Sept. 4, 1962 W. C. PIKE 3,052,774

SWITCH CONSTRUCTION

Filed April 13, 1959 2 Sheets-Sheet 1

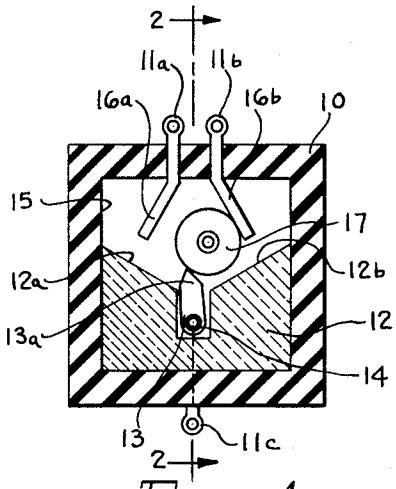


FIG. 1

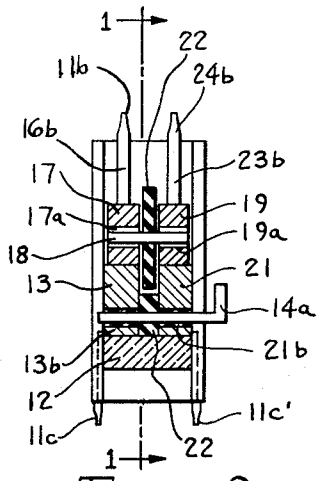


FIG. 2

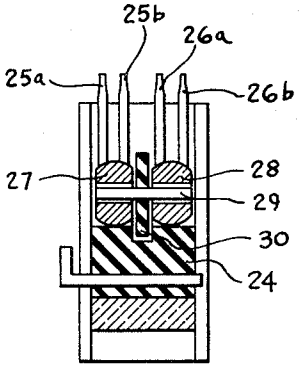


FIG. 3

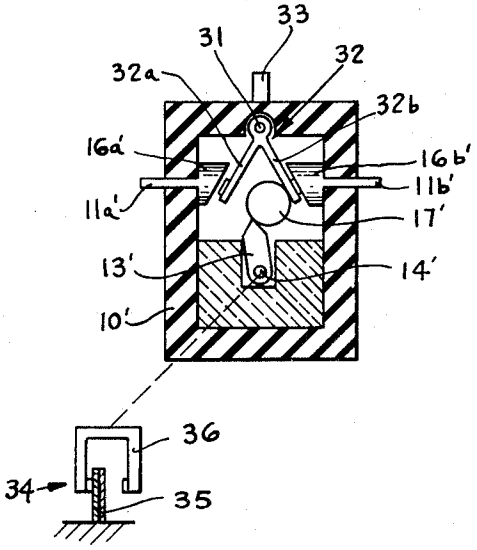


FIG. 4

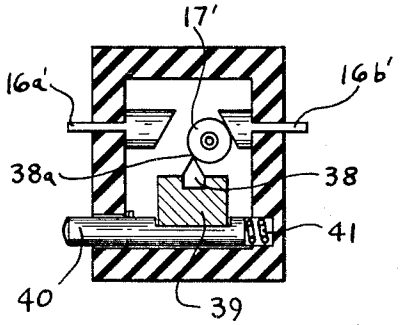


FIG. 5

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SWITCH CONSTRUCTION

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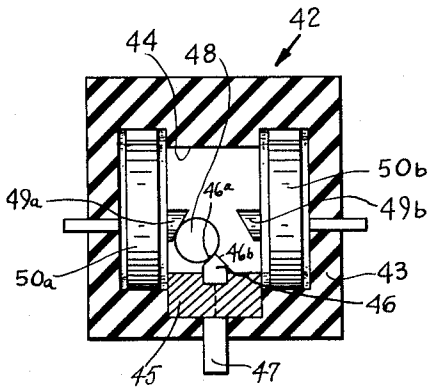


