

June 19, 1962

P. W. PEAY ET AL
ENCAPSULATED SWITCH

3,040,143

Filed April 3, 1959

2 Sheets-Sheet 1

FIG-1-

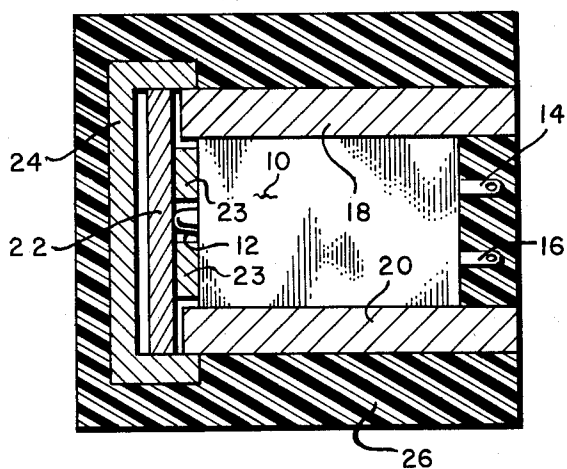


FIG-2-

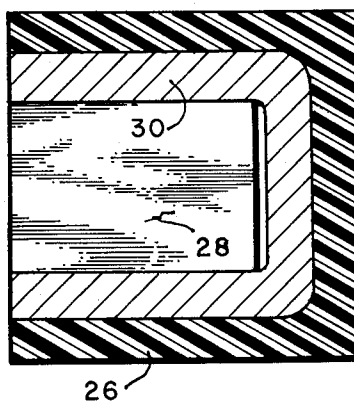


FIG-3-

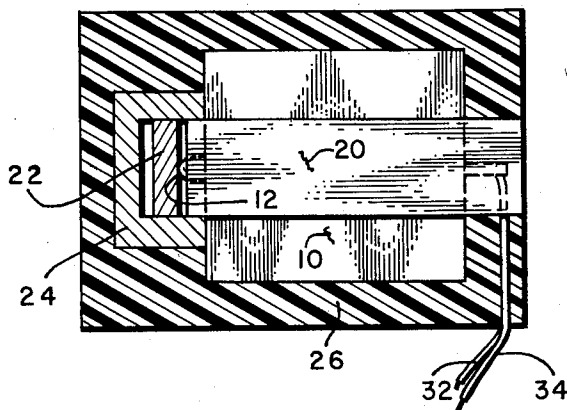


FIG-4-

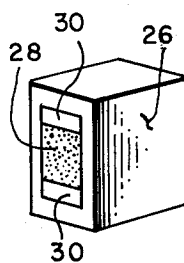
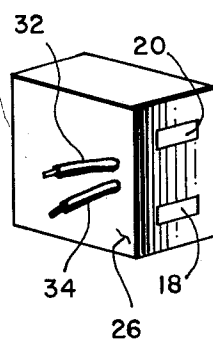


