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LIMIT SWITCHES

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Fig. 1.

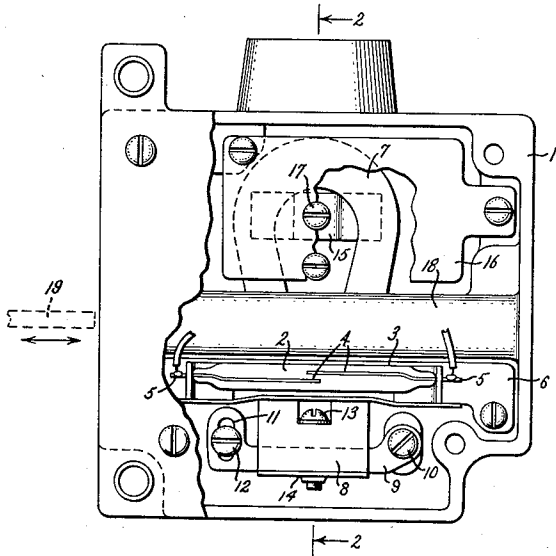


Fig. 2.

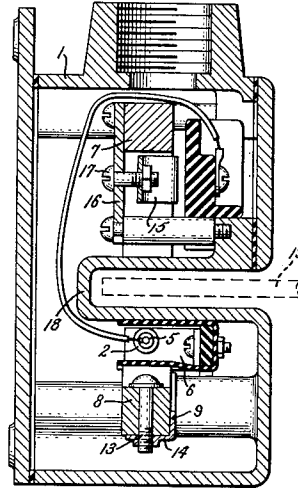
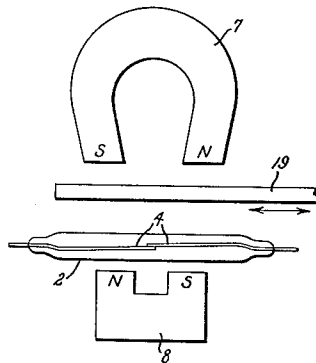


Fig. 3.



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3,009,033

LIMIT SWITCHES

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This invention relates to limit switches and more particularly to limit switches operated without physical contact with the actuating member.

Limit switches are those switches used to initiate or cause cessation of a given function upon the movement of a controlled member to or beyond a given limit or position. They have utility in a large number of applications among which is the control of movements of machine tools. Especially when applied to machine tool controls, limit switches have remarkably stringent design requirements imposed upon them. Such switches may be required to withstand literally millions of operations without failure or malfunction, to remain unaffected by metal chips and other incidents of an industrial environment, and to respond precisely and repeatedly to very small incremental displacements of the actuating member.

Since frictional and impact engagements between relatively slidable or rotatable members are among the principal causes of premature switch failure, it is an object of the present invention to provide a limit switch having no frictional engagement between parts and a minimum of impacting members, and which is capable of operating millions of times in an industrial environment.

A further object of the present invention is to provide a novel limit switch of rugged and simple construction whose functional repeatability is characterized by an unusual precision, responding accurately to the relative position of an actuating member.

A preferred embodiment of the present invention makes use of a magnetic reed switch positioned to extend through the space between two oppositely located U-shaped magnets which are spaced apart such that the poles of one magnet are opposite dissimilar poles of the other. The reed switch thus crosses through opposite air spaces in a series magnetic circuit. The reed switch itself, which comprises elongated and overlapping resilient contact members of soft magnetic material, is placed at a particular location between the two magnets where, although flux from the magnetic circuit passes through each of the two contact members, the flux component in a direction along the long dimension of the contact members is substantially zero. Since it is the axially directed components of an external magnetic field which cause the two contact reeds to have a mutual attraction which closes the contacts, the switch is normally open. The contacts are closed by the passage within a channel provided between one of the magnets and the reed switch of a soft iron shield which, by shielding the reed switch from a portion of the magnetic field created by one of the magnets, causes a shift in equilibrium of the field between the two magnets. Because of the normal balance between the relatively strong magnetic fields along the reeds of the switch, it will be seen that positive and precise operation of the switch in relation to the actuator position is obtained since only a small differential movement of the actuator results in unbalancing and rebalancing the fields alternately to close and to open the switch.

Further objects and advantages of the present invention will be perceived with reference to the following more detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a plan view partially cut away of a magnetic limit switch constructed in accordance with the present invention:

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FIG. 2 is a cross-section view taken on line 2—2 of FIG. 1; and

FIG. 3 is a diagrammatic representation of certain parts of the switch shown in FIGS. 1 and 2.

Referring now to FIGS. 1 and 2 there is shown a switch casing 1 within which is mounted a magnetic reed switch 2. The reed switch typically comprises a sealed glass envelope 3 with a pair of flexible iron alloy reeds 4 mounted inside in overlapping relationship. The overlapping ends of the reeds are usually plated with a suitable contact material such as rhodium, while the opposite ends pass through the glass envelope and form a pair of external terminals 5. The reed switch is cradled on a switch support 6 which may be removed from the case to substitute another reed switch should this be necessary.

