

[54] **ELECTRIC SWITCH**

[76] Inventor: **Rudolf Steiner**, 3624 Inglewood Boulevard, Los Angeles, Calif. 90066

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[58] Field of Search **335/205-206, 207**

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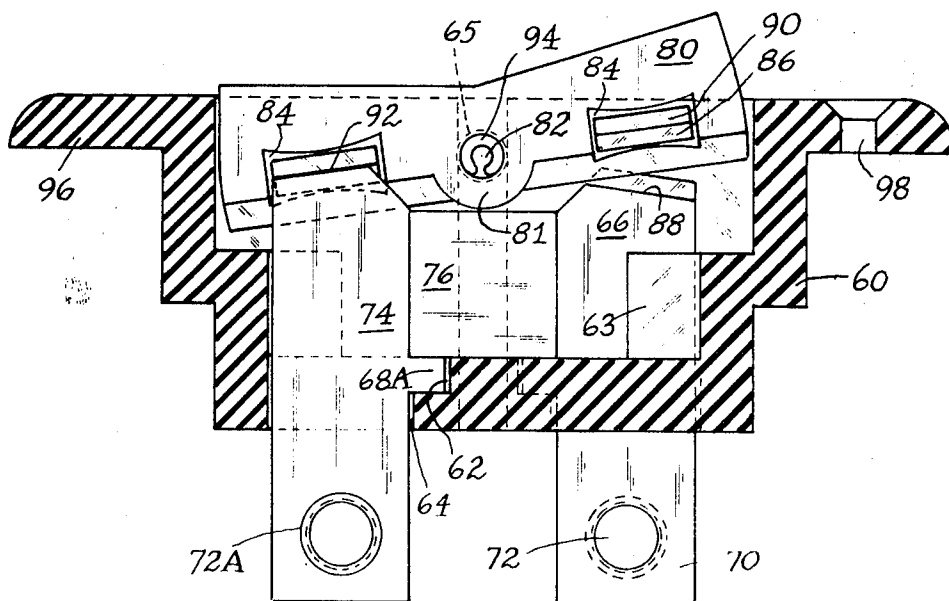
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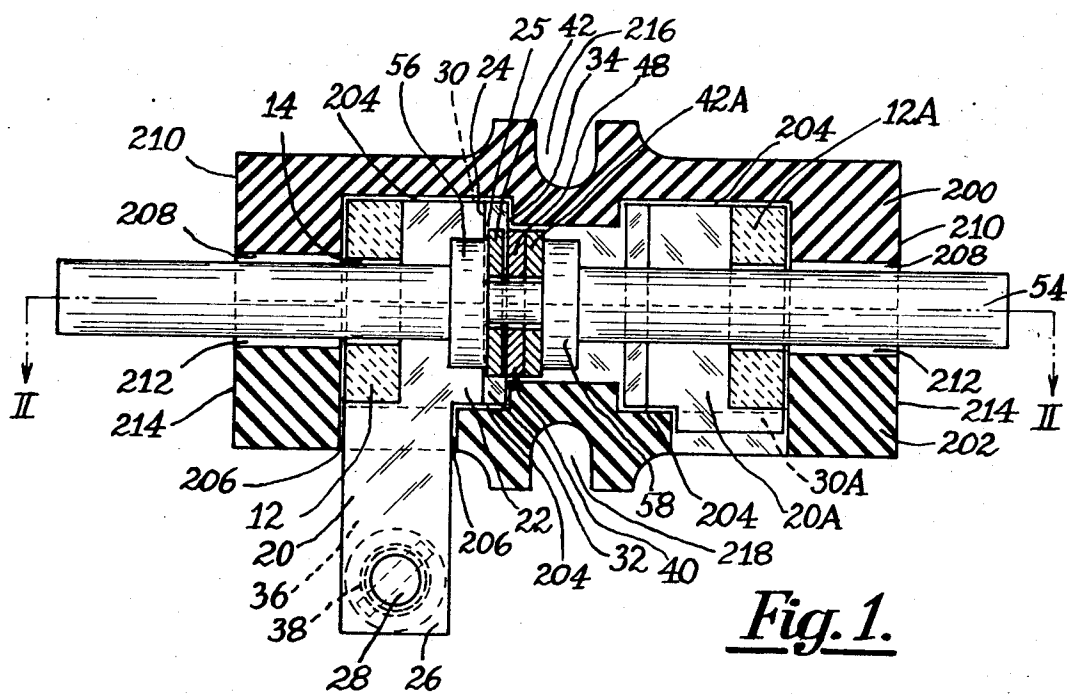
Primary Examiner—Roy N. Envall, Jr.