FIG-5-

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2 Sheets-Sheet 2

FIG-6-

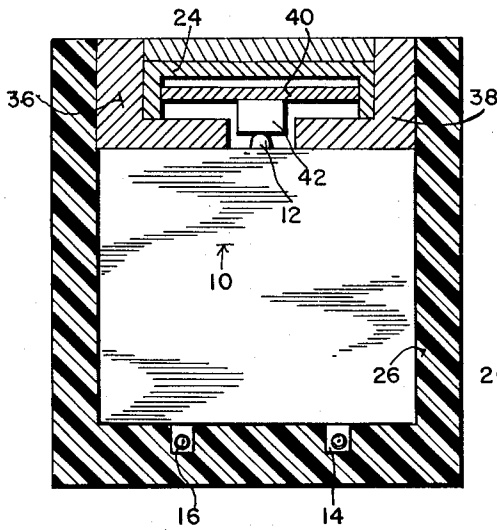


FIG-7-

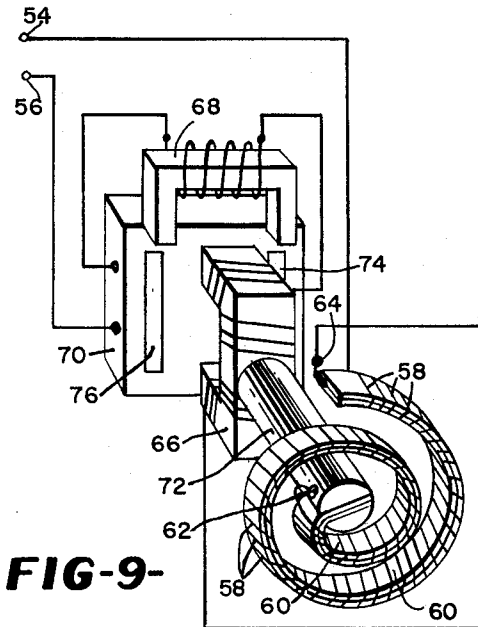
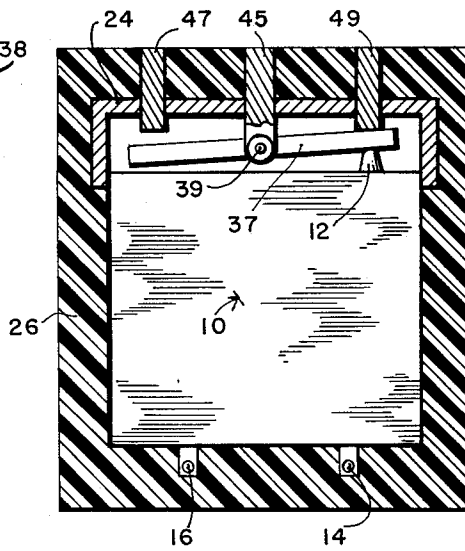
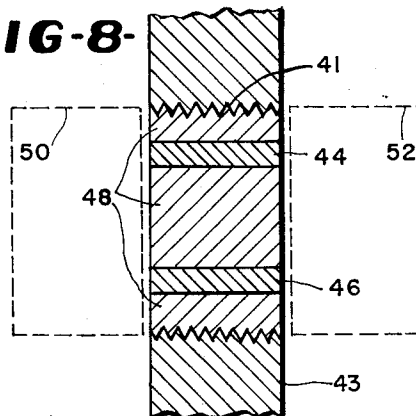


FIG-8-



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3,040,143

ENCAPSULATED SWITCH

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Filed Apr. 3, 1959, Ser. No. 803,865
7 Claims. (Cl. 200—88)

This invention relates to switching mechanisms, and more particularly to switch mechanisms which are magnetically actuated from a remote location.

The invention is described as embodied in a contact mechanism sealed inside an enclosure, and actuatable by a movable armature which is also located within the sealed enclosure. The armature is caused to move by a magnetic field generated outside of the sealed enclosure and communicated to the armature by a pair of pole pieces. This magnetic field causes the armature to be attracted to the pole pieces, thereby operating the contact mechanism. Interruption of the field will cause the contact mechanism to return to its open condition.

It is a primary object of the invention to provide a hermetically sealed switch which can be magnetically actuated from a remote position.

Other and further objects of the invention will be more readily understood by reference to the specifications and accompanying drawings, in which:

FIG. 1 is a sectional view of a switch embodying the invention;

FIG. 2 is a sectional view of an actuator embodying the invention intended for use with the switch of FIG. 1;

FIG. 3 is a sectional view of the switch of FIG. 1 taken transversely to the view of FIG. 1;

FIG. 4 is a perspective view of the switch shown in FIGS. 1 and 3;

FIG. 5 is a perspective view of the actuator shown in FIG. 2.

FIG. 6 is an illustration of an alternative switch embodying the invention.

FIG. 7 is an illustration of another alternative switch embodying the invention.

FIG. 8 is an illustration of a device embodying the invention which may be used in conjunction with a switch and an actuator; and

FIG. 9 is a schematic illustration of a device embodying the invention which may be used as a circuit breaker.

Referring now to FIG. 1, a switch embodying the invention is shown wherein a contact mechanism 10 having a control element 12, and terminals 14 and 16 is located between two pole pieces 18 and 20. Contact mechanism 10 operates in such a way that a very small motion of the control element 12 causes a closed circuit to be made between terminals 14 and 16, and is preferably a microswitch having rapid make and break characteristics. Control element 12 is spring loaded within contact mechanism 10 in the conventional manner so that terminals 14 and 16 form a normally open circuit, which recurs when the force on control element 12 is removed. Of course, normally closed or multipole contacts may also be used.