Within the case 1 and completely enclosed thereby a pair of oppositely positioned magnets may be observed: an operating magnet 7, and a bias magnet 8 of somewhat smaller dimensions and pole strength. These two magnets are arranged facing each other on opposite sides of the reed switch such that dissimilar poles are juxtaposed. The arrangement forms, as it were, a series magnetic circuit with oppositely disposed air gaps spanned by the magnetic reed switch. As can be seen in FIG. 1, despite the proximity of the magnets to the reed switch, the contacts of the switch remain normally open. This condition is achieved by an adjustment of the relative locations of the operating bias magnets such that the resulting field strength longitudinally of the magnetic reeds is zero, or very nearly so.

Naturally, of the total flux set up by each magnet a substantial amount will "leak" across the two ends of each magnet and another substantial portion will pass directly through and about the magnetic reeds 4 from a pole of one magnet to the opposite pole of the other magnet. Somewhere between the two magnets is a region where the field strength is very low due to the cancellation in that region of the two opposing leakage fields. The polarity of the field in planes parallel to the pole faces of the magnets reverses in this region where the reeds of the switch are located. The resultant magnetic vector along the two reeds is therefore normally not great enough to magnetize the reeds to a degree sufficient to overcome their resilience and cause them to close. To obtain the necessary adjustment of the field strength in the vicinity of the overlapping magnetic reeds the bias magnet 8 is mounted on an adjustment lever 9 pivotally mounted about a lever screw 10. The opposite end of the adjustment lever has an elongated slot 11 which, in cooperation with a fastening screw 12, is employed to fix the bias magnet in a preselected position to obtain in the region of the reeds the correct balance or cancellation between the fields of the bias magnet and the operating magnet.

The attachment of the bias magnet to the adjustment lever is accomplished by means of a threaded fastener 13 passing through the bias magnet and engaging a turned-up lip 14 on the adjustment lever. The operating magnet 7 is fastened by clamping it between a retaining clip 15 and an underlying magnet support plate 16 by means of a threaded fastener 17.

The case 1, formed of a non-magnetic material provides a completely sealed enclosure for the magnetic parts of the limit switch preventing the entry of iron particles and other industrial contaminants. It has on one side a relieved or indented portion forming a slot 18 for the passage of a switch actuating member 19. The switch actuating member should be of soft iron or of a similar magnetic material capable of shunting magnetic fields with ease. The slot 18 is strategically located between the operating magnet 7 and the reed switch 2 for

reasons more easily understood in connection with FIG. 3.

The working parts of the switch shown in FIG. 3 bearing the same numerals applied to them in FIGS. 1 and 2 occupy relative positions resulting in the reed switch contacts being closed. When the actuating member 19, which may simply be an iron vane fastened to the member whose position should control the opening and closing of the switch, has advanced to the position shown in FIG. 3 it has shunted the major portion of the total field contributed by the operating magnet 7 and has upset the balance between the two magnetic fields within the area occupied by the overlapping contact elements of the reed switch. Since the flux component contributed by the bias magnet 8 in a direction longitudinally of the reed switch no longer has an opposing flux component to cancel its effect, the consequent magnetic vector along the reeds results in a magnetic attraction more than sufficient to overcome the inherent resilience of the reeds and causes them to close with a snap action. This closure of the contacts actually takes place before the vane 19 has advanced to the fully effective shunting position shown in FIG. 3.

Without the opposing bias magnet in the arrangement described the limit switch would provide normally closed contact operation. That is, the field of the operating magnet would normally create a magnetic vector along the axis of the reed switch sufficient to maintain the contacts closed until the interposition of a magnetic actuating member would shield the reed switch from the field of the operating magnet and permit the switch contacts to open under the influence of their natural resilience. The flux opposition between the operating and bias magnets is a feature which not only provides normally open switch contact but also results in a much smaller minimum differential displacement of the switch actuator to operate the switch contacts. Because of this the position repeatability of the limit switch, that is, the response of the switch to the precise position and not just the movement of the actuating member, is very much improved. The accuracy of response of the limit switch described therefore commends the switch to machine tool applications and to other instances where a precise and consistently repeatable correlation between the relative positions of controlled elements is required and where no sacrifice of ruggedness and no compromise of the useful life of the switch is expected.

While I have shown and described but one preferred embodiment of the present invention it should be evident that alternative forms of the invention will doubtless occur to those skilled in the art and I wish it to be understood therefore that all such variations and substitutions within the scope of this invention are intended to be covered by the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A switch device comprising: a pair of spaced flux producing members forming a single magnetic circuit having oppositely situated air gaps through which fluxes established by said members pass in opposing directions; and an elongated magnetic reed switch in the space between said members spanning said gaps and having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along its elongated dimension, said switch being positioned in a region where the resultant of the fluxes is normally insufficient to close said contacts, the space between said magnetic members being sufficient to allow the passage between one of said members and said reed switch of a magnetic switch actuating shield member.