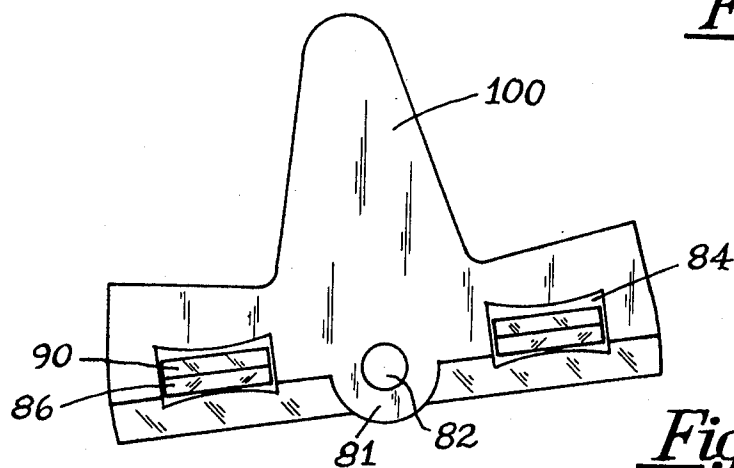
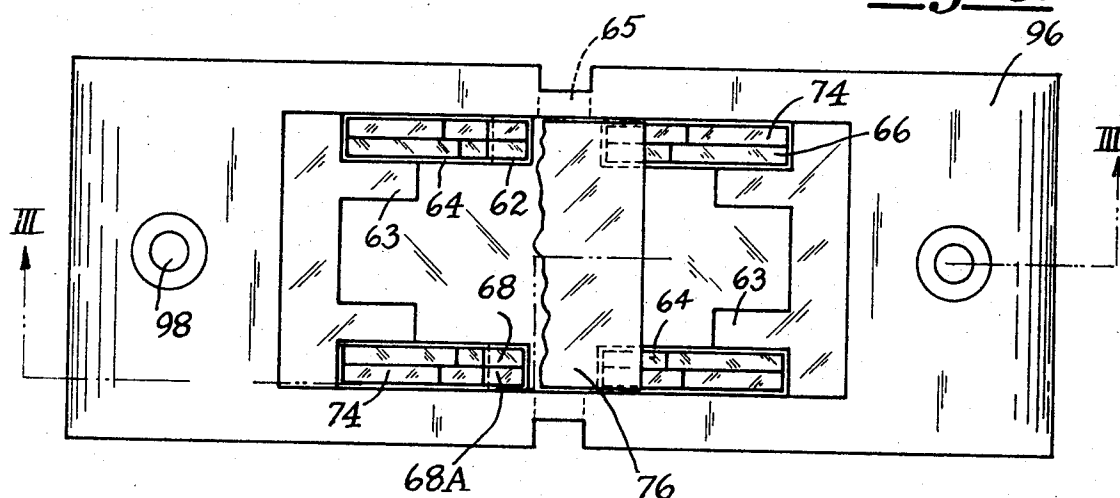
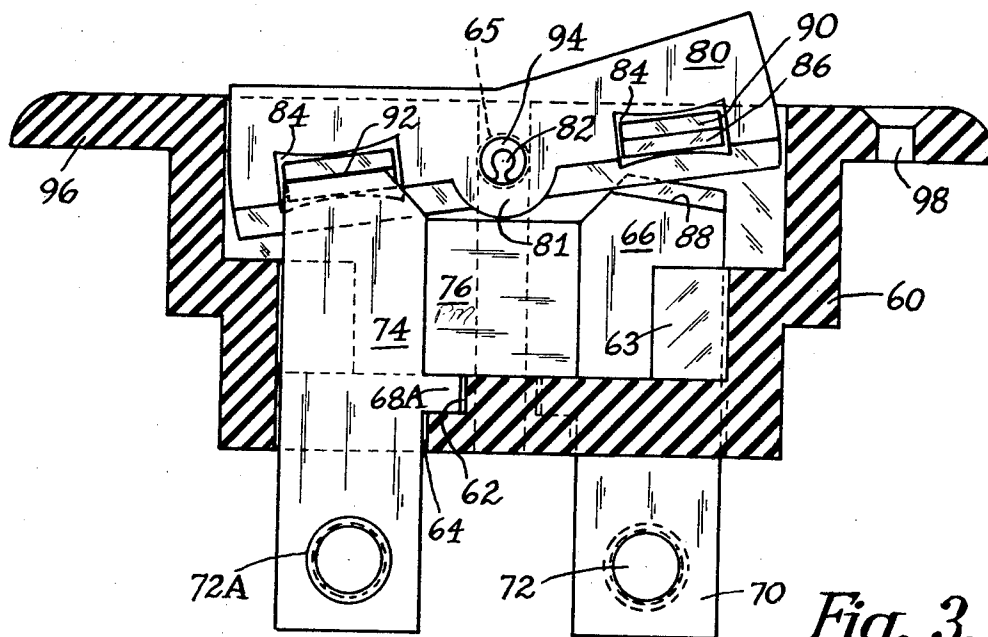
[57] **ABSTRACT**