Pole pieces 18 and 20 are disposed adjacent the contact mechanism 10 and on opposite sides thereof. The ends of pole pieces 18 and 20 protrude beyond the terminals 14 and 16 and, on the other side of contact mechanism 10 are even with control element 12 when it is in its depressed position.

Armature 22 is disposed adjacent control element 12 and cushion 23, in a position normally displaced from the pole pieces 18 and 20 by a short distance substantially equal to the distance that control element 12 of contact mechanism 10 may be moved. When a difference in

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magnetomotive force is present between pole pieces 18 and 20, there is a flux pattern set up in armature 22 which causes it to move so as to minimize the air gaps in the magnetic circuit. Thus armature 22 is pulled toward the ends of pole pieces 18 and 20, compressing cushion 23 and moving control element 12 so as to actuate contact mechanism 10. Pole pieces 18 and 20, and armature 22 are all composed of materials having a relatively high permeability and low residual magnetization. Armature 22 is preferably composed of permeable material having low density, and for that reason ceramic permeable material primarily composed of iron oxide and barium carbonate, or other suitable low density-high permeability material is preferred. The mass of armature 22 is not sufficient to cause actuation of contact mechanism 10 by vibration or other accelerations, as long as no difference in magnetomotive force exists across the armature. Cushion 23 is preferably made of rubber or some other material offering low resistance to the sustained pressure of armature 22 during actuation, but high resistance to shocks and high frequency vibration.

The armature 22 is free to move in a cavity bounded by contact mechanism 10, pole pieces 18 and 20, and non-permeable cup 24. Cup 24 is adapted to fit over pole pieces 18 and 20, to define the cavity in which armature 22 can move, by excluding potting compound 26 therefrom. This cavity may be filled with air, an inert gas, or a liquid. Potting compound 26 surrounds all of the other elements of the device with the exception of the free ends of pole pieces 18 and 20, which are substantially flush with the potting compound 26, and may optionally be painted or coated to avoid corrosion. Armature 22 may, alternatively, be hinged at one pole piece. The particular type of potting compound is selected according to the environment to be encountered, this being a matter of ordinary skill in the art.

Referring now to FIG. 2, which shows the preferred actuator which may be used with the device of FIG. 1, it contains a ceramic permanent magnet 28, polarized so as to induce a difference in magnetomotive force in a pole piece 30 of suitably permeable material, which surrounds magnet 28. The elements are surrounded with potting compound 26 which protects them from environmental conditions. The two opposite ends of pole piece 30 are substantially flush with potting compound 26, and the ceramic magnet is flush with the potting compound to allow for interchangeability. The magnet may instead be slightly recessed and covered with potting compound. The actuator may also take the form of an electromagnet rather than a ceramic permanent magnet. The latter, however, is preferred from the standpoint of flexibility of application.

FIG. 3 shows a sectional view of the device of FIG. 1, and indicates how non-permeable cup 24 fits over the pole pieces and is flush with contact mechanism 10. Leads 32 and 34 are from terminals 14 and 16 of contact mechanism 10 and are brought out through the potting compound 26.

FIGS. 4 and 5 show the switch mechanism and actuator in perspective and illustrate that the elements of both are completely potted except the end faces of pole pieces 18, 20, and 30, and the ceramic magnet 28 which may alternatively also be potted.

In operation, the contact mechanism of the switch may be closed by bringing the faces of the pole piece 30 into proximity with the faces of pole pieces 18 and 20. This may be accomplished by a push-pull motion, where the relative movement of the switch device and its actuator is along an axis passing through their centers; by rotation, where the relative movement is rotary and will cause closure of the switch at two points of each cycle; by sliding, where the relative motion of each of the two

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units is along a line parallel to the face of the other; or by any combination of these. Of course, when an electromagnet is employed in the actuator, the switch may be actuated simply by controlling the current through the coil of the electromagnet.

FIG. 6 shows an alternative switch structure wherein the pole pieces are brought out at the control-element end of the contact mechanism 10. Pole pieces 36 and 38 are L-shaped and extend toward control element 12. The armature 40 has attached to it an element 42, which extends between pole pieces 36 and 38. When a magnetomotive force exists between the pole pieces, a flux pattern will be set up in armature 40 which will be drawn toward the pole pieces and cause element 42 to push in control element 12, thus operating contact mechanism 10. Element 42 is preferably non-permeable so as not to create excessive leakage flux across the pole pieces.

