May 2, 1967 J. A. BEAR 3,317,870

MAGNETICALLY OPERATED SWITCHES

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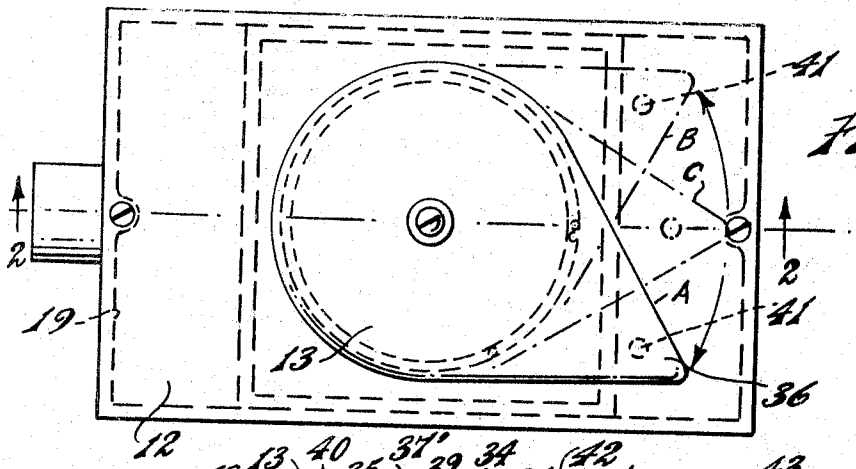


Fig. 1.

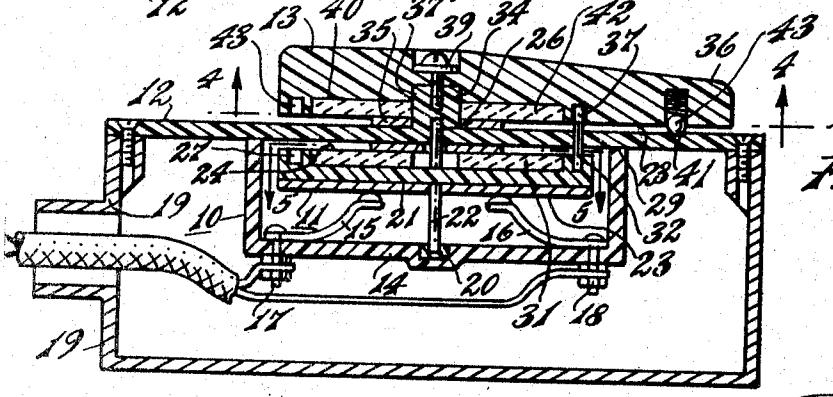


Fig. 2.

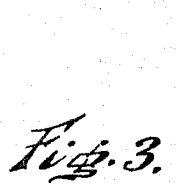


Fig. 3.

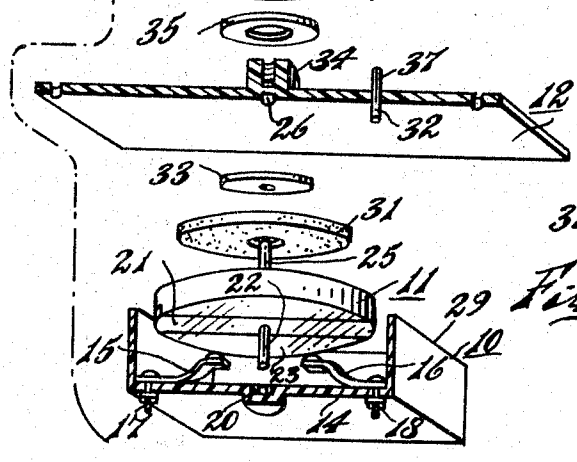
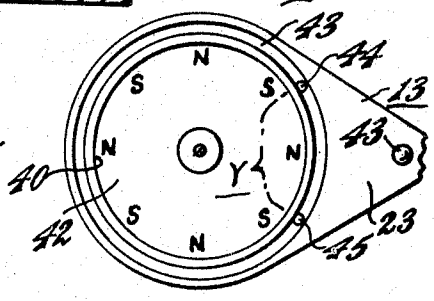


Fig. 4.