FIG. 6

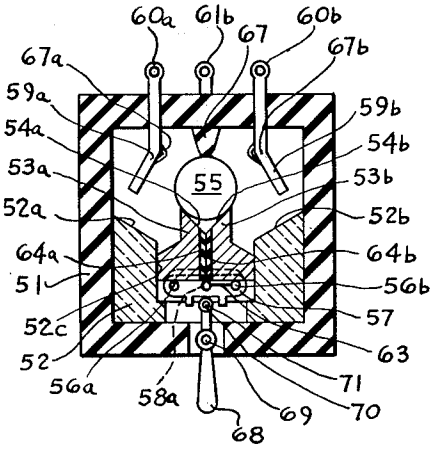


FIG. 7A

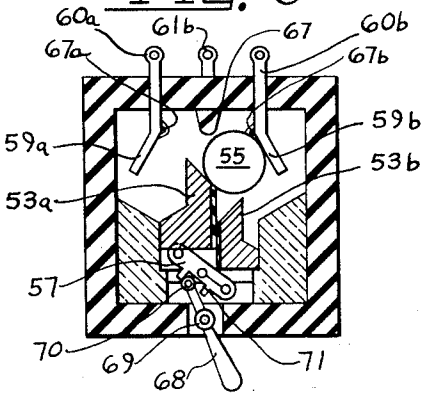


FIG. 7B

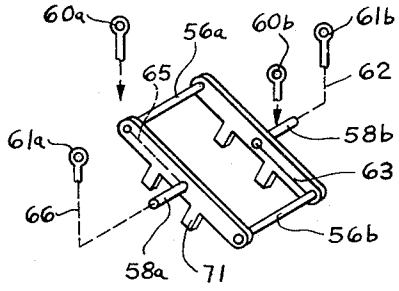


FIG. 8

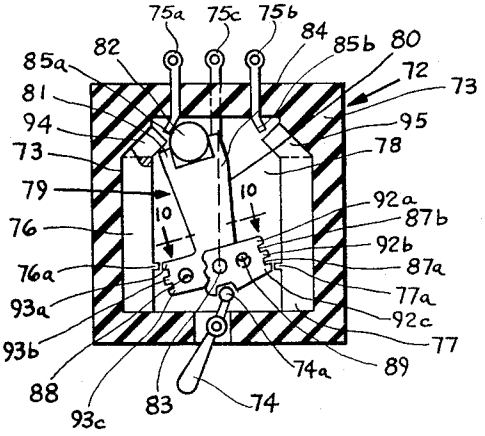


FIG. 9

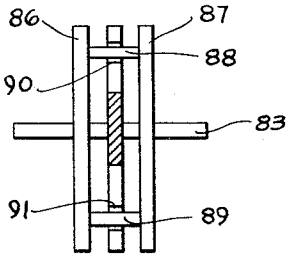


FIG. 10

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United States Patent Office 3,052,774 Patented Sept. 4, 1962

3,052,774

SWITCH CONSTRUCTION

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Filed Apr. 13, 1959, Ser. No. 806,032
26 Claims. (Cl. 200—67)

This invention relates to electrical switches, and more particularly to electrical switch designs which can be fabricated in a wide range of sizes including sub-miniature sizes, and which can be furnished with a wide range of contact arrangements.

Electrical switch devices, particularly in small sizes, are difficult to fabricate because of the problems of assembling interacting movable parts in small spaces while providing for sufficient spring pressures to insure efficient electrical contact and protection against mal-functioning under acceleration forces. Also, because most switches require snap action to insure good operating characteristics and to protect the contacts, relatively intricate toggle or over-centering linkages are used. These linkages tend to be costly and almost invariably are subject to breakdown.

It is, therefore, an object of the present invention to provide an improved electrical switch construction overcoming the above and other disadvantages of conventional designs.

Another object of the invention is to provide an electrical switch design which, using modular components, can be assembled in a relatively wide range of contact combinations and arrangements.

Still another object of the invention is to provide a multiple contact electrical switch assembly having snap switch action without the use of springs and other components which are frequently the basis for switch breakdown and failure.

Still another object of the invention is to provide an improved electrical switch construction which is adaptable for use with both manual actuators and electro-magnetically driven actuators to establish automatic relay actions.

In accordance with the present invention, there is provided a switch construction having complementary magnetic parts including a magnetic pole structure having a pair of spaced pole pieces and a magnetic, movable member captured within the flux field with at least two positions of equilibrium, i.e. maximum attracting force. The position which the movable member assumes is controlled by an actuator which is movable to urge the movable member toward either of its stable positions and which engages the member in an unstable support. The actuator preferably takes the form of a knife-edged rocker on which the movable member rolls to assume its stable positions. If preferred, the magnetic member can be utilized as part of the electrically conducting path between contact abutments which determine its limit positions. Movable contact elements can be interposed between the movable member and the abutments to eliminate the electrically conducting path through the magnetic member. In order to provide automatic relay action, field coils can be utilized in place of the movable actuator which then becomes a fixed pivot over which the movable member rolls in moving between its bistable positions.

The above and other features and objects of the invention will be readily understood having reference to the accompanying drawings in which:

FIGURE 1 is a view in vertical section taken on the line 1—1 of FIGURE 2 looking in the direction of the arrows of a switch assembly embodying the present invention;

FIGURE 2 is a view in transverse section taken on the line 2—2 of FIGURE 1 looking in the direction of the arrows;

FIGURE 3 is a view in transverse section of a switch assembly having a modified contact configuration;

FIGURE 4 is a view in vertical section of a switch assembly embodying a modified actuating linkage;

FIGURE 5 is a view in vertical section of a modified switch construction;

FIGURE 6 is a view in vertical section illustrating the switch construction embodied in a relay;

FIGURES 7A and 7B are views in vertical section partly diagrammatic in nature, illustrating another modified switch construction;

FIGURE 8 is a view in perspective of a component of the switch of FIGURES 7A and 7B;

FIGURE 9 is a view in vertical section of a modified switch construction; and

FIGURE 10 is a view in transverse section taken on the line 10—10 of FIGURE 9 looking in the direction of the arrows.