FIG. 7 illustrates another embodiment of the switch which is less sensitive to shock and acceleration forces, armature 37 is pivoted at its center of gravity about axle 39 carried by central pole piece 45. Thus acceleration forces in any direction acting on the switch will not tend to rotate armature 37. In addition, pole pieces 47 and 49 are provided at opposite ends of armature 37. When a magnetomotive force exists between pole pieces 45 and 49, the switch is positively biased open and acceleration cannot cause operation of the switch. When a magnetomotive force exists between pole pieces 45 and 47, however, the armature is rotated clockwise positively operating control element 12 and acceleration cannot cause the release of control element 12.

The degree of proximity which is required depends largely on the strength of the field produced by the actuator, and the permeability of the components and of any material which may be disposed between the switch and actuator. If the field created by the actuator is strong enough, the switch can be actuated through a great thickness of material having low permeability. If the permeability of any interposing material is too high, however, the field will be destroyed and will not cause the switch to be actuated.

It may be desirable also to use a slightly magnetized armature 22, especially when the polarity of the actuating field is known, to further reduce the requisite strength of the field.

FIG. 8 illustrates a way in which the switch can be operated though separated by a great distance from an actuator with ordinary or low field strength. Wall 43 is interposed between switch 50 and actuator 52 which may be very thick and composed of permeable or non-permeable material. A plug having threads 41 is fitted into wall 43 and preferably sealed therein to allow no leakage through the wall. The plug is composed of material 48 having low permeability but is equipped with pole pieces 44 and 46 which have high permeability, thereby readily allowing the passage of flux through the plug. Of course, the switch could also be actuated by controlling the flow of current through the coil of an electromagnet placed on the other side of wall 43.

FIG. 9 shows an embodiment of the invention which may be used as a circuit breaker. The current to be limited flows through a circuit defined by terminals 54 and 56. The current flows from terminal 54 through coil 58 wrapped around a coiled bi-metallic element 60 to point 62. From there it flows through the bi-metallic element back to point 64, through the coils of electromagnets 66 and 68, through the normally closed contacts of switch 70. Shaft 72 connects the center of bi-metallic element 60 with electromagnet 66, the poles of which are both equally spaced between pole pieces 74 and 76 of switch 70 so that no magnetomotive force normally exists across them.

When current flows through coil 58 and back through bi-metallic element 60, the temperature of the element

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5 rises and it tends to loosen its coiled shape. As the outside of the element is supported in space, shaft 72 rotates as the element unwinds, rotating electromagnet 66 with it. The higher the current through bi-metallic element 60 and its coil 58, the larger will be the magnetomotive force generated by electromagnet 66 and the faster will be the rotary motion of electromagnet 66. As electromagnet 66 rotates, its poles are no longer equidistant between pole pieces 74 and 76 of switch 70, and a magnetomotive force will be present between them proportional to the product of the current and the sine of the angle through which shaft 72 has rotated. Thus the time required to actuate the switch will be an inverse function of the current. That is, for small currents, the switch will never be actuated, for larger currents the switch will be actuated after a long time interval, and for higher currents, the switch will be actuated after a short time interval. For very large currents it is desired to actuate the switch immediately, and for that reason electromagnet 68 is provided in fixed spatial relation to pole pieces 74 and 76 of switch 70. Electromagnet 68 has relatively few turns in its winding and is spaced relatively far from the pole pieces so that the predetermined amount of electromotive force between pole pieces 74 and 76 is attained as soon as a predetermined amount of current flows through the coil of electromagnet 68, and actuates switch 70 instantaneously.

Of course, the device of FIG. 9 may be used to break a circuit other than that exciting bi-metallic element 60, in which terminal 56 would be connected directly to the coil of electromagnet 68, and the terminals of switch 70 would be connected in series with the circuit to be broken.

Having shown and described an exemplary embodiment of the invention, it is obvious that minor modifications may be made therein without departing from the invention, which is defined only by the appended claims.