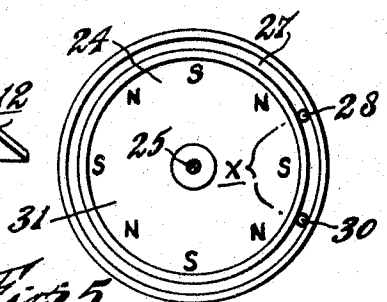


Fig. 5.

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MAGNETICALLY OPERATED SWITCHES

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Fig. 6.

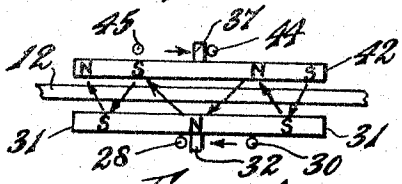


Fig. 7.

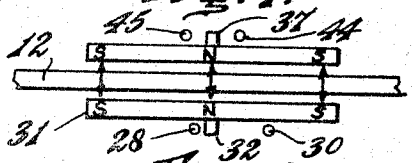


Fig. 8.

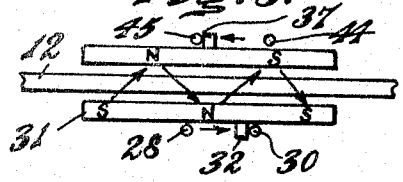


Fig. 9.

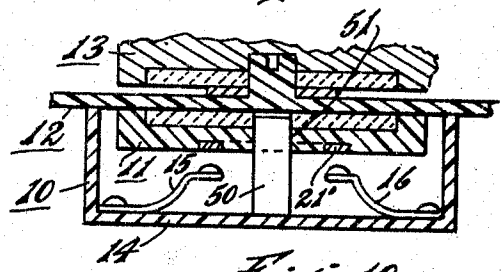


Fig. 10.

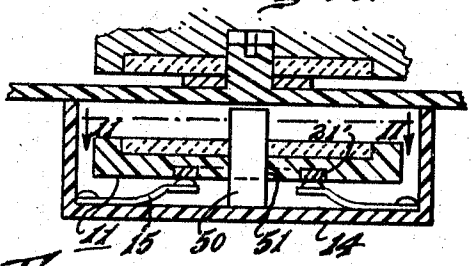


Fig. 11.

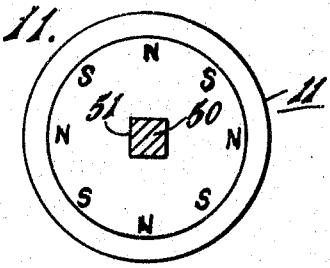


Fig. 12.

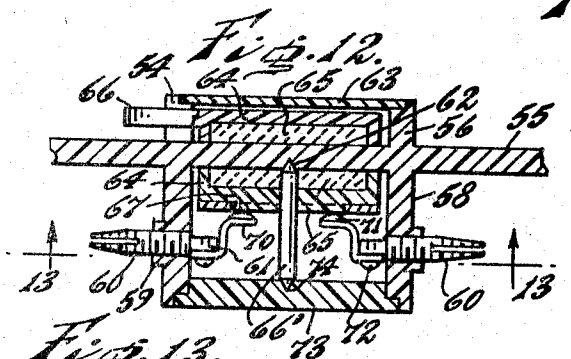


Fig. 13.

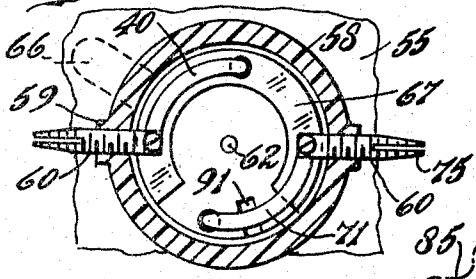


Fig. 15.

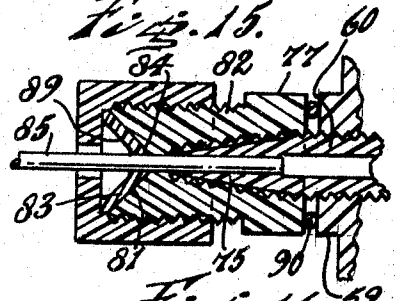


Fig. 16.