Referring to the specification and FIGURES 1 and 2 in particular, there is illustrated a switch assembly including a casing **10**, preferably formed of electrically insulating material such as plastic, and having three terminals, **11***a*, **11***b*, and **11***c* and **11***c'*. Mounted within the housing **10** is a permanent magnet **12** preferably taking the form of a ceramic magnet which is electrically insulating, although it will be understood that more conventional ferro-magnetic materials such as Alnico V can be used. The magnet **12** is in a generally horseshoe configuration with its pole faces **12***a* and **12***b* inwardly inclined. Mounted between the pole faces of the magnet **12** is a constraining or barrier member **13** which in the illustrated arrangement is movable with a pivot shaft **14** so that its upper relatively narrow edge **13***a* swings over an arc of approximately ten degrees. In this arrangement the constraining or barrier member is also a common electrical contact, as will be described below. Referring only to FIGURE 1 for purposes of explanation, there are disposed in the chamber **15** above the magnet **12** a pair of contact arms **16***a* and **16***b* connected respectively to the terminals **11***a* and **11***b*, and freely mounted between the contact arms **16***a* and **16***b* and resting on the edge **13***a* of the member **13** is a ferromagnetic movable member **17**, which is circular about an axis normal to the paper as viewed in FIGURE 1, so that it is capable of rolling over the edge **13***a*. Thus the movable member **17** is positioned or constrained by the member **13** and the contact arms **16***a* and **16***b* while under the influences of the magnetic attraction.

The size of the movable member **17** is such that it wedges between the common contact **13** and either of the contact arms **16***a* and **16***b*, depending on which way the common contact is swung. As illustrated in FIGURE 1, an electrical circuit is completed between the terminals **11***b* and **11***c*, the common contact **13** having been swung to the left in a counter clockwise direction. To open the circuit between the contacts **11***b* and **11***c* and to establish a circuit between the contacts **11***a* and **11***c* the actuator and common contact **13** is swung clockwise to the right, driving the movable member **17** to the top of the knife edge **13***a*, at which point it is unstable, after which it snaps into position between the contact **13** and the contact arm **16***a*. Thus there is provided by the contacts **16***a–b* and **13** a snap actuating single pole double switch. The contacts are held closed by the magnetic attraction between the permanent magnet **12** and the magnetic member **17** with wiping action being established each time the contacts close and with extremely high contact pressures obtained due to the inclined surfaces of the contact arms **16***a* and **16***b* with respect to a line perpendicular to the oblique pole faces **12***a* and **12***b*.

As will be apparent from the specification which follows, various means for actuating the movable common contact **13** can be provided. In FIGURES 2 and 3 the actuator **13** is shifted angularly by means of torque applied to the pivot shaft **14**, which driving forces can be applied through any suitable means, i.e. knob (not shown) or a radius arm **14***a* (FIGURE 2). Other actuating techniques including a rectilinearly movable common contact (FIGURE 5) and an electro-magnetically driven system (FIGURE 6) will be described at a later point.

Referring now to FIGURE 2, it will be seen that the movable member **17** is mounted on an electrically insulated pin **18** by means of an enlarged aperture **17***a* through its center. The pin carries a second movable member **19**, also preferably formed of ferro-magnetic material and having an enlarged central opening **19***a* which also receives the pin **18**. The second movable members **18** and **19** are separated by an electrically insulating spacer or washer **20**. A second contact element and common contact or actuator **21**, duplicating the actuator **13** is also mounted on the torsion pin **14** to turn therewith. Preferably the two actuators **13** and **21** are electrically insulated from the pin **14** by insulating sleeves **13***b* and **21***b* and are electrically insulated from each other by a spacer **22**. A second pair of contact arms, identical to the contact arms **16***a*–**16***b* of FIGURE 1, are disposed on opposite sides of the member **19**, only the contact element **23***b*, having a terminal **24***b*, being visible in FIGURE 2 of the drawing. Thus, there is provided a double pole, double throw switch wherein the action of one pole or side of the switch does not impede the action of the other. This is achieved by providing the clearance between the pin **18** and the ferro-magnetic members **17** and **19** so that relative movement can occur or provide full wedging and wiping action for each set of contacts. It will be understood that additional contact assemblies can be added by providing a wider housing and stacking additional modular units on the insulating pin **18** and the actuating pin **14**.

