Dec. 24, 1968 W. R. POUNDS 3,418,611

MAGNETICALLY ACTUATABLE SWITCH HAVING NON-LINEAR CONTACTS EMBEDDED WITHIN RESINOUS SWITCH HOUSING

Filed Aug. 1, 1966 2 Sheets-Sheet 1

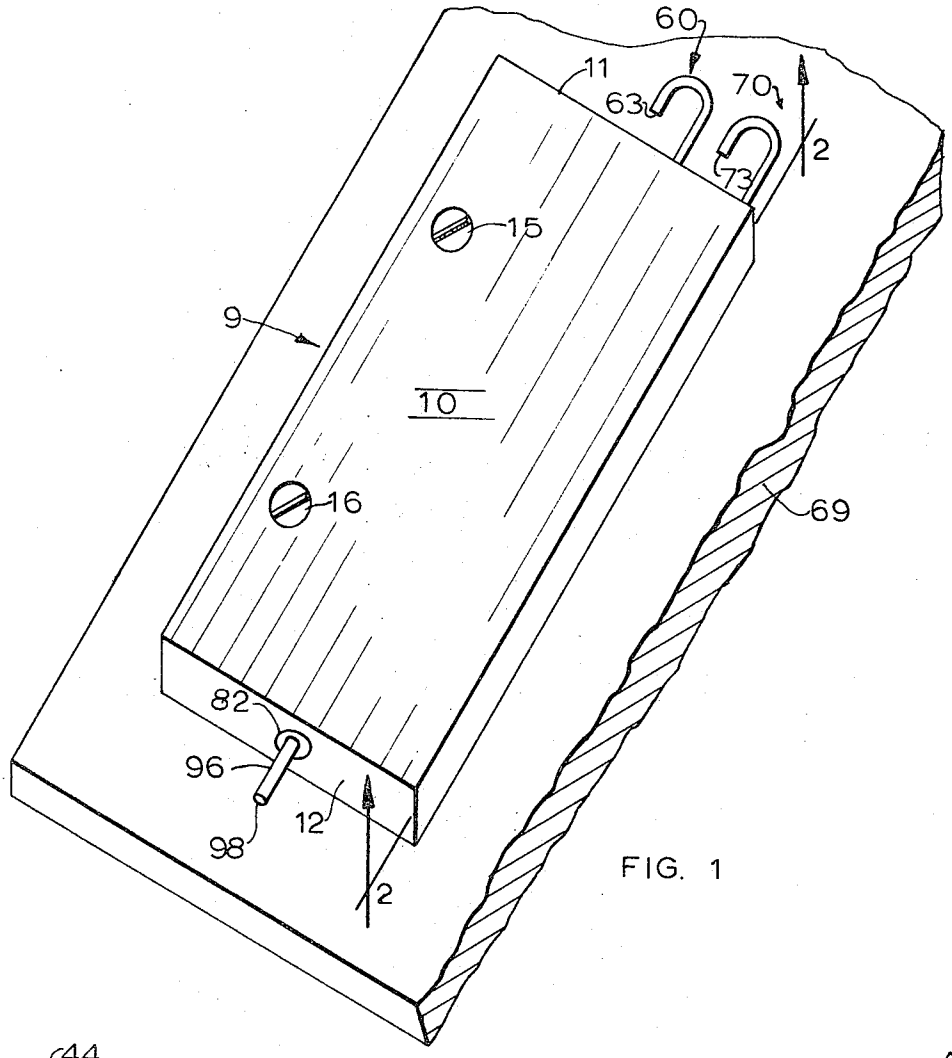


FIG. 1

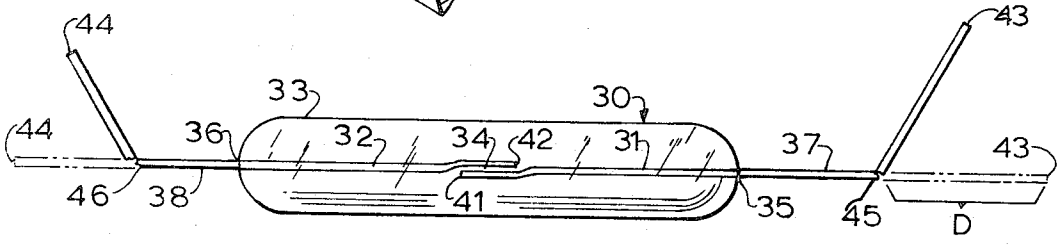


FIG. 3

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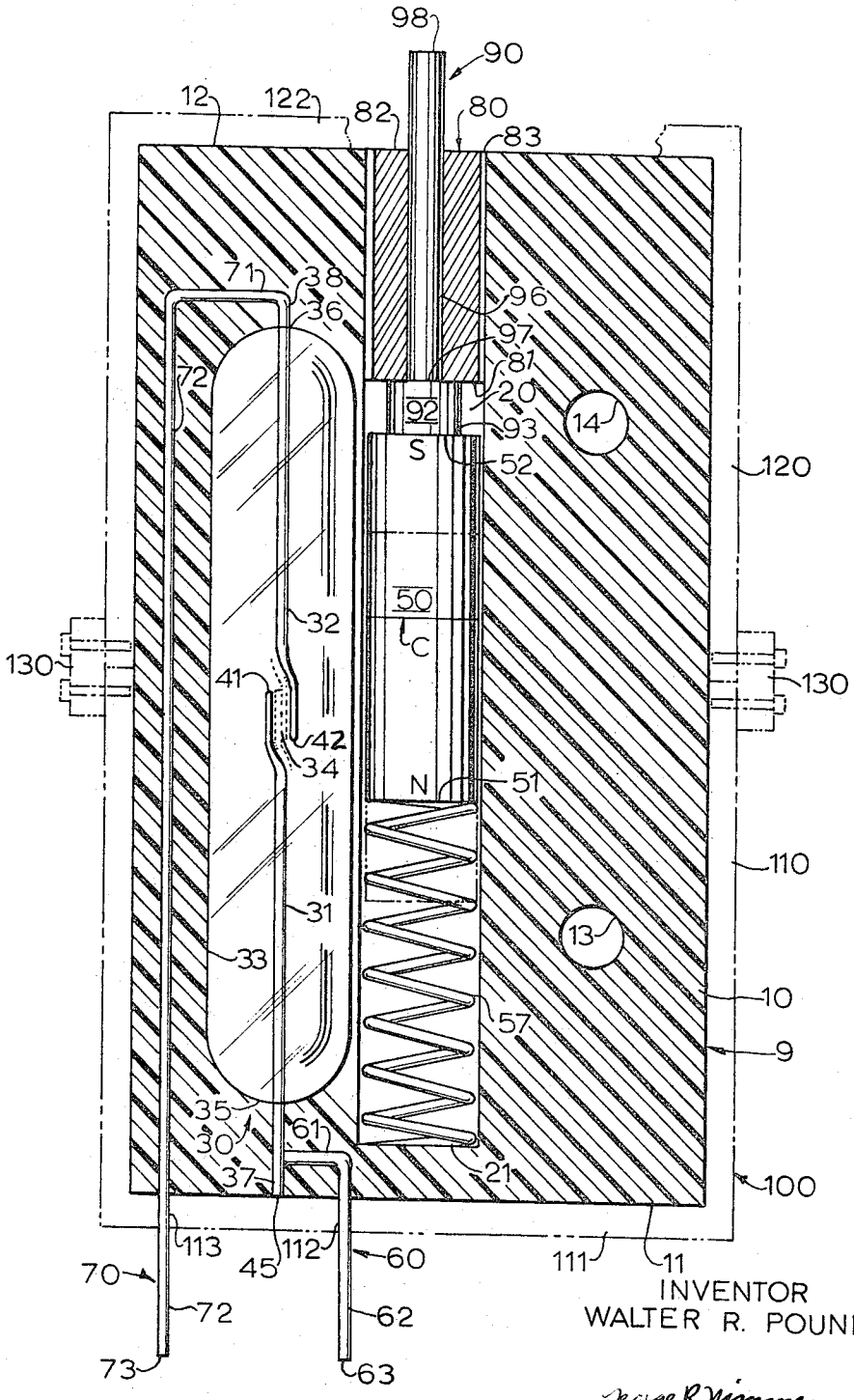