We claim:

1. A switch of the character described comprising, in combination; switching means, separating means, and actuator means displaceable with respect thereto; said switching means having an axis, an actuation surface oriented transversely to said axis, and a contact mechanism; said contact mechanism having an axis aligned with said axis, an enclosing housing, a control element extending through said housing, and at least two electrical contacts within said housing, each of said electrical contacts provided with a connection adapted to provide electrical contact with conductive circuits external to said switching means; said control element being movable between first and second positions and spring biased to remain in one of said two positions in the absence of an externally applied force; a movable armature adjacent to said control element oriented transversely to said axis of said switching means; said armature adapted to move said control element from said one biased position to the other of said two positions in response to the application thereto of a magnetic field of at least a predetermined density, having actuating portions, and consisting of magnetically responsive material; pole piece means aligned with said axis of said switching means for concentrating magnetic fields applied externally of said switching means substantially at said actuation surface and applying such magnetic fields to said armature; said pole piece means comprising two aligned pole piece elements symmetrically oriented with respect to said axis of said switching means and said actuating portions of said armature and extending substantially from said actuation surface to a position adjacent to said armature; said pole piece elements spaced a predetermined distance apart in planes transverse to said axis of said switching means; a cup-shaped member positioned to enclose said armature; said cup-shaped member cooperating with said housing of said contact mechanism and said pole piece elements to provide a completely enclosed chamber surrounding said armature; said contact mechanism, said

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pole piece means, and said cup-shaped member enclosed by a supporting housing integral therewith, said pole piece means extending substantially to the surface thereof, and said connections to said electrical contacts extending therefrom; said actuator having an operative axis, an actuating surface transverse to said operative axis, and comprising magnet means; said magnet means having two magnetic poles of opposite polarity near said actuating surface spaced apart substantially the same predetermined distance as said pole piece elements in planes transverse to said operative axis; said separating means comprising a fluid impervious wall aligned with said actuation surface and interposed between said actuation and actuating surfaces, said wall consisting of non-magnetic material with two magnetically responsive inserts extending therethrough, said inserts aligned with said pole piece elements; the permeability of said magnet means, said inserts, said pole piece elements, and said armature so correlated that said armature is moved from said one position to the other of said two positions whenever said two magnetic poles are displaced less than a predetermined distance from the portions of said pole piece elements extending near said actuation surface.

2. A switch of the character described comprising, in combination; switching means and actuator means displaceable with respect thereto; said switching means having an axis, an actuation surface oriented transversely to said axis, and a contact mechanism; said contact mechanism having an axis aligned with said axis, an enclosing housing, a control element extending through said housing, and at least two electrical contacts within said housing, each of said electrical contacts provided with a connection adapted to provide electrical contact with conductive circuits external to said switching means; said control element being movable between first and second positions and spring biased to remain in one of said two positions in the absence of an externally applied force; a movable armature adjacent to said control element oriented transversely to said axis of said switching means; said armature adapted to move said control element from said one biased position to the other of said two positions in response to the application thereto of a magnetic field of at least a predetermined density, having actuating portions, and consisting of magnetically responsive material; pole piece means aligned with said axis of said switching means for concentrating magnetic fields applied externally of said switching means substantially at said actuation surface and applying such magnetic fields to said armature; said pole piece means comprising two aligned pole piece elements symmetrically oriented with respect to said axis of said switching means and said actuating portions of said armature and extending substantially from said actuation surface to a position adjacent to said armature; said pole piece elements spaced a predetermined distance apart in planes transverse to said axis of said switching means; a cup-shaped member positioned to enclose said armature; said cup-shaped member cooperating with said housing of said contact mechanism and said pole piece elements to provide a completely enclosed chamber surrounding said armature; said contact mechanism, said pole piece means, and said cup-shaped member enclosed by a supporting housing integral therewith, said pole piece means extending substantially to the surface thereof, and said connections to said electrical contacts extending therefrom; said actuator having an operative axis, an actuating surface transverse to said operative axis, and comprising magnet means; said magnet means having two magnetic poles of opposite polarity near said actuating surface spaced apart substantially the same predetermined distance as said pole piece elements in planes transverse to said operative axis; the permeability of said magnet means, said pole piece elements, and said armature so correlated that said armature is moved from said one position to the other of said two positions whenever said two magnetic poles are displaced less than a

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predetermined distance from the portions of said pole piece elements extending near said actuation surface.