Referring to FIGURE 3, there is illustrated a modified arrangement of the switch wherein the common contact member or actuator, such as the members **13** and **21** of FIGURES 1 and 2, is replaced by an electrically insulating member **24** and eliminating that member from the electrical circuit. To this end, there are provided pairs of companion contacts **25***a*, **25***b*, **26***a*, and **26***b*, each corresponding generally to the contact arm **16***a* of FIGURE 1. The pairs of contact arms **25***a*–**25***b* and **26***a*–**26***b* are bridged respectively by movable members **27** and **28**, both being formed of ferro-magnetic material and both being electrically conducting. The two members **27** and **28** are loosely mounted on a common, electrically insulating supporting pin **29** and are separated by an electrically insulated spacer **30**. The movable members **27**, which are circular, are preferably crowned or transversely rounded on their peripheries, as viewed in FIGURE 3. In other respects, the arrangement of FIGURE 3 generally conforms to that illustrated by FIGURE 1 so that with the actuating member **24** swung toward the reader, the member **27** will engage the contacts **25***a* and **25***b* and the member **28** will engage the contacts **26***a* and **26***b*. In each case, the movable member will seek a position, due to the combined effects of the crowning and the loose mounting, which achieve maximum contact pressures. As described, there is provided a single-throw, double-pole switch. It will be understood that either an abutment stop or a second battery of four contact arms can be disposed in the housing for the other position of stable equilibrium of the members **27** and **28**, thereby providing in effect a pair of double-pole, double-throw switches, all within an extremely small space.

Referring to FIGURE 4, there is illustrated a modified switch construction wherein the movable, ferro-magnetic member is not utilized in the electrically conducting path. In FIGURE 4, parts which are functionally equivalent to parts of the switch of FIGURE 1, are identified by like, primed reference numerals. Pivotally mounted to the housing **10'** on an axis **31** is an electrically conducting common contact member **32** electrically connected to an output terminal **33**, as through a flexible coupling (not shown). The two diverging arms **32***a* and **32***b* of the common contact member **32** are disposed respectively between the contact **11***a'* and the movable member **17'** and between the contact **16***b'* and the movable member **17'**. As illustrated in FIGURE 4, the movable member **17'** takes the form of a ferro-magnetic ball. In operation, as the actuator **13'** is swung either to the right or to the left, the movable member **17'** will drive one or the other set of electrical contacts into engagement as it seeks its position of stable equilibrium. It is preferred in the arrangement of FIGURE 4 to use an insulating material for the actuating member **13'** or otherwise to insulate the member from the exterior of the switch.

As stated, the shaft **14'** on which the actuating member **13'** pivots can be driven by manual action. It can also be operated automatically, for example by thermostat **34** in which a bi-metal element **35** working against a double rock shaft linkage **36** turns the shaft **14'**. Lost motion between the arms of the rock shaft linkage **36** and the bi-metal element **35** enables the inherent snap action to occur within the switch body **10'**.

Referring to FIGURE 5, there is illustrated an arrangement whereby the pivoted or swinging actuator and common contact (identified by the numeral **13** in FIGURE 1) is replaced by an actuator and common contact element **38** having a knife or narrow edge **38***a* supporting the movable, ferro-magnetic member and carried in a supporting block **39** which is also a permanent magnet. The supporting block and permanent magnet **39** is mounted on a rectilinearly movable plunger **40** working against a spring **41**. When the plunger **40** is pressed inwardly, the movable member **17'** will snap with the contact **16***a'* to close the circuit between the contact and the common contact **38** and to open the circuit between the normally closed contacts **16***b'*–**38**. By utilizing a sufficiently strong spring **41** this arrangement results in a momentary type single-pole switch for the contacts **38***a*–**16***a'*. It will be understood that multiple momentary contacts can be provided in this switch configuration by applying thereto the multiple or stacked arrangements of FIGURE 2 or 3. Also contact **16***b'* may be used as a normally closed contact or used as an abutment stop. It will be observed that the working faces of the contacts **16***a'* and **16***b'* are inclined to the opposing surfaces of the common contact **38**, thereby to facilitate the wedging and wiping actions described above.