FIG. 2

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MAGNETICALLY ACTUATABLE SWITCH HAVING NON-LINEAR CONTACTS EMBEDDED WITHIN RESINOUS SWITCH HOUSING

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4 Claims. (Cl. 335—205)

ABSTRACT OF THE DISCLOSURE

A magnetically actuatable reed switch having an unusually high degree of resistance to shock, vibration, and to atmospheric chemicals such as oxygen and water vapor, said switch being amenable to economical manufacture without detracting from the switch quality and reliability. The switch comprises a resinous matrix housing and several internal components disposed within said housing at a specified spacial relationship including non-linear portions of the switch contacts being rigidly embedded into the resinous matrix housing.

Magnetically actuatable reed switches of miniature size are exceedingly difficult to manufacture because the reeds and actuation magnet must be precisely positioned in relationship with each other to result in an operable structure. For example, in the prior art the degree of skill necessarily to be exercised by the assembly worker is akin to that of a precision watchmaker, and appropriately, the compartmentalized metallic matrix for the switch is termed a "watch case" in the jargon of the trade. Consequently, the great deal of hand labor necessary results in an expensive product and in unpredictable quality and reliability. Further, the use of a compartmentalized matrix for hand setting the various switch components into the required spacial relationship results in a product having poor resistance to shock and vibration and having poor resistance to atmospheric chemicals.

It is accordingly a general object of the present invention to provide an improved magnetically actuatable reed switch that overcomes many of the disadvantages of the prior art.

It is a specific object of the present invention to provide a magnetically actuatable reed switch construction that lends itself to mass production techniques requiring a minimal degree of hand labor.

It is another object to provide a magnetically actuatable reed switch having an unusually high degree of resistance to shock and vibration and to atmospheric chemicals including oxygen and water vapor.

It is yet another object to provide a magnetically actuatable reed switch, the construction of which is amenable to consistent and reproducible high quality and uniformity of internal structure and performance.

It is yet another object to provide a magnetically actuatable reed switch that is functionally independent and that is resistant to magnetic interference from adjacently positioned switches of the same type.

With the above and other objects and advantages in view, which will become apparent as the description proceeds, the invention comprises the novel form, combination, and arrangement of parts as hereinafter more fully described, reference being had to the accompanying drawings wherein like numbers refer to like parts in the several views and in which:

FIGURE 1 is a perspective view of the magnetically actuable switch of the present invention shown abuttably mounted against an external panel member.

FIGURE 2 is sectional plan view of the magnetically actuatable switch of the present invention taken along line 2—2 of FIGURE 1.

FIGURE 3 is a perspective view of a standard dual-reed assembly which provides an essential raw material component of the invention.

The magnetically actuatable switch assembly **9** of the present invention comprises: an outer housing **10** of a structurally-continuous resinous material that provides a hermetically sealed unit while also maintaining the spacial relationship of certain interior components; a longitudinally disposed cavity **20** for housing **10** commencing at the rearward end **12** of housing **10**; a permanent elongate bar magnet **50** slidably disposed axially along internal cavity **20**, said magnet **50** being biased against a spring means **57**; a dual-reed assembly **30** disposed within housing **10** substantially parallel to cavity **20**; a pair of electrically-conductive contacts **60** and **70** extending outwardly from the forward end **11** of housing **10**; and actuation means to cause permanent bar magnet **50** to travel a prescribed distance along cavity **20** so as to alter the position of reeds **31** and **32** with respect to each other.