An electric switch having stationary structures, each consisting of a magnetic circuit portion which is energized by a permanent magnet, and an electric circuit portion which is positioned adjacent to that magnetic circuit portion and equipped for the connection with an external electric circuit, and a movable armature structure having a member capable of controlling, upon actuation and in combination with the specific magnetic forces, the magnetic circuit portion concurrently with the electric circuit portion of a like stationary structure of the electric switch.

5 Claims, 7 Drawing Figures







ELECTRIC SWITCH

The subjects of this invention are improved electric snap switches utilizing various basic teachings and component parts covered in my U.S. Pat. No. 3,537,047, including the property that the snap action is effected through the forces of magnetic attraction and repulsion, selectively.

One of the improvements consists in an arrangement which increases the conductivity of the current-carrying switch parts and reduces thereby both the contact resistance and the contact voltage drop.

Another improvement is the adaptation of the basic, push-push type switch actuation to those of the rocker and toggle types, respectively.

A further improvement resulted from the application of a single permanent magnet for the preparation of two magnetic circuits, to be available for more than one switch position, selectively.

Still another improvement is the application of the basic switch concept for key-switch configurations.

An additional improvement is the incorporation of a contact-wiping action to attain self-cleaning contacts.

Further advantages of the subject improvements over both the basic patent and prior art will become apparent from the following description and the accompanying drawing.

In the drawing, forming a part of this application:

FIG. 1 shows in front elevation and cross-section in the plane I—I a switch assembly equipped with low-conductivity contact members,

FIG. 2 indicates, in plan view and cross-section in the plane II—II, the switch contact arrangement equipped with low-conductivity contact members,

FIG. 3 shows, in front elevation and cross-section in the plane III—III, a rocker-type switch equipped with low-conductivity contact members, wiping-action contacts and a single permanent magnet.

FIG. 4 illustrates in plan view the switch arrangement of FIG. 3, without the rocker,

FIG. 5 portrays in side elevation, a toggle-type switch handle,

FIG. 6 indicates, in elevational cross-section, a basic key-switch variety, and

FIG. 7 indicates, in elevational cross section, a typical key board embodiment portion.