3. A switch of the character described comprising, in combination; switching means, separating means, and actuator means separately displaceable with respect thereto; said switching means having an axis, a substantially planar actuation surface oriented transversely to said axis, and a contact mechanism; said contact mechanism having an axis aligned with said axis, an enclosing housing, a control element extending through said housing, and at least two electrical contacts within said housing, each of said electrical contacts provided with a connection adapted to provide electrical contact with conductive circuits external to said switching means; said control element having an axis aligned with said axis of said contact mechanism, being movable between first and second positions, and spring biased to remain in one of said two positions in the absence of an externally applied force; a substantially planar movable armature adjacent to said control element oriented transversely to said axis of said switching means; said armature adapted to move said control element from said one biased position to the other of said two positions in response to the application thereto of a magnetic field of at least a predetermined density, having actuating portions, and consisting of magnetically responsive material; pole piece means aligned with said axis of said switching means for concentrating magnetic fields applied externally of said switching means substantially at said actuation surface and applying such magnetic fields to said armature; said pole piece means comprising two aligned pole piece elements symmetrically oriented with respect to said axis of said switching means and said actuating portions of said armature and extending substantially from said actuation surface to a position adjacent to said armature; said pole piece elements spaced a predetermined distance apart in planes transverse to said axis of said switching means; each of said pole piece elements having a flange portion extending transversely to said axis of said switching means and toward said control element; a cup-shaped member positioned to enclose said armature; said cup-shaped member cooperating with said housing of said contact mechanism and said pole piece elements to provide a completely enclosed chamber surrounding said armature; said contact mechanism, said pole piece means, and said cup-shaped member enclosed by a housing integral therewith, said pole piece elements extending substantially to the surface thereof, and said connections to said electrical contacts extending therefrom; said actuator having an operative axis, an actuating surface transverse to said operative axis, and comprising a permanent magnet; said permanent magnet having a geometric axis aligned with said operative axis and being magnetized in a direction substantially transverse to said geometric axis to provide two operative poles therefor; a unitary pole piece of U-shaped configuration surrounding said magnet with the leg portions of said U spaced apart substantially the same predetermined distance as said pole piece elements in planes transverse to said operative axis and positioned immediately adjacent to said two operative poles; said magnet and said unitary pole piece enclosed by an actuator housing integral therewith; the leg portions of said unitary pole piece aligned to terminate at said actuating surface; said separating means comprising a fluid impervious wall aligned with said actuation surface and interposed between said actuation and actuating surfaces, said wall consisting of non-magnetic material with two magnetically responsive inserts extending therethrough, said inserts aligned with said pole piece elements; the field strength of said magnet, the permeability of said unitary pole piece, said pole piece elements, said inserts, and said armature so correlated that said armature is moved from said one position to the other of said two positions whenever the leg portions of said unitary pole piece are displaced less than a predetermined distance from the portions of said pole piece elements extending near said actuation surface.

4. The combination set forth in claim 3 wherein said armature and said pole piece means are so oriented that said armature is attracted away from said actuation surface upon application thereto of any magnetic field of at least a predetermined density.