As can best be seen in FIGURE 3, the dual-reed assembly **30** is a standard, commercially-available component generally employed as a switching mechanism within electronic circuit packages. Dual reed assembly **30** comprises a pair of substantially colinear magnetically-permeable reeds including a forward reed **31** and a rearward reed **32** said reeds **31** and **32** being disposed within an elongate envelope **33**, the structural material of which is relatively magnetically-impermeable. By "magnetically-permeable" material is meant that along which magnetic flux tends to travel or "shunt" as for example ferrous, nickelous, and cobaltous materials, and "magnetically-impermeable" denotes those materials e.g. resins, glass etc., that will not appreciably "shunt" or divert therethrough magnetic lines of flux. Accordingly, the reeds **31** and **32** are usually supplied as flexible straps of ferrous metal and the elongate envelope **33** is ordinarily of glass material. At a forward portion of reed **31** near the forward end **35** of envelope **33**, the generally strap-like forward reed **31** narrows into a forward lead **37** of circular cross-sectional shape and the glass envelope **33** is fusibly welded around forward lead **37** to provide a sealed forward end **35** for elongate envelope **33**. Similarly, at a rearward portion of reed **32** near the rearward end **36** of envelope **33**, the generally strap-like rearward reed **32** narrows into a rearward lead **38** of circular cross-sectional shape, and the glass envelope **33** is fusibly welded around rearward lead **38** to provide a sealed rearward end **36** for elongate envelope **33**.

The rearward end **41** of forward reed **31** is slightly offset with respect to the main body of reed **31** and the forward end **42** of rearward reed **32** is similarly offset with respect to the main body of reed **32** so that the adjacent ends **41** and **42** overlap each other for a finite distance to provide a spatial gap **34** between reed ends **41** and **42**. Thus, the normally flexible magnetically-permeable reeds are adapted to flex across gap **34** and to contact each other near their adjacent ends **41** and **42** when when a source of magnetic flux is brought nearby so as to provide an electrically conductive relationship between reeds **31** and **32**.

As commercially supplied, most dual reed assemblies **30** are provided with leads **37** and **38**, each having a definitely prescribed length as measured from gap **34** to the original termini **43** and **44**. A method step in the making of switch assembly **9** comprises severing forward lead **37** a prescribed distance "D" from forward terminus **43** to provide a forward end **45** for forward lead **31**, said forward lead end **45** extending a finite distance externally of envelope forward end **35**. Similarly, rearward lead **38**

is severed to provide a rearward end 46 for rearward lead 38, said rearward lead end 46 extending a finite distance externally of envelope rearward end 36.

As can best be seen in FIGURE 2 which illustrates the interior configuration of magnetically actuatable switch 9, a pair of rod-like electrically-conductive L-shaped contacts 60 and 70 are attached in electrically-conductive relationship, as by resistance welding to leads 37 and 38. The shorter transverse arm 61 of a first L-shaped rod-like contact 60 is attached to forward lead 37, preferably between forward lead end 45 and envelope forward end 35, and at least the rearward portion of the longer longitudinal arm 62 of contact 60 extends forwardly of assembly 30 substantially parallel to its longitudinal central axis, to reeds 31 and 32, and to the longitudinal central axis of cavity 20. Similarly, the shorter transverse arm 71 of a second L-shaped rod-like contact 70 is attached to rearward lead 38, and the major portion of the longer longitudinal arm 72 of contact 70 extends along the length of assembly 30 substantially parallel to the longitudinal axis thereof, to reeds 31 and 32, and to the longitudinal central axis of cavity 20. Longitudinal arms 62 and 72 extend beyond the forward end 11 of housing 10 a prescribed distance and the outward termini 63 and 73 of contacts 60 and 70, respectively, preferably extend equal distances beyond housing forward end 11.

Housing 10 comprises a structurally-continuous matrix of a resinous material that both hermetically seals and maintains a rigid relationship for assembly 30, leads 37 and 38, and portions of contacts 60 and 70. Resinous housing 10, which may be of the block-like external form shown in FIGURE 1, fills the interstices between leads 37 and 38, L-shaped contacts 60 and 70, and reed assembly 30. Further structural details of housing 10 will be explained later in conjunction with the method manufacture therefor.