Referring now to the drawing, wherein like reference characters designate like or corresponding parts, and more particularly to FIG.'s 1 and 2, a, but typical, contact structure 10 is shown having the subject improvements over the respective configuration in my U.S. Pat. No. 3,537,047. An electrically nonconductive permanent magnet 12 having the shape of a rectangular prism and having a cylindrical hole 14 formed concentric with its axis and across its width is mounted at, at least, one switch position. Adjacent to each of its two side faces 16 and 18, constituting a magnetic north pole and south pole, respectively, a stationary pole piece 20 of ferrous and, therefore, electrically conductive material is placed adjacent to each said pole face 16 and 18. Each of said pole pieces has a first extremity 22 having the front face 24. A second pole piece extremity 26, having a hole 28 formed therein, acts as a wiring terminal to which a cable can be connected. If said hole 28 is tapped, a binding screw can be employed for the cable connection. In accordance with one objective of this invention, another stationary contact member 30

of a material having superior electrical conductivity without requiring magnetic conductivity characteristics is placed adjacent to and, for example, outside of each said pole piece 20. Each said member 30 has a first extremity 32 having the front face 34. It should be noted, however, that each first extremity 32 of each member 30 extends beyond the respective first extremity 22 of each said pole piece 20, completing a typical stationary contact arrangement. A second extremity 36 of each said member 30 having a clearance hole 38 formed therein, but otherwise of identical shape as the second extremity 26 of each pole piece 20 extends in the same direction as said extremity 26. The clearance hole 38 being concentric with the tapped hole 28 allows for the use of a cable binding screw in the aforescribed manner.

The movable switch contact 40 having the subject improvements consists of an armature member 42 of ferrous and, therefore, magnetically and electrically conductive material. It has the shape of rectangular prism and extends in length so as to mate with the pole piece faces 24, clearing and avoiding the front faces 34. In the configuration shown in FIG.'s 1 and 2, a slot 44 is formed in the armature member 42, extending from its geometric center to its outside face 46. Its thickness is smaller than the distance between the face 24 of a pole piece 20 and a face 34 of a member 30.

In accordance with the aforementioned objective of this invention, a movable contact member 48 of a material having superior electrical conductivity without requiring magnetic conductivity is placed adjacent to and outside of said armature member 42. The member 48 is also a rectangular prism having a slot 50 formed therein extending from its geometric center to one of its outside faces 52. This contact member 48 extends in length so as to mate with the faces 34 of the member 30.

A, for example, cylindrical actuator 54 having two collars 56 and 58 formed thereon, is movably installed through the hole 14 of the permanent magnet 12. The two members 42 and 48 of the movable contact 40 are positioned between said two collars 56 and 58. This arrangement results in the first of the herein enumerated improvements over the teachings in my U.S. Pat. No. 3,537,047. Because of the introduction of one member, having superior electric conductivity, adjacent to each ferrous member having a certain, but no longer required electric conductivity, the member having the superior electric conductivity will carry the main share of the electric current, reduce a possible temperature increase and improve the entire switch performance. The aforementioned operation can be further advanced through specific selections of tolerances between the movable contact parts. It may advantageous to effect the closing of only the member having superior electric conductivity and leaving a gap between the armature and the pole pieces. Conversely, an exchange of the mutual position between the magnetic and electric structure members with respect to those shown in, especially, the FIG.'s 1, 2, 3, 4 and 5, may render further operational improvements. In other instances, a rigid assembly among the armature parts 42, 48 and 42A will be the most desirable and effective armature construction. This may require a mutual operational tolerance so as to leave a gap 25 between the armatures 42 and 42A and the respective pole piece faces 24 to assure a dependable closing of the electric circuits. If a second

stationary contact structure is used, as in a two-position switch, another armature member 42A, identical in its geometry and characteristics with the armature member 42 is placed adjacent to the contact member 48 opposite member 42 and positioned, likewise, between the collars 56 and 58. Its magnetic attraction and electric performance with regard to the members of the second stationary contact structure is also identical with the operation described for the first stationary contact structure.