Referring to FIGURE 6, there is illustrated an electromagnetic relay **42**, the housing **43** of which is formed with a chamber **44** in which is mounted a permanent magnet **45** through which extends a fixed or immovable common contact **46** connected to a terminal **47**. If a ceramic, electrically insulating magnet is used, the magnet need not be electrically insulated from the contact and its terminal. However, if a ferro-magnetic material is used for the magnet, it is for most purposes, preferred to insulate the magnet from the electrical circuit. Disposed to the left of the common contact **46** is a movable circular member **48**, such for example as a steel ball or roller and flanking the member **48** are a pair of inclined contacts **49***a* and **49***b* so dimensioned and positioned relative to the fixed contact **46** that the movable member **48** wedges itself therebetween in an efficient electrical contact under the magnetic pull. The movable member **48** is stable on either side of the common contact **46** and to determine on which side the member comes to rest, there are provided a pair of electro-magnetic coils **50***a* and **50***b* associated respectively with the contacts **49***a* and **49***b*. In this fashion, a double-throw, and, if desired, polarized relay is established. It will be understood that by changing

the spacing and shaping of one of the contacts, i.e. the contact 49*b*, it is possible to provide an arrangement in which the movable member will remain against the contact 49*b* only while the coil 50*b* is energized. In such case, it is possible to eliminate the coil 50*a* because the contacts 49*a*–46 will be normally connected by the movable member 48 at any time the coil 50*b* is deenergized. The arrangement as illustrated in FIGURE 6, requires only a momentary pulse in one or the other coils to establish, for an indefinite period, closing of the appropriate contacts.

As in the case of the other arrangements of the invention described herein, multiple contact arrangements can be incorporated in relay designs (see FIGURES 1–3) and, if desired, the movable member 48 need not be part of an electrically conducting circuit (see FIGURE 4). Referring now to FIGURES 7A, 7B and 8, there is illustrated an arrangement of the invention which can be used to provide a center-off action. The switch includes a housing 51 having a permanent magnet assembly 52 including a pair of inwardly inclined pole faces 52*a* and 52*b*. Mounted in a central recess 52*c* of the magnet are a pair of vertically-movable, switch-actuating members 53*a* and 53*b* having complementary, inwardly inclined upper ends 54*a* and 54*b* on which rests a movable member 55, which is preferably circular, taking the form, for example, of a roller or a ball of magnetic material. In the central position illustrated in FIGURE 7A, the magnetic attraction between the movable member 55 and the magnet 52 imposes downward forces on the vertically movable members 53*a* and 53*b*, urging them downwardly against a pair of transverse supporting bars 56*a* and 56*b* carried by a yoke 57. The yoke 57 rocks on pivots 58*a* and 58*b* (FIGURE 8) extending outwardly therefrom and supported in the housing of the switch. The two vertically movable members 53*a* and 53*b* are also relatively movable so that one may slide vertically relatively to the other as shown in FIGURE 7B. This relative vertical movement occurs when the yoke assembly 57 is rocked clockwise, as in FIGURE 7B, or counterclockwise. In the former case, the member 53*b* will be lowered and the member 53*a* raised, thereby freeing the movable member 55 for movement to the right toward the pole face 52*b* and at the same time imparting a pushing force thereto. The magnetic forces then come into play to urge the member toward the pole face 52*b*.

Disposed above the pole faces 52*c* and 52*b*, on either side of the movable member 55, are contact elements 59*a* and 59*b* supported from above in the housing. The contact elements are disposed relatively to the diameter of the movable member 55 and to the raised positions for the actuating members 53*a* and 53*b*, so that the member 55 will wipe and firmly seat itself in contact-closing position. The angle formed by the working face 54*a* of the actuating element 53*a*, and of the contact element 59*b* also controls the wiping and seating action which, in conjunction with the magnetic attraction between member 55 and the magnet 51, establishes the contact pressure.

The electrical circuit includes terminals 60*a* and 60*b* connected respectively to the contact elements 59*a* and 59*b* and a terminal 61*b* (FIGURE 8) connected to the pivot 58*b* by a conductor 62. The pivot shaft 58 is electrically connected to the transverse supporting bars 56*a* and 56*b* which support the actuating members 53*a* and 53*b*, the latter four elements all being electrically conducting. Thus, when the yoke 57 is rocked in a clockwise direction, as seen in FIGURE 7B, the movable member 55 will establish an electrical connection between the terminals 60*b* and 61*b*. When the yoke is rocked in a counterclockwise direction, the circuit will be completed between the contacts 60*a* and 61*b*. Each time the yoke 57 rocks, the supporting bars 56*a* and 56*b* wipe on the lower surface of the members 53*a* and 53*b*. When the yoke is in a horizontal position, as seen in FIGURE 7A, both circuits are open.