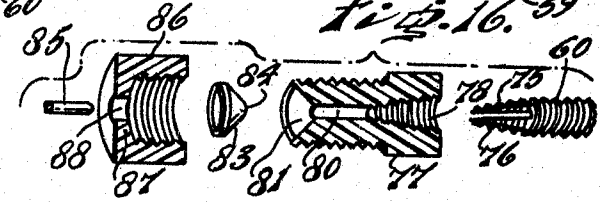
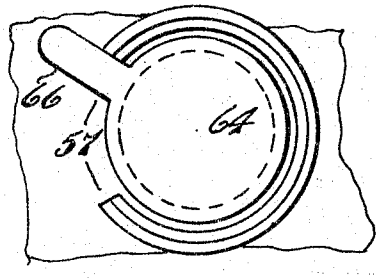


Fig. 14.



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3,317,870

MAGNETICALLY OPERATED SWITCHES

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Filed Apr. 3, 1963, Ser. No. 270,401
2 Claims. (Cl. 335—207)

This invention relates to magnetically operated switches.

It is among the objects of the invention: to improve the art of magnetic switches; to lower the costs of such switches; to provide a magnetically operated switch which is magnetically locked in both on and off positions and is therefore free from chattering or moving in response to blows or vibrations; to provide a magnetic switch which is explosion-proof; to provide a magnetic switch having a snap action both in opening and closing the circuit controlled thereby; to provide a switch the components of which are in both dynamic and static balance without the use of counterweights; to provide a rotary magnetic switch of peripherally uniform and symmetrical flux-couple torque distribution; to provide a magnetic switch comprised of a rotational master or control magnet of minimal angular motion and a complemental slave or captive magnet movable axially to control a circuit selectively in response to either, attraction between unlike or opposite poles, or repulsion between like poles as the control magnet is moved angularly; to provide a rotary magnetic switch comprised of master or control, and complemental slave or captive, magnets of annular form each comprised of multiple poles symmetrically spaced peripherally of the respective magnets whereby the attractive or repulsive torque distribution is uniformly symmetrical, and of enhanced total force; to provide a magnetic switch comprising an oscillatable master magnet having a pivotal axis, and a slave unit which is movable primarily axially of said axis; to provide a wiping switch contact with means for interrupting a leakage path without causing an untoward discontinuity of circuit controlling contact; and many other objects and advantages will become more apparent as the description proceeds.

Illustrative forms of the magnetic switch are disclosed in FIGS. 1 to 8, and FIGS. 12 to 16 of the attached drawings, and an illustrative modification thereof is disclosed in FIGS. 9 to 11.

In the accompanying drawings forming part of this description:

FIG. 1 represents a plan of an illustrative form of switch showing the master, switch-actuating, element externally of the mounting plate, in full lines positioned at position "A," "off," and showing in dash dot lines its position "B," "on," toward both of which positions the master switch unit is forced by magnetic reactions with the slave or captive unit (not shown), to be described, and which also indicates in dashed lines an intermediate transitory position C, between positions A and B, at which magnetic torque between the master and slave unit is neutral.

FIG. 2 represents a longitudinal section through the illustrative switch organization of FIG. 1, taken on line 2—2 thereof.

FIG. 3 represents an exploded perspective of the components of the instant illustrative switch.

FIG. 4 represents a purely diagrammatic bottom plan of the master or control switch, showing an illustrative eight poles and the spacing y between stops.

FIG. 5 represents a purely diagrammatic top plan of the slave magnet organization, also showing an illustrative eight poles and the spacing x between stops.

FIGS. 6 to 8, represent purely schematically, in edge elevation, the juxtaposed parallel spaced concentric disc

magnets of the master and slave units in their respective several successive relationships incident to angular motion of the slave unit in one organization thereof, and ultimate motion of the slave magnet unit, in which attraction between opposite poles of the respective units establishes magnetic flux couples, and with augmentation by repulsion of like poles, creates the torque force controlling the slave unit, and thus the snap action of the switch.

FIGS. 9 and 10 represent schematically the two positions of the magnetic slave unit relative to the oscillatable master or control unit, in which angular motion of the master unit affects axial movement only of the slave unit, on an angular guide post due to repulsion of like poles, and reducing the angular movement of the master or control magnet unit by one-half over the motion essential in the device of the preceding figures.

FIG. 11 represents a fragmentary top plan partially in section of the axially movable slave unit of the organization shown in FIGS. 10 and 11, taken on line 11—11 of FIG. 10.