2. A switch device comprising: a switch housing; an operating permanent magnet having spaced magnetic poles supported within said housing; a permanent bias magnet

having spaced magnetic poles supported opposite and spaced from said operating magnet within said housing, the poles of said operating magnet facing dissimilar poles of said bias magnet and said operating magnet possessing a greater pole strength than that of said bias magnet; a magnetic reed switch comprising a pair of normally open relatively movable elongated contact members of flexible magnetic material in overlapping relationship spanning the area between the poles of said magnets from pole to pole and positioned in a region between said magnets where the component of magnetic flux directed axially of said contact members is substantially zero; said housing being indented to allow for the passage of a magnetic switch actuating shield member between said reed switch and said operating magnet poles, whereby a small incremental movement of such a shunt member between said reed switch and said operating magnet poles is effective to actuate said switch device.

3. A switch device comprising: an operating permanent magnet having spaced magnetic poles; a biasing permanent magnet having spaced magnetic poles supported opposite and spaced from the poles of said operating magnet, the poles of said operating magnet facing dissimilar poles of said biasing magnet; a magnetic reed switch comprising a pair of relatively movable elongated contact members of flexible magnetic material in overlapping relationship spaced from and spanning the areas adjacent said spaced magnetic poles; and means fixing the relative locations of said reed switch and said permanent magnet including a switch housing totally enclosing said permanent magnet and said reed switch, said housing being indented between said reed switch and said operating magnet to allow for the passage of a magnetic switch actuating shield member therethrough.

4. A switch device comprising: a switch housing; a first permanent magnet supported in said housing having spaced-apart pole pieces; a second permanent magnet having spaced magnetic pole pieces supported opposite and spaced from said first permanent magnet, the pole pieces of each of said magnets facing dissimilar pole pieces of the other of said magnets; and a switch mounted within said housing comprising a pair of elongated contact members of magnetic material each disposed adjacent a respective pair of said facing magnetic pole pieces and having contact surfaces overlapping each other at an area intermediate said poles, said contact surfaces being biased toward normally open positions and being relatively movable to normally closed positions by a flux component of sufficient magnitude directed lengthwise of said contact members causing mutual attraction, said housing completely enclosing said permanent magnets and said switch and being relieved along a portion thereof between the first of said magnets and said switch to form an elongated aperture for the passage therewithin of a magnetic switch actuating shield member to shunt away from said reed switch at least a portion of the field established by said first magnet to cause actuation of said switch by said second magnet.

5. A switch device comprising: a pair of permanently magnetized magnetic members forming a single magnetic circuit having a pair of oppositely situated air gaps through which fluxes established by said magnetic members pass in opposing directions; and an elongated magnetic reed switch spanning said circuit from gap to gap and having normally open contacts closed by mutual attraction in the presence of a magnetic flux component of sufficient strength directed along its elongated dimension, said switch being fixed in a position where the resultant of the flux components set up by said magnetic members is normally insufficient to close said contacts, and the space between said magnetic members being sufficient to allow the passage between one of said members and said reed switch of a magnetic switch actuating shield member to permit the flux component set up by the other of said magnetic members to close said switch contacts.

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6. A switch device comprising: a switch housing; a pair of permanent magnets supported in said housing with the magnetic poles of one magnet spaced apart from and facing dissimilar poles of the other magnet to form a series magnetic circuit having oppositely situated air gaps therein; and an elongated switch mounted within said housing with opposite ends respectively adjacent opposite air gaps, said switch comprising a pair of elongated contact members of magnetic material having contact surfaces overlapping each other at an area intermediate said air gaps, said contact surfaces being biased toward normally open positions and being relatively movable to normally closed positions by a magnetic flux component of sufficient magnitude directed lengthwise of said contact members causing mutual attraction, the elongated contact members being positioned in an area adjacent said magnets where the said lengthwise flux component is normally insufficient to close said contact surfaces, and said housing providing sufficient clearance between said elongated contact members and one of said magnets for the passage therebetween of a magnetic switch actuating shield member to cause closing of said contacts by the magnetic field set up by the other of said magnets.

7. A switch device comprising, a pair of spaced magnetic flux producing members each having two spaced

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poles, one of said members having a greater pole strength than the other of said members, an elongated magnetic reed switch having normally open elongated overlapping magnetic contacts which are closed by mutual attraction in the presence of an operating magnetic flux of sufficient strength directed along their elongated dimension, said switch being positioned closer to said other member than to said one member with said contacts extending in directions generally parallel to the direction of spacing of the poles of each member such that substantially zero operating magnetic flux is normally directed along the contacts, said members being positioned relative to each other such that magnetic fluxes produced thereby establish a force of attraction therebetween, said contacts being closed by passage therethrough of operating magnetic flux from said other member in response to the passage between said members of a magnetic vane.

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