Housing 10 includes an elongate cavity 20, preferably of circular cross-sectional shape, commencing at and perpendicularly to the housing rearward end 12 and having a forward end 21 disposed internally of housing 10 rearwardly of forward end 11. The longitudinal central axis of cavity 20 is substantially parallel to the longitudinal central axis of assembly 30, to reeds 31 and 32, and to contact longitudinal arms 62 and 72. Cavity 20 passes in parallelism alongside envelope 33. Although the resinous structural material of housing 10 is magnetically-impervious, very close spacing between cavity 20 and assembly 30 is desirable, and accordingly, at least that elongate exterior surface of envelope 33 adjacent to cavity 20 is preferably of smoothly linearly generated configuration. For ease of manufacture and in order to practically nullify any space between cavity 20 and assembly 30, envelope 33 is desirably of an elongate cylindrical nature. There must be a finite permanent separation between cavity 20 and contacts 60 and 70 and leads 37 and 38, and the resinous structural material of housing 10 is adequate to the attainment of this objective. Housing 10 includes a plurality of perforations therethrough e.g. 13 and 14, so that switch 9 may be conveniently mounted to an external panel e.g. 69, as by means of screws 15 and 16 passing through holes 13 and 14, respectively, and into mounting panel 69.

There is a permanent bar magnet 50 having a permanently positioned "North" pole N at one end and a permanently positioned "South" pole S at the other end. Although in FIGURE 3 "North" pole N is shown at the rearward end 52 of magnet 50 while "South" pole S is shown at the forward end 51 of magnet 50, the polarity positions of magnet 50 could be reversed without departing from the spirit of the invention. Magnet 50 is slidably disposed longitudinally along cavity 20, in substantial parallelism with reeds 31 and 32. Since a permanent bar magnet e.g. 50, has its greatest degree of flux density and lateral flux extension at the longitudinal midpoint C, rather than at ends N or S, such permanent bar magnets are commonly moved in parallelism along the colinear reeds of a dual-reed apparatus e.g. 30, to cause the reeds to either draw physically together or to separate apart at gap position 34, depending upon position of magnet midpoint C with respect to gap position 34, thus switching electrical current along reeds 31 and 32. Consequently, in the art the length and flux density for a reciprocatable magnet e.g. 50, are chosen empirically based upon the following variables: the size and stiffness of reeds 31 and 32, the width of spatial gap 34, the desired length of travel for magnet 50 alongside apparatus 30, the distance between magnet 50 and reed 31 and 32, and the degree of magnetic-impermeability for envelope 33. The same type empirical determination must be made with regard to the magnet 50 component of switch 9 with an added variable being the degree of magnetic-impermeability for any resinous material of housing 10 that might exist between cavity 20 and apparatus 30. Having empirically chosen the size and flux density for permanent magnet 50, the reeds 31 and 32 will physically draw together when magnet midpoint C is adjacently alongside gap position 34 (as can be seen in phantom line in FIGURE 2), and said reeds will assume their normal separation when magnet midpoint C is at another position remote of gap position 34.

Magnet 50 is slidably disposed along cavity 20 so that it may pass in substantial parallelism alongside reeds 31 and 32. There is a spring means biased against magnet 50 to normally urge magnet 50 at a normal or first station such that magnet midpoint C is normally positioned right at or at a given distance rearwardly of gap position 34. Preferably, the spring means is a helical spring 57 positioned within cavity 20 between magnet forward end 51 and cavity forward end wall 21. There is electrical insulation means between cavity forward end wall 21 and contacts 60 and 70 and reeds 37 and 38, herein as the resinous material of housing 10.