If desired, the central position for the movable member 55 can be utilized as a closed-contact position for a switch utilizing the elements 53*a* and 53*b* as the contacts. To this end, the inner sliding faces of the elements 53*a* and 53*b* are insulated either by spacing the two elements apart, or as illustrated in FIGURE 7A, by applying insulating layers 64*a*, 64*b*, such for example as nylon or Teflon to the sliding faces. In this arrangement, the yoke 57 is so arranged that one of the supporting bars 56*b* is electrically connected to the pivot 58*b* by the conductor 63, and the other bar 56*a* is connected to the pivot 58*a* by a conductor 65. The pivot 58*a* is connected to the terminal 61*a* by the conductor 66 and the pivot 58*b* is connected to a terminal 61*b* by the conductor 62. If it is desired to use a switch merely as a center-off switch, the terminals 61*a* and 61*b* can be bridged. When it is desired to use the switch with a supplementary set of contacts, the bridge is opened and the terminals 61*a* and 61*b* utilized as a switch connection, wherein actuation of the yoke, either in a clockwise or counterclockwise direction, opens the circuit between the terminals 61*a* and 61*b* while closing one or the other circuits between the terminals 60*a*–61*a* or 60*b*–61*b*.

The switch assembly can be actuated in any one of several ways by rocking the yoke 57. This can be accomplished by driving through the pivots 58*a*–58*b* or, as illustrated in FIGURE 7A, by the use of a bat handle actuator 68 pivoted to the housing at 69 and having its inner end 70 slidably received in a vertical channel 71 carried on the underside of the yolk 57. In operation, the handle 68, when disposed in its center position, as indicated in FIGURE 7A, will hold the yoke 57 in its horizontal position. To augment this position, it is preferred to provide a detent at the pivot 69. Swinging the handle 68 to the right, as indicated in FIGURE 7B, rocks the yoke in a clockwise direction and the over centering or toggle-like action of the movable member 55 will afford a positioning force for holding the handle in position.

The inwardly sloping surfaces 54*a* and 54*b* of the actuating members tend to hold the movable member 55 stably in its central position. Any tendency of the member 55 to move away from its central position while actuating members 53*a* and 53*b* remain in their neutral positions will require that the movable member increase its distance from the pole pieces of the magnet. Thus, the magnetic forces also contribute to stabilization in the central position. If desired, this magnetic holding force can be augmented by including an extension of the permanent magnet upward along the center axis of the switch beneath the movable member, this extension passing through the yoke 57 and through suitable openings in the actuating members 53*a* and 53*b*. Also, a positioning abutment 67, preferably formed of non-magnetic material, can be permanently mounted on the vertical axis of the switch directly above the movable member 55 which blocks movement of the member off of the actuating members 53*a* and 53*b* while the latter are in their neutral or horizontally matched positions. When the switch is actuated, however, causing one of the actuating members to move downward, the movable member is free to shift without engaging the abutment 67. Similarly, anchoring abutments 67*a* and 67*b* can be provided on the inner surfaces of the contact elements 59*a* and 59*b* respectively to block movement of the movable member out of either of its contact closing positions.

The center-off arrangement of FIGURES 7–8, while affording a central position for the movable member and hence a more flexible switch action, tends for some configurations to lack the strong magnetic toggle or snap action of the switch constructions of FIGURES 1–6. Referring to FIGURES 9 and 10 there is illustrated a switch 72 which incorporates both a center-off position as well as stronger snap action to the left and to the right of center. The switch 72 includes a housing 73, an actuator or handle 74 pivotally mounted in the housing, contact

terminals 75*a*, 75*b* and 75*c* and an actuating mechanism which selectively, through snap action, closes the circuit either between the contact terminals 75*a*–75*c* or the contact terminals 75*b*–75*c*. Mounted within the housing 72 is a fixed magnetic assembly including a pair of permanent magnets 76 and 77 having pole faces 76*a* and 77*a* bounding a central chamber 78 in which is mounted an actuating assembly indicated generally by the numeral 79.

The actuating assembly 79 includes a carrier arm 80 having a bifurcated tip 81 which receives a movable member 82 which is formed of magnetic material and which is preferably circular, the member 82 being loosely fitted between the arms of the bifurcated tip 81. The carrier arm 80 swings on a constraining pivot 83 supported in the housing 73 and electrically connected by a conductor 84 to the terminal 75*c*. As the carrier arm swings from its extreme lefthand position as illustrated in FIGURE 9 to its corresponding extreme righthand position, the movable member 82 is carried first out of contact with the contact blade 85*a* of the terminal 75*a* and into engagement with the contact arm 85*b* of the terminal 75*b*. The contact openings as well as the contact closing motion occurs with attendant snap action and passes through a stable or open circuit position at the center of its stroke.