Both the aforementioned switch parts and structures are assembled within a frame which in this, but representative, embodiment is an enclosure made of, for example, bakelite. This enclosure consists of a top 200 and a bottom 202 mating with each other in a horizontal plane II — II, located through the axis of the actuator 54. Each stationary member, namely, the permanent magnet 12, the pole pieces 20 and the stationary contact members 30 are lodged within recesses 204 formed into said top 200 and said bottom 202, respectively, as are the corresponding members of a second stationary structure, enumerated in the same order, 12A, 20A and 30A, except that, in this example, the members 20A and 30A are shown as electrically inactive parts without a secondary wiring extremity. The pole piece extremities 26 and the stationary contact member extremities 36, both of which are absent from the members 20A and 30A, extend through and beyond the slots 206, formed in the bottom 202, to the exterior of the enclosure, making them accessible for the attachment of cables in the aforescribed manner. A, for example, semicylindrical hole 208 is formed at each side 210 of the top 200 concentric with the axis of the actuator 54. A coacting, in this case likewise semicylindrical hole 212 is formed at each side 214 of the bottom 202, also concentric with the axis of the actuator 54. Upon the completed switch assembly, the actuator is radially captive, but free to be moved axially through the holes 14 formed in the permanent magnet 12 and in the respective holes of an opposite stationary structure, and within the clearance holes established through the mating of each semicylindrical hole 208 with its corresponding semicylindrical hole 212. An open slot 216 is molded into the upper portion of the top 200 across its width and perpendicular to the actuator axis, and an open slot 218 is arranged correspondingly in the lower portion of the bottom 202. Both these slots are provided to accommodate mounting screws (not shown) for the switch. The assembly of the top 200 with the bottom 202 and thereby of the entire switch may be performed with screws as shown in my U.S. Pat. No. 3,537,047, with eyelets and with chemical binding compounds applied to the surfaces common to the top 200 and the bottom 202, selectively.

Whereas all aforementioned stationary parts are retained through ribs and within recesses of the switch enclosure, and extending through apertures, respectively, the movable contact members 42, 48 and 42A and the actuator 54, which constitute the only movable switch parts, are floating within a channel formed within the switch enclosure, comparable to the embodiment shown in the FIG.'s 2 and 3 of my U.S. Pat. No. 3,537,047.

It should be noted that all other switch configurations, depicted in FIG.'s 6, 7, 8, 9, 10 and 11 of my U.S. Pat. No. 3,537,047, can be produced utilizing the herein described, improved construction.

A further improvement, incorporating the foregoing, is illustrated, as a rocker-switch variety, in FIG. 3 and 4. The switch case 60, made, for example, of a polycarbonate material, is an upwardly open container having the recesses 62, ribs 63 and the holes 64 formed in its bottom portion and the holes 65 formed in its longer sides. A pole piece 66 of ferrous material having an extremity 68 is inserted into each each hole 64 so that it becomes lodged adjacent to a rib 63 and its extremity 68 inside the recess 62. The wiring terminal extension 70 of each pole piece 66 extends, through the hole 64 beyond the switch case bottom so as to be accessible from the outside of the switch case. A hole 72 formed in the wiring terminal extension 70 is available for the connection with a cable. If the hole 72 is tapped, the cable can be attached with a binding screw (not shown). Adjacent to each said pole piece 66 and between this pole piece 66 and the switch case wall, a stationary contact member 74 of a material having superior electrical conductivity without requiring magnetic conductivity is positioned. This contact member 74 is of a shape identical with the shape of the pole piece 66, including its extremity 68A and the hole 72A, except extending in its height beyond the height of the pole piece 66. The hole 72A may be a clearance hole with respect to the tapped hole 72.