There are actuation means to cause permanent bar magnet 50 to travel a prescribed distance along cavity 20 from its normal station to a second station, one of said two magnet stations resulting in a magnetic drawing together or "closing" of the magnetically-permeable reeds 31 and 32 at gap position 34, and the second of said two magnet stations exerting little or no effect upon reeds 31 and 32 allowing them to assume their normal "open" spacing at gap position 34. The said actuation means may comprise a tubular bushing 80 and a plunger member 90. Tubular bushing 80 is of similar cross-sectional shape to that of cavity 20, both being preferably circular, and bushing 80 is positioned with cavity 20 at the rearward end thereof, the rearward surface 82 of bushing being substantially planar and being preferably substantially coplanar with the rearward end 12 of housing 10. Bushing 80 may be frictionally engaged at said rearward extremities of housing 10 and cavity 20, the cross-sectional size of bushing 80 being slightly greater than the cross-sectional size of cavity 10, bushing 80 preferably having exterior longitudinal grooves 83 to facilitate frictional engagement with housing 10. Plunger 90 includes a narrower shank portion 96 slidably engaged within the longitudinal bore of bushing 80 and a wider head portion 92 integrally connected at the forward end 97 of shank 96, head portion 92 being cross-sectionally larger than the bore of bushing 80 so that head 92 is maintained forwardly of bushing forward end 81. The rearward end 98 extends a finite distance rearwardly of bushing rearward end 82. The distance between shank rearward end 98 and bushing rearward end 82 determines the maximum amount of slidable forward travel for plunger 90 and magnet 50 from magnet normal rearward station (shown in solid line in FIGURE 2) and magnet second forward station (shown in phantom line in FIGURE 2). As can be seen in FIGURE 2, at its normal spring-biased rearward station, the mid-point C of magnet 50 is rearwardly remote of gap position 34 and dual-reed apparatus 30 is normal-

ly open. However, when the plunger **96** is depressed forwardly against spring means e.g. **57**, the full prescribed distance i.e. between **98** and **82**, the magnet midpoint C is brought alongside gap position **34** to magnetically draw the flexible reeds **31** and **32** together to complete a circuit path from contact **60** to reed **31** to reed **32** to contact **70**. On the other hand, to provide a normally closed type switch, the midpoint C of magnet **50** should be adjacent to gap position **34** at the magnet's normal rearward station, and this can be accomplished by employing a lengthier bushing **80** or by employing a lengthier plunger head **92** or a composite lengthening of both bushing **80** and head **92**.

As explained above, the relative positions of the normally rearward and the forward stations for magnet **50** must be determined with a high degree of exactness, and thus during the manufacture of actuatable switch **9** there is a problem in fixing the critical distance between bushing rearward end **82** and gap position **34**. In order to attain the critical spacing it has been found exceedingly desirable to mold the resinous housing **10** with planar ends **11** and **12**, as for example with the block-like housing shown in FIGURE 1. Accordingly, the housing mold **100** (shown in phantom line surrounding housing **10** in FIGURE 2) comprises two abuttable parts appropriate to the molding of a block-like housing **10**, said mold **100** including a forward part **110** having a planar forward end **111** to provide a planar housing forward end **11** and including a rearward part **120** having a planar rearward end **122** to provide a planar housing rearward end **12**. The mold parts **110** and **120** are maintained abuttably together as by means of suitable fastener means **130**. Mold rearward part **120** includes an interior shaft portion (not shown) perpendicular to rearward end **122** to provide a longitudinal cavity e.g. **20**, in conventional fashion. Mold **100** also includes a conventional inlet (not shown) for introducing a fluidized form of the resin to be employed for housing **10**.