To this end the actuating assembly 79, as best seen in FIGURE 10 includes, at the lower end of the carrier 83, a pair of interlock plates 86 and 87 of magnetic material. Both are constrained for pivotal movement by the shaft 83 which functions in the manner of the constraining elements or barriers 13, 13', 38 and 53 of FIGURES 1–8. Preferably the carrier arm 80 is rigidly secured to the pivot shaft 83 to afford good electrical contact therewith. The interlock plates 86 and 87 are joined to each other by studs 88 and 89 which pass through enlarged openings 90 and 91 in the carrier arm to afford lost motion. In this fashion the interlock plates 86 and 87 are coupled to the swinging carrier arm 80. The ends of both interlock plates 86 and 87, as well as the ends of the lower portion of the carrier arm 80, are slotted as best seen in FIGURE 9. The slots 87*a* and 87*b* define three magnetic pole tips 92*a*, 92*b* and 92*c* in the righthand end of the interlock plate 87. The interlock plate 86 is similarly contoured, as are the two ends of the interlock plate 87. Similarly the lower end of the carrier arm 80 is formed with pole tips 93*a*, 93*b*, and 93*c* on its lefthand end as well as similar pole tips on its righthand end (not shown). The several pole tips work in conjunction with the pole faces 76*a* and 77*a* of the permanent magnets 76 and 77.

The lower sides of the interlock plates 86 and 87 are notched to receive the working end 74*a* of the actuator or handle 74. Thus, as the handle 74 is swung to drive the assembly 79 toward its central position, the movable member 82 remains in engagement with the contact 85*a* until such time as the central pole tips, of which the tips 92*b* and 93*b* are examples, come under the influence of the attracting force of the flux in the pole faces 76*a* and 77*a*. At the time the actuator assembly 79 snaps to its central position, it drives the member 82 away from the contact 85*a*. In a similar fashion, the member 82 can be snapped into engagement with the contact 85*b* or back into engagement with the contact 85*a* to complete the electrical circuits.

In certain cases it is desired to apply additional magnetic force to hold the movable member in engagement with one or the other of its contacts. To this end, the permanent field magnets 76 and 77 can be formed with slotted pole tips 94 and 95 which terminate adjacent the contacts 85*a* and 85*b* respectively. The slotted pole tips receive a portion of the free end of the carrier arm 80 and thus allow the movable member 82, which is magnetic, to be brought into close proximity with a pole face so that the magnetic forces augment those generated in the lower pole tips 76*a* and 77*a*. As in the case of the arrangements of the switches described above, the use of a central terminal 75*c* connected to the pivot shaft 83 and hence to the movable member 82 through the carrier arm 80, can be omitted by providing pairs of spaced apart contacts and terminals which are bridged by the movable member 82 at either end of its stroke, in the manner illustrated in FIGURE 3, for example. In such cases it is preferred to utilize a roller configuration for the movable member 82 which might otherwise take the form, for example, of a ball.

In case multiple contacts are provided at each end of the stroke, it is preferred that the carrier arm 80, at least at its upper end, be formed of electrically insulating material.

It will be understood that various combinations of the features and structures described above and illustrated in the drawings can be incorporated in a given switch design, depending on the particular requirements for the switch. In most cases a magnetic toggle action is provided which is strong and fast acting while requiring a minimum of mechanical parts, none of which is required to function as a spring. Also, while the invention has been shown and described in representative embodiments for purposes of illustration, it can take various other forms and arrangements and should not be regarded as limited except as defined by the following claims.

I claim:

1. An electrical switch comprising a housing, a magnetic assembly including at least a pair of complementary relatively movable magnetic parts, at least one of the parts having pole faces to which the other is relatively attracted, the other part comprising a switch member, constraining means including a barrier interposed in the path of relative movement to define, together with the mutual magnetic attraction of the magnetic parts, said barrier engaging the switch member in all positions of equilibrium, a plurality of positions of stable equilibrium for the relatively movable parts, actuating means to shift the parts between positions of equilibrium and electrical contact means controlled by the relative movement thereof.

2. An electrical switch comprising a housing, a magnet assembly including at least a pair of complementary, relatively movable magnetic parts, one part having a pair of pole faces between which the other moves, said other part comprising a movable switch member, barrier means interposed between the pole faces and normally engaging the switch member in all of its positions, at least a pair of abutment means flanking the movable switch member and disposed respectively adjacent the pole faces, said movable switch member having at least a pair of stable positions of equilibrium between the barrier and the respective abutment means, the switch member being held in said positions under the influence of magnetic attraction of the proximate pole face and switch actuating means to shift the movable switch member between stable positions.

3. Apparatus as set forth in claim 2, said barrier means being movable to drive the movable switch member out of either of its stable positions to assume the other position.

4. Apparatus as set forth in claim 2, said movable switch member being circular, said barrier means comprising a relatively narrow edge engaging the movable switch member and over which the switch member rolls in assuming its stable positions, the switch member being unstably supported by the edge in the absence of the abutment means.

5. Apparatus as set forth in claim 2, said abutment means being inclined to define a wedging action to support the movable switch member together with said barrier means.

6. Apparatus as set forth in claim 2, said movable

switch member, abutment means and barrier means all being electrically conducting.

7. Apparatus as set forth in claim 2, including movable contact members supported in the housing and adapted to be engaged by the movable switch member to be driven into contact-closing positions.

