switch would have two separate sensing areas each detecting the proximity of the same or different magnetic bodies thereto. In such an embodiment along the lines of FIGURE 7, for example, the proximity of one magnetic body to one sensing area would close contacts **14** and **15**, while the proximity of a different magnetic body to the other sensing area, at a subsequent time, would open these contacts.

Although all of the previous figures show two spring reed contacts **14** and **15** each capable of motion toward and away from one another, other contact arrangements may be provided. For example, a single moving armature may be pivoted at one end in the nature of a single-pole single-throw switch so that its free end moves toward and away from a fixed contact depending upon the magnitude of the field linking it with the auxiliary poles N′ and S′ of a magnet **12**. It would also be possible with a single armature type of switch to use biasing magnets and/or solenoids in the manner shown in FIGURES 6 through 10. Therefore, the basic novel principle of operation of the present invention may be adapted for use in a variety of environments.

FIGURES 11 and 12 of the drawings show two ways in which the novel switch of the present invention may be fabricated for commercial uses. In FIGURE 11, a switch having a mode of operation described in connection with FIGURES *4a* and *4b* is shown. Contacts **14** and **15** are located in a glass enclosure **20** which is hermetically sealed with glass to metal seals at the points where the

contacts emerge from the glass wall. The glass enclosure **20** itself is filled with a non-conducting gas so that no current flows when the contacts are open and an E.M.F. impressed across the contacts. Conductors **21** and **22** are mechanically and electrically connected to their respective contacts **14** and **15** and extend through the hollow interior of a mounting conduit **23** in order to provide access to the external electrical circuit that they are controlling. Conduit **23** has external threads and is placed in a plastic potting compound **24** prior to the setting of the compound after it has been poured. The plastic compound **24** actually provides a case for the glass closure **20** with the latter being potted therein. A lock nut **25** may be provided having internal threads that are engaged to the external threads of conduit **23**. This lock nut may have flats to accommodate a wrench to facilitate the connection of conduit **23** to an external supporting object. The lower face of lock nut **25** is in contact with the plastic potting material **24**, which greatly improves the mechanical bond between the conduit **23** and compound **24**. Magnet **12** is a ceramic type wafer magnet of the type described and so magnetized to form two main poles on the surface adjacent the exterior of potting compound **24**. In addition, two auxiliary poles are formed on the surface of the wafer **12** which is adjacent the glass container **20**. The lower face of magnet **12**, which is that containing the main poles, may be flush with the lowermost edge of the plastic compound **24** in the manner shown in FIGURE 11.

FIGURE 12 shows another embodiment of switch mounting means, said switch also having the mode of operation described in connection with FIGURES *4a* and *4b*. This embodiment is very much like that shown in FIGURE 11 in that the switch contacts **14** and **15** are hermetically sealed in a glass envelope **20** which in turn is encased by a potting compound **24**. External conductors for contacts **14** and **15** are provided by threaded rods **26** and **27** which are secured both mechanically and electrically to their associated contacts **14** and **15**. Portions of the threaded rods **26** and **27** are also encased in the potting compound **24** but extend therethrough via internal threaded pieces **28** and **29** which in turn are partly submerged in the plastic potting compound which affords resistance to the turning of the threaded rods as nuts **30** and **31** are tightened. The potted switch is mounted on a plate **32** that is designed to serve as the cover for a standard conduit fitting **33**. Conduit fitting **33** has an internal threaded hub **34** designed to be supported by an external conduit screwed therein. The conduit **34** is also used to house wires from the external electrical circuit to threaded rods **26** and **27**. Gaskets **35** are used to provide a water and dust tight seal between the cover plate **32** and the conduit fitting **33** to which it is attached by means of screws **36**. Cover plate **32** should be made of non-magnetic material since it is adjacent the sensing area located opposite the main poles of the ceramic wafer **12**.