The forward panel of mold forward part **110** includes a pair of substantially parallel perforations **112** and **113** at forward end **111** for accommodation of the longitudinal portions **62** and **72** of contacts **60** and **70** during the injection molding process. Since perforations **112** and **113** are substantially perpendicular to forward end **111** and to rearward end **122**, and since contact longitudinal arms **62** and **72** are substantially parallel to each other and to cavity **20** and to reeds **31** and **32**, cylindrical envelope **33** is made to be substantially parallel to cavity **20**. Since the mold parallel opposite ends **111** and **122** are spaced apart a prescribed distance, and since the bushing rearward end **82** will be at housing rearward end **12**, bushing rearward end **82** is fixedly spaced with respect to housing forward end **11**. In order to attain the critical spacing between bushing rearward end **82** and gap position **34**, the spacing between gap position **34** and housing forward end **11** e.g. mold forward end **111**, must be accurately provided, and this is desirably accomplished by abutting forward lead forward end **45** against the mold forward end **111** during the molding process. As has been pointed out earlier, the distance between gap position **34** and forward lead forward end **45** is determined by severing forward lead **37** at a measured point **45**. Thus, by virtue of the fixed distance between mold ends **111** and **122**, by virtue of the fixed distance between gap position **34** and forward lead forward end **45**, and by virtue of the forward lead forward end **45** abuttable position against mold end **111**, the distance between gap position **34** and bushing rearward end **82** (which is coplanar with housing rearward end **12**) is accurately determined. Accordingly, in the final product **9**, forward panel forward end **45** is substantially conterminous with housing forward end **11**. Of course, the contacts **60** and **70** together with forward lead **37** must have sufficient columnar structural strength to uprightly support envelope **33** and the enclosed reeds **31** and **32** within mold **100** during the molding operation.

The elongate bar magnet element e.g. **50**, is preferably of uniform cross-sectional shape along substantially the entire length thereof, the rectangular and circular cross-sectional shapes being typical. Surprisingly, it has been found that cylindrical bar magnets (as shown in FIGURE 2) are superior to rectangular cross-sectional shapes because the cylindrical shape minimizes the effects of inter-switches magnetic interference when groups of switches are employed in side-by-side relationship.

The resinous material for housing **10** is preferably of the thermoplastic resinous type which may be liquified for an injection molding process. The resinous material may contain appropriate pigments and fillers, including reinforcing glass fibers. The resin must remain solid at the rated operating temperature for switch **9** which is about 300° F. Accordingly "nylons" (condensation products of acrylonitrile and hexamethylene diamine) are preferred since they are comparatively heat stable and will not melt at 300° F. and will moldably form at 575° F. Nylons are relatively moisture impervious and will adequately seal the apparatus **30** and its contacts **60** and **70** from damaging environments. The elongate arms of contacts **60** and **70** are preferably flexible so that those portions extending forwardly of housing forward end **11** may be bent to whatever configuration desired.

From the foregoing, the construction and operation of the magnetically actuatable switch will be readily understood and further explanation is believed to be unnecessary. However, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the appended claims.

I claim:

1. A magnetically actuatable switch comprising:

(A) A pair of magnetically-permeable flexible reeds disposed in substantially colinear relationship, the first of said reeds being a forward reed and the second of said reeds being a rearward reed, adjacent portions of said reeds overlapping each other in substantially parallel relationship to provide a finite spacial gap position between the forward end of the rearward reed and the rearward end of the forward reed, a first L-shape rod-like contact for the forward reed the transverse arm of the first L-shaped contact being attached in electrically conductive relationship to the forward reed at least a portion of the longitudinal arm of the first contact being substantially parallel to the said reeds, a second L-shaped rod-like contact for the rearward reed the transverse arm of the first L-shaped contact being attached in electrically conductive relationship to the forward reed at least a portion of the longitudinal arm of the first contact being substantially parallel to the said reeds, the first and second contacts being provided of an electrically-conductive material having sufficient structural strength that when the longitudinal arm is uprightly positioned in columnar configuration said longitudinal arm will support the associated reed in substantial parallelism to the contact longitudinal arm,

(B) A structurally-continuous housing for said switch, said housing providing a matrix that substantially surrounds and supports the transverse arms and at least a portion of the longitudinal arms of said L-shaped contacts whereby rearward portions of the contacts are maintained substantially parallel to each other, the spacial gap position for said reeds being devoid of the resinous material, the forward portions of the contacts extending forwardly of the housing forward end, said housing including an elongate cavity that commences at the housing rearward end, said housing cavity having a forward terminus within said housing

nearer to the forward end of the housing, the longitudinal central axis of said cavity being substantially parallel to and spaced a finite distance from said reeds,

(C) A permanent bar magnet slidably disposed along the longitudinal central axis of the housing cavity, said bar magnet having a permanently positioned North pole at a first end and a permanently positioned South pole at a second end, one of the magnet polar ends being permanently positioned nearer to the cavity forward terminus than is the other magnetically polar end, the combination of the distance between the reeds spacial gap position and the flux density of said permanent magnet being such that when the longitudinal midpoint of the bar magnet is in adjacently opposite registry with the reeds spacial gap position, the magnetically permeable reeds will contact each other, and that when the longitudinal midpoint of the other bar magnet moves to another position within the cavity remote of the reeds spacial gap position, the reeds will become separated at the reeds spacial gap position.