A single permanent magnet 76 of electrically non-conductive material and the shape of a rectangular prism is inserted into the switch bottom cavity, so as to make intimate contact with the, in this case, four ferrous pole pieces 66 and their extremities 68. The permanent magnet 76 is magnetized so as to have a, say, south pole at its near face 78 and a north pole at its far face, both with respect to the presentation in FIG. 3.

A rocker 80, serving as the switch actuator in this embodiment has a horizontally positioned through-hole 82 and two holes 84 of inwardly double-convex profiles formed therein. A bar 86 of ferrous material is positioned at the bottom of each hole 84 and adapted to float therein. Its length so as to extend between and over the top surfaces 88 of two mating ferrous pole pieces 66 and to mate with them in the respective closed switch position. Adjacent to and on top of each bar 86, a bar 90 of a material having superior electric conductivity is placed within the hole 84 and adapted to float therein. Its length is so as to extend between and over the top faces 92 of the members 74 and to mate with them in the respective closed switch position.

The so equipped rocker 80 is mounted in the upwardly open switch case. A spring pin 94 is inserted through a hole 65 in the case wall, the through-hole 82 of the rocker and the opposite case wall hole 65, whereby the holes 65 are clearance holes for the spring pin 94 which, however, seats firmly within the rocker hole 82. The holes 65 are formed through off-set vertical mold protrusions, obviating the drilling of the holes 65.

The following should be especially noted: Firstly, the rocker 80, in addition to being the switch actuator, constitutes also the switch cover. Secondly, the spring pin 94 is not only the pivot for the actuator and the only general nature hardware part of this switch construction, but it completes the entire switch assembly, in conjunction with the lower rocker portion 81 which prevents the permanent magnet 76 from escaping from its assigned position. The permanent magnet 76 arrests

the pole piece extensions 68 and the contact member extensions 68A. If intended for surface mounting on a panel, the switch case 60 is equipped with coverplate-bezel mounting extensions 96 having at least one clearance hole 98 formed therein to accommodate a binding screw. Other mounting means known in this art are also possible, namely, snap-in spring members, brackets, box plates, to mention but a few.

The rocker 80 can readily be replaced with an actuator having the form of a toggle 100, as shown in FIG. 5. Except for the toggle proper, this actuator has each and every other characteristic of the previously described and shown rocker 80.

It should especially be noted that both the rocker and the toggle actuators constitute mechanically balanced configurations of this, the only, respective movable switch part, imparting a shock- and vibration resistant property. This is of particular importance for switch applications in, for example, moving vehicles, elevators, commercial and military aircraft and in the aerospace domain. They also perform the contact opening in an acute angle which provides a very desirable horn-shaped arc-extinguishing mode.

Another improvement, especially, over the switch variety shown in FIG. 11 of my U.S. Pat. No. 3,537,047, is the key switch 102, illustrated in FIG. 6, and in its basic form as a so-called low-profile key switch. This switch type utilizes a base 104 of, say, polycarbonate having at least one blind hole 106 formed therein. This hole 106 has, for example, a recessed lower portion 108. The hole 106 and the hole 108 can be cylindrical, however, if a registration of specific moving parts is desired, or required, a square cross-sectional hole area will be preferable. A first annular permanent magnet 110 of an electrically nonconductive material and magnetized across its thickness is positioned, under forced fit, within the recessed lower portion 108 of the base 104. At least two stationary contacts 112 and 114 are installed within the bottom 111 of the blind hole 106, providing the wiring terminals 118 and 119 accessible from the exterior of the switch 102 and base 104. A second annular permanent magnet 116 of, for example, an electrically conductive material and, likewise, magnetized across its thickness, is disposed in such a manner that it faces the upper pole of the stationary magnet with like polarity. The diameter of the second annular magnet 116 is smaller than the diameter of the round hole 106 and smaller than the inscribed circle to a square hole, resulting in a floating of the second permanent magnet 116 above the first permanent magnet 110 through the effect of mutual magnetic repulsion. A disc 117 of electrically nonconductive material is positioned on top of the second permanent magnet 116 without requiring any assembly means. The shape of the disc 117 corresponds with the shape of the hole 106. If the switch 102 requires no legend, a cylindrical hole 106 will suffice. Whenever the key requires a legend which should be legible from or in one preferred orientation, a hole 106 having a square cross-section in, at least, its upper portion, becomes necessary. The entire aforescribed switch construction is covered, for example, with a lid 120, having cylindrical holes 122 formed therein, each concentric with the axis of a blind hole 106. The diameter of each hole 122 is somewhat smaller than that of a cylindrical blind hole 106 to prevent the escaping of the repelled, second permanent magnet 116. If a blind hole 106 of square cross-section