8. Apparatus as set forth in claim 2, including electromagnetic means to shift the movable switch member between its stable positions.

9. Apparatus as set forth in claim 8, including a pair of electro-magnetic coils associated respectively with the stable positions of the movable switch member.

10. Apparatus as set forth in claim 2, said movable switch member being circular and divided with a plurality of laterally spaced, electrically conducting parts, a common support for said parts, and a plurality of electrical contacts associated respectively with said parts to be actuated thereby.

11. Apparatus as set forth in claim 2, said movable switch member being circular and divided into a plurality of laterally spaced, electrically conducting circular parts each electrically insulated from the next, a common support for said parts affording rotation and relative translation movement thereof, and electrical contacts associated with each of said parts to be actuated thereby.

12. Apparatus as set forth in claim 2, said barrier means including at least a pair of relatively movable parts mounted for movement transversely of the flux path between the pole faces.

13. Apparatus as set forth in claim 12, said barrier being mounted between the pole faces of the magnet and including a pair of relatively movable members movable transversely across the magnetic flux between the pole faces, said relatively movable barrier member defining on their upper surface a seat to receive and support the movable member in a stable central position between the pole faces, said switch actuating means being connected to the movable barrier members to establish relative movement to disable the seat for the movable member and to urge the member in the direction of one or the other pole faces to be captured by the magnetic attraction thereof.

14. Apparatus as set forth in claim 13, said relatively movable barrier members being movable in differential motion with one member retracting between the pole faces of the magnet and the other moving outwardly therefrom, said members each including an inwardly sloping face to define when the parts are side by side a concave seat for stably supporting the switch member, and to define singly an inclined ramp pitched toward a pole face.

15. Apparatus as set forth in claim 13, said movable switch member being circular, and an abutment above the movable switch member when seated on said barrier members to block the movement of the movable switch member from the seat in the absence of differential movement of the barrier members.

16. Apparatus as set forth in claim 15, said electrical contact means each including an abutment to block the movement of the movable switch member out of its stable position when the relatively movable barrier members are differentially displaced.

17. Apparatus as set forth in claim 13, said movable barrier members and said switch member being electrically conducting, means to electrically insulate one barrier member from the other, whereby the movable switch member, seated thereon, affords an electrical path between the barrier members, and electrical terminals connected to the respective barrier members, whereby a switch section is provided in addition to that afforded by the arrayed electrical contact means and the barrier.

18. Apparatus as set forth in claim 13, said switch actuating means including a pivot member supported generally between the movable barrier members and engaging the respective barrier members and engaging the respective barrier members on opposite sides of the pivot axis, and means to rock the pivot member to withdraw one movable barrier member between the pole faces and to extend the other outwardly across the flux path.

19. Apparatus as set forth in claim 18, said pivot member including a pair of electrically conducting members slidably engaging the respective barrier members on a transverse surface thereof, said electrically conducting members being electrically insulated from one another, and a pair of electrical terminals connected respectively to said electrically conducting members.

20. Apparatus as set forth in claim 18, said switch actuating means including a handle pivotally mounted in the housing, a pair of shoulders on the pivot member embracing the inner end of the handle, the outer end of the handle extending outwardly from the housing to form an actuating lever for the switch, whereby the central position of the handle holds the movable barrier members in side-by-side relationship to define a stable seat for the movable member and, when moved to one side or the other, differentially displaces the barrier members to urge the movable member toward one or the other of said pole faces to be seated thereadjacent in switch-actuating positions.

21. Apparatus as set forth in claim 2, said permanent magnet being movably mounted in the housing, said barrier means being supported by the magnet.

22. Apparatus as set forth in claim 1, said constraining means comprising a pivot supported by the housing, one of said relatively movable parts comprising an elongated member centrally supported by the pivot and having pole faces at its ends, second pole faces on the other magnetic part, opposing and complementary to the respective pole faces on said one part, at least one pole face being formed with a plurality of sections to define a plurality of positions of stable equilibrium, said electrical contact means being controlled by said elongated member.

23. Apparatus as set forth in claim 22, including a switch member, a carrier for the switch member mounted on said pivot, and a lost motion coupling between the elongated member and the carrier member.

24. Apparatus as set forth in claim 22, including a circular switch member, a carrier for the switch member supported by said pivot, said switch member being movable in the carrier in the direction of pivotal movement, electrical contact means being disposed to be engaged by the switch member at extreme positions of pivotal movement of the carrier, and means connecting the elongated member and the carrier.

25. Apparatus as set forth in claim 24, including magnetic pole pieces disposed adjacent said contact means, said switch member being magnetic.

26. Apparatus as set forth in claim 25, said pole faces adjacent said contacts having openings to receive said carrier.

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