(D) Spring means to resiliently urge the permanent bar magnet to a normal first station within said housing cavity, and

(E) Actuation means to cause the permanent bar magnet to move a prescribed distance along the housing cavity from a normal station to a second station, one of said two stations resulting in a magnetic drawing together of the reeds at the spacial gap position and the second of said two magnet stations causing the reeds to assume a finite spacial gap at the spacial gap position.

2. The magnetically actuatable switch of claim **1** wherein the magnetically-permeable flexible reeds are disposed within a relatively magnetically-impermeable elongate envelope having at least one elongate linearly generated surface that is substantially parallel to said reeds and that is positioned between the reeds and the housing elongate cavity, the forward reed being affixed to a forward portion of the envelope.

3. The magnetically actuatable switch of claim **2** wherein the magnetically-permeable flexible reeds are of strap-like flattened configuration; wherein the elongate envelope is a substantially cylindrical glass tube, the linearly generated exterior surface thereof being substantially parallel to the reeds and to the longitudinal central axis of the housing cavity; wherein the forward end of the forward reed includes a forward lead portion that extends a finite distance forwardly of the envelope forward end to provide a forward lead forward end and wherein the rearward end of the rearward reed includes a rearward lead portion that extends a finite distance rearwardly of the envelope rearward end to provide a rearward lead rearward end, the glass envelope being fused to the forward and rearward leads to attach the reeds to the envelope; wherein the transverse arms of the contacts are of shorter length than the longer longitudinal arms thereof, wherein the transverse arms of the contacts are attached to the leads externally of the glass envelope, wherein the longitudinal arm of the second L-shaped contact passes along the entire elongate length of the glass envelope, and wherein rearward portions of the contacts longitudinal arms are substantially parallel to each other, to the reeds and to the longitudinal central axis of the housing cavity; wherein the longitudinal arms of the contacts are flexible yet of sufficient structural strength that when the longitudinal arms are uprightly positioned as parallel columns said longitudinal arms will support the glass envelope and the enclosed reeds in substantial parallelism to the contacts longitudinal arms; wherein the structurally-continuous resinous housing ing substantially surrounds the envelope whereby the envelope is maintained in a fixed spacial separation with respect to the contacts transverse arms and to the housing cavity; wherein the spring means is a helical spring positioned at the forward terminus of the housing, the resinous material providing electrically-insulative separation between the helical spring and the reeds.

4. The magnetically actuatable switch of claim **3** wherein the housing is of a block-like configuration having a pair of substantially parallel ends including a forward end and a rearward end, the housing cavity having a substantially uniform circular cross-sectional shape, said housing cavity being substantially perpendicular to the housing rearward end; wherein the leads are substantially colinear with the reeds; wherein the first contact shorter transverse arm is perpendicularly attached to the forward lead between the forward end thereof and the glass envelope; wherein the forward end of the forward lead is substantially conterminous with the housing forward end; and wherein the actuation means comprises a bushing having a longitudinal bore along the cavity longitudinal axis and a plunger member, the bushing being engaged within the cavity at the rearward end thereof, the rearward end of the bushing being substantially conterminous with the housing rearward end, the plunger comprising a headed portion and an integral shank portion, the shank portion being slidably disposed within the bushing bore, the rearward terminus of the shank extending a finite distance rearwardly of the housing rearward end, the plunger head being disposed within the cavity forwardly of the bushing, the cross-sectional size of the plunger head being greater than that for the bushing bore, said helical spring means normally urging the magnet toward the housing rearward end so as to normally abut the plunger head against the forward end of the bushing.

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