is used, the diameter of the hole 122 can be equal to one side of the square cross-sectional dimension of the hole 106 because the solid disc portions extending inside of the corners of the square profile will serve as stops.

When a hole 106 having a square cross section is used, the second permanent magnet can have the shape of a thin, rectangular prism, in which case it can be made to register within the square hole 106. Such an arrangement allows for a magnetization of both magnets in a direction across their respective widths and, if desired, for a number of additional, new and mutual repulsion and, consequently, operational switching effects.

Commensurate with the teachings of this invention, a layer 113 of material having superior electric conductivity can be permanently attached to the second permanent magnet to enhance the contact making and current-carrying switch capabilities. An assembly of this kind allows for the use of a second permanent magnet 116 of a material which is not an electrical conductor, as portrayed in FIG. 6.

Key switches in general and of the herein described configuration in particular, are expected to operate as momentary, normally OFF type switches. Consistent with the teachings of both, my referenced senior patent and this invention, they provide the desirable and functionally superior double-break action, in addition to all the other enumerated features.

Switch structures having the aforementioned characteristics can be arranged in sets, be they of a side-by-side and of any other desired grouping, selectively. Switch arrays of this kind are suitable for bookkeeping machine, computer and other software keyboards, and telephone dials, to mention but a few applications.

An actual, however representative, key board 123 utilizing key switches is shown in FIG. 7, together with various other improvements and modifications commensurate with the spirit of this invention.

A board 124 of an electrically nonconductive material constitutes the support for stationary contacts 126 mounted in clearance holes formed in the board 124, whereby the contact points 130 face in an upwardly direction, leaving their opposite ends 131 accessible for the connection of wires. It should be noted that these contacts can be mounted in board positions unsymmetrical with respect to any major assembly axis, unlike that indicated in FIG. 7, to cause specific and advantageous operational effects. A permanent bar magnet 134 of ferrous and nonferrous material, selectively, and magnetized across its vertical width is positioned between each pair of stationary contacts 126-126 belonging to the same key switch 132 and attached, for example, through an epoxy bond to the bottom of the board 124, if desired insulated with the sleeve 135. A combination cover and key guide 137 of both utilitarian and attractive design is mounted on the top of the board 124 through screws 136. This cover 137 may be made of, for example, molded plastic material and formed as shown in FIG. 7. The cover 137 has a frame portion surrounding the key board 123 of, if desired, decorative design, and holes 140 of square cross-section, surrounded by operational recesses 142 formed in its top and holes 144 of circular and square cross-section, selectively, formed in its bottom. Each key 132 of, preferably, a plastic material has a touch portion 146 followed by a stem portion 148 having a square cross sec-