5. A switch of the character described comprising, in combination; switching means and actuator means separately displaceable with respect thereto; said switching means having an axis, a substantially planar actuation surface oriented transversely to said axis, and a contact mechanism; said contact mechanism having an axis aligned with said axis, an enclosing housing, a control element extending through said housing, and at least two electrical contacts within said housing, each of said electrical contacts provided with a connection adapted to provide electrical contact with conductive circuits external to said switching means; said control element having an axis aligned with said axis of said contact mechanism, being movable between first and second positions, and spring biased to remain in one of said two positions in the absence of an externally applied force; a substantially planar movable armature adjacent to said control element oriented transversely to said axis of said switching means; said armature adapted to move said control element from said one biased position to the other of said two positions in response to the application thereto of a magnetic field of at least a predetermined density, having actuating portions, and consisting of magnetically responsive material; pole piece means aligned with said axis of said switching means for concentrating magnetic fields applied externally of said switching means substantially at said actuation surface and applying such magnetic fields to said armature; said pole piece means comprising two aligned pole piece elements symmetrically oriented with respect to said axis of said switching means and said actuating portions of said armature and extending substantially from said actuation surface to a position adjacent to said armature; each of said pole piece elements having a flange portion extending transversely to said axis of said switching means and toward said control element; a cup-shaped member positioned to enclose said armature; said cup-shaped member cooperating with said housing of said contact mechanism and said pole piece elements to provide a completely enclosed chamber surrounding said armature; said contact mechanism, said pole piece means, and said cup-shaped member enclosed by a housing integral therewith, said pole piece elements extending substantially to the surface thereof, and said connections to said electrical contacts extending therefrom; said actuator having an operative axis, an actuating surface transverse to said operative axis, and comprising a permanent magnet; said permanent magnet having a geometric axis aligned with said operative axis and being magnetized in a direction substantially transverse to said geometric axis to provide two operative poles therefor; a unitary pole piece of U-shaped configuration surrounding said magnet with the leg portions of said U immediately adjacent to said two operative poles; said magnet and said unitary pole piece enclosed by an actuator housing integral therewith; the leg portions of said unitary pole piece aligned to terminate at said actuating surface; the field strength of said magnet, the permeability of said unitary pole piece, said pole piece elements, and said armature so correlated that said armature is moved from said one position to the other of said two positions whenever the leg portions of said unitary pole piece are displaced less than a predetermined distance from the portions of said pole piece elements extending near said actuation surface.

6. The combination set forth in claim 5 wherein said armature and said pole piece means are so oriented that said armature is attracted away from said actuation surface upon the application thereto of any magnetic field of at least a predetermined density.

7. A switch of the character described comprising, in combination; switching means and actuator means displaceable with respect thereto; said switching means having an axis, an actuation surface oriented transversely to said axis, and a contact mechanism; said contact mechanism having an axis aligned with said axis, an enclosing housing, a control element extending through said housing, and at least two electrical contacts within said housing, each of said electrical contacts provided with a connection adapted to provide electrical contact with conductive circuits external to said switching means; said control element being movable between first and second positions and spring biased to remain in one of said two positions in the absence of an externally applied force; a movable armature adjacent to said control element oriented transversely to said axis of said switching means; said armature adapted to move said control element from said one biased position to the other of said two positions in response to the application thereto of a magnetic field of at least a predetermined density, having actuating portions, and consisting of magnetically responsive material; pole piece means aligned with said axis of said switching means for concentrating magnetic fields applied externally of said switching means substantially at said actuation surface and applying such magnetic fields to said armature; said pole piece means comprising two aligned pole piece elements symmetrically oriented with respect to said axis of said switching means and said actuating portions of said armature and extending substantially from said actuation surface to a position adjacent to said armature; said pole piece elements spaced a predetermined distance apart in planes transverse to said axis of said switching means; a cup-shaped member positioned to enclose said armature, said cup-shaped member cooperating with said housing of said contact mechanism and said pole piece elements to provide a completely enclosed chamber surrounding said armature; said contact mechanism, said pole piece means, and said cup-shaped member enclosed by a supporting housing integral therewith, said pole piece means extending substantially to the surface thereof, and said connections to said electrical contacts extending therefrom; said actuator having an operative axis, an actuating surface transverse to said operative axis, and comprising a permanent magnet; said permanent magnet having a geometric axis aligned with said operative axis and being magnetized in a direction substantially transverse to said geometric axis to provide two operative poles therefor; a unitary pole piece of U-shaped configuration surrounding said magnet with the leg portions of said U spaced apart substantially the same predetermined distance as said pole piece elements in planes transverse to said operative axis and positioned immediately adjacent to said two operative poles; said magnet and said unitary pole piece enclosed by a supporting housing integral therewith, the leg portions of said unitary pole piece aligned to terminate at said actuating surface; the field strength of said magnet, the permeability of said unitary pole piece, said pole piece elements, and said armature so correlated that said armature is moved from said one position to the other of said two positions whenever the leg portions of said unitary pole piece are displaced less than a predetermined distance from the portions of said pole piece elements extending near said actuation surface.

References Cited in the file of this patent

UNITED STATES PATENTS

2,521,753	Hubble	Sept. 12, 1950
2,573,920	McLeod	Nov. 6, 1951
2,637,115	Watson	May 5, 1953
2,658,970	Hurley	Nov. 10, 1953
2,666,823	Wilson	Jan. 19, 1954
2,767,278	Collins	Oct. 16, 1956