Although only the basic switch in FIGURE 4 has been shown mounted in the manner of FIGURES 11 and 12, it is obvious that modifications of this basic switch as shown in FIGURES 5 through 10 may also be mounted in a similar fashion. Thus, while preferred embodiments of the invention have been shown and illustrated in detail, it is obvious that many modifications may be made thereto by persons skilled in the art without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. A switching device which comprises:

(a) a first pair of unlike magnetic pole surfaces, and means to support said first pair pole surfaces in generally a same first plane so that both said first pair pole surfaces face in generally a same first direction, said last named means further supporting said first pair pole surfaces in a spaced apart relationship

such that a first flux path is formed therebetween which lies therefrom in said first direction and whose reluctance is inversely proportional to the degree of proximity of magnetic material thereto;

(b) a second pair of unlike magnetic pole surfaces, and means to support said second pair pole surfaces in generally a same second plane parallel to said first plane so that both said second pair pole surfaces face in generally a same second direction opposite to said first direction, said last named means further supporting said second pair pole surfaces in a spaced apart relationship such that a second flux path is formed therebetween which lies therefrom in said second direction and with each said second pair pole surface being in line with an unlike pole surface of said first pair so as to form other flux paths between the unlike pole surfaces in different pairs, whereby the value of flux in said second flux path varies inversely with the reluctance of said first flux path;

(c) switch apparatus responsive to a particular flux value, and means positioning said switch apparatus adjacent to said second pair pole surfaces in said second direction therefrom so as to be within said second flux path; and

(d) magnetic shunt material positioned in said second flux path and parallel with said switch apparatus to provide a shunt therearound, said magnetic shunt material being sufficiently saturated by flux in said second flux path such that said predetermined flux value in said switch apparatus is absent or present for the absence or presence, respectively, of magnetic material in said first flux path.

2. A switching device according to claim 1 wherein said switch apparatus comprises electrical contact means normally biased open for flux values other than said particular value, but which close for said particular value of flux.

3. A switching device according to claim 1 wherein said switch apparatus comprises electrical contact means normally biased closed for flux values other than said particular value, but which open for said particular value of flux.

4. A switching device which comprises:

(a) a thin wafer of magnetizable material less thick than wide and long, whose thickness dimension is bounded by opposed parallel first and second major faces, and having a first pair of spaced apart unlike permanent magnetic pole areas on said first major face and a second pair of spaced apart unlike permanent magnetic pole areas on said second major face which are arranged so that the north and south pole areas of said first pair are respectively opposite the south and north pole areas of said second pair, with said first major face being a sensing region for magnetic material brought into proximity with the magnetic field of said first pole pair such that the magnetic field of said second pole pair increases with an increase in the magnetic field of said first pole pair;

(b) switch apparatus responsive to a particular flux value which is positioned externally to said wafer and adjacent said second major face in the magnetic field of said second pole pair; and

(c) magnetic shunt material located externally to said wafer in the magnetic field of said second pole pair and between said second major face and said switch apparatus to provide a shunt therearound, said magnetic shunt material being sufficiently saturated by flux between said second pole pair such that said predetermined flux value in said switch apparatus is absent or present for the absence or presence, respectively, of magnetic material in proximity with the magnetic field of said first pole pair.

5. A switching device according to claim 4 wherein said switch apparatus comprises a pair of cooperating electrical contacts normally open for flux values less than said predetermined flux value.

6. A switching device according to claim 4 wherein said switch apparatus comprises a pair of cooperating normally open electrical contacts, and means located adjacent to said contacts for generating a magnetic field in said contacts to bias them closed, said last named magnetic field having a direction opposed to the direction of the magnetic field of said second pole pair.

7. A switching device according to claim 4 wherein said switch apparatus comprises a pair of cooperating electrical contacts normally open for flux values less than said predetermined flux value, means located adjacent to said contacts for generating a first magnetic field in said contacts to maintain them closed when once they have been closed, said first magnetic field having the same direction as the direction of the magnetic field of said second pole pair, and means located adjacent said contacts and selectively operable to generate a second magnetic field in a direction and of a strength to cancel said first magnetic field.

8. A switching device according to claim 4 wherein said switch apparatus comprises a pair of cooperating electrical contacts normally open for flux values less than said predetermined flux value, means located adjacent to said contacts for generating a first magnetic field in said contacts to maintain them closed when once they have been closed, said first magnetic field having a direction opposed to the direction of the magnetic field of said second pole pair, and means located adjacent to said contacts and selectively operable to generate a second magnetic field in said contacts in the same direction as said first magnetic field for closing said contacts.

9. A switching device according to claim 4 wherein said switch apparatus comprises a pair of cooperating electrical contacts normally open for flux values less than said predetermined flux value, means located adjacent to said contacts for generating a first magnetic field in said contacts to bias them closed, said first magnetic field having a direction opposed to the direction of the magnetic field of said second pole pair, and means located adjacent to said contacts and selectively operable to generate a second magnetic field in said contacts in opposition to said first magnetic field.

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