FIG. 12 represents a longitudinal vertical section through a modified form of the invention according to FIGS. 1 to 8, showing the lead-in connections molded into the switch unit, by which the switch is enhancedly explosion proof.

FIG. 13 represents a transverse section taken on line 13—13 of FIG. 12.

FIG. 14 represents a fragmentary top plan of the switch of FIG. 12 with the cover plate removed.

FIG. 15 represents a fragmentary section through the assembly of lead-in wire and the molded lead-in connection to the switch organization of FIG. 12.

FIG. 16 represents an exploded perspective view of the components of the explosion proof lead-in assembly.

In the illustrative form of efficient and highly economical switch comprising an article of manufacture, shown in FIGS. 1 to 8, the components comprise, a usually molded, housing **10**, an angularly movable slave or captive magnetic switch unit **11**, pushed vertically downwardly into the housing, a cover plate **12**, of non-magnetic material, such as of non-magnetic stainless steel, aluminum, or a suitable plastic, hermetically sealed to the housing **10**, and an angularly movable master control unit **13**, mounted pivotally externally of the plate **12** for arcuate motion in the plane of and relative thereto. The assembly of these components may be mounted on a junction box or the like **19**.

The housing **10** has formed in the lower wall **14** a central journal recess **20**, and mounts any desired form of electrical make-and-break contacts, such as blades, or the like. Illustratively these comprise two upwardly and laterally projecting resilient wiping contacts **15** and **16**, electrically bonded to hermetically sealed binding posts, respectively **17** and **18**, extending through and below the lower wall **14**. The side walls of the housing **10** have their upper edges in a common plane **29**, usually parallel to the bottom wall **14**, for hermetic sealing to plate **12**. The sealing is effected after the slave or captive unit **11**, to be described, has been placed in the housing **10**, bearing lightly against the resilient wiping contacts **15** and **16**. After sealing the enclosed space in housing **10** may be evacuated, or charged with inert gas.

The slave unit **11** comprises a cylinder of suitable plastic or other non-magnetic material, having embedded flush with its lower surface **23**, a centrally apertured contact strip or arcuate bar **21**, through which, or concentric with which, a perpendicular downwardly extending post or stud **22** projects, for anti-friction journalling in the recess **20** in the lower wall **14** of the housing **10**.

The wiping contacts **15** and **16** bear against the lower surface **23** of the slave unit, and, in accordance with movements of the latter about the axis of stud **22**, engage or

disengage contact strip **21**, closing or opening the circuit therethrough, as will be clear. The contact strip **21**, and the resilient wiping contacts **15** and **16** are illustrative of a circuit controlling organization, for which many others may be substituted.

The upper surface of the slave unit **11** has a peripheral or annular surface groove or recess **24**, surrounding a vertical axis pin **25** mounted on or formed with the slave cylinder, extending oppositely to but co-axial with the lower stud **22**. The vertical pin **25** is ultimately seated in a closed journal-recess **26** formed in the lower surface of the plate **12**. By means of the oppositely extending and seated stud and pin the slave unit **11** is mounted for free anti-friction mounting in the housing, except for the incidental friction of the illustrative wiping contacts **15** and **16** against the lower surface **23**, which in view of the angular torque incident on the slave unit, to be described, is so minimal as to be inconsequential. It will be observed that with the journalled axially restrained mounting described there is no significant weight carried by the wiping contact arms. The recited annular surface recess **24** receives and mounts a washer-like, planar, centrally apertured, disc type of magnet **31**, to be described, generally flush with the upper surface of the slave unit. This latter surface is also provided with a peripheral groove or recess **27**, in which are mounted stop pins **28** and **30**, of given arcuate spacing *x*. A depending pin **32** is mounted on the lower surface of plate **12** and extends into the peripheral groove **27** between the stop pins **28** and **30**, and forms a limiting abutment against which the respective stop pins abut in alternation in oscillation of the slave unit between "on" and "off." Preferably a washer **33**, as of nylon or the like, surrounds the upper stud **25** and engages between the lower surface of plate **12** and the upper surface of unit **11**, to enhance the anti-friction freedom of the slave unit in angular motion relative to said plate, between limits established by stop pins **28** and **30** relative to abutment pin **32**.

The plate **12**, in addition to the lower surface downwardly projecting closed