tion of dimensions smaller than the square cross section of the holes 140 so as to provide operational tolerances for the key 132. A cylindrical stem portion 150 is provided at the end of the key stem portion 148 having a tapped hole 152 formed therein. A, for example, annular permanent magnet 154 is installed about the cylindrical stem portion 150, followed in a downward direction, by another annular permanent magnet 156 and an annular disc 158, and by the assembly screw 160. Both magnets 154 and 156 are magnetized across their widths and of ferrous and nonferrous materials, selectively. This disc 158, however, is of a material having superior electric conductivity, whereas the assembly screw 160 is of a plastic material. Assuming the bar magnet 134 is mounted so as to provide a magnetic north pole at its upper side, the magnet 156 is installed to display a magnetic north pole at its lower side and, obviously, a south pole on its upper surface. The magnet 154, in turn, is arranged so as to present a magnetic south pole on its lower face. Considering further that the diameters of the inside bores of each the magnet 154 and 156 and the disc 158 are larger than the diameter of cylindrical stem portion 150, a floating but self-positioning assembly exists by virtue of the mutual repulsion of the aforementioned permanent magnets 154 and 156 and the disc 158, although the latter may not possess magnetic properties. The entire key 132 with its magnets 154 and 156 and the disc 158 is repelled, and held in its OFF position through the effect between the bar magnet 134 and the magnet 156.

The operation of such a key switch is as follows: Upon the depression of the key 132 through the engagement of a finger with the touch portion 146 and overcoming the repellent magnetic force between the bar magnet 134 and the annular magnet 156, the disc 158 will close the circuit across the two stationary contacts 126—126 and their points 130—130. The finger, being preloaded by opposing the aforementioned magnetic force which increases in an inversed squared-law proportion as this magnetic gap decreases, continues to depress the key 132 so as to overcome the opposing force existing between the magnet 156 and the magnet 154. Whereas each of these two magnetic effects will impart a highly desirable "feel" to the key operator assuring him of the completed switch function, the dual-action among the three permanent magnets 134, 156 and 154 will, and in this sequence, greatly enhance this switch property. If the stationary contacts 130—130 of each key switch are mounted on the board 124 in the aforementioned unsymmetrical fashion, both the disc 158 and the magnet 156 will first approach only one stationary contact 130 to then become leveled and to mate with the other of the two contacts 130. This mechanical feature produces a contact-wiping action having self-cleaning contact surface effects, which not only contribute to a dependable contact operation but also extends the life expectancy of the contacts and, therefore, of the entire switch.

The opening of the circuit across the closed contacts 130—130 occurs through magnetic repulsion of the magnets 156 and 154 with respect to magnet 134, together with the disc 158, upon the removal of the operator's finger from the key 132.

It is apparent that more than two stationary contacts can be served by one disc 158 of each key switch 132, whereby each of these contacts may be an element of an individual, electrically disassociated circuit. If the permanent magnet 156 is of a ferrous and electrically conductive material, the disc 158 may be omitted, without sacrificing the aforementioned contact wiping action and circuit switching varieties. Numerous additional contact making circuit combinations appear to be feasible within the switch concept in accordance with this invention.

It becomes also apparent that the herein described and shown switch embodiments are merely of an illustrative nature and that additional configurations, combinations and variations are obtainable without departing from the spirit of this invention.

What is claimed is:

1. An electric switch mounted on a frame comprising:
 - at least one first structure composed of two parallel spaced members of a magnetically conductive material,
 - a permanent magnet of an electrically nonconductive material disposed within said two members of said first structure adapted to establish at least one U-shaped, open, magnetic circuit,
 - at least one second structure composed of two members covering the outside of said first, U-shaped, structure adapted to establish an open electric circuit,
 - an actuator engagable from the exterior of said switch and movable with respect to at least one said first and one said second structure,
 - at least one armature of a magnetically conductive material disposed within said actuator and opening and closing over the arms of the "U" and adapted to coact with said first structure and its magnetic circuit, said armature including an element of an electrically conductive material adapted to coact with said second structure and its electric circuit.
2. An electric switch as defined in claim 1 wherein a pivot is mounted in said frame and said actuator is mounted rotatably on said pivot.
3. An electric switch as defined in claim 2 wherein said actuator forms the cover of said frame when in each possible actuator position including when in transfer.
4. An electric switch as defined in claim 1 wherein said actuator is formed as a rocker.
5. An electric switch as defined in claim 1 wherein said actuator is formed as a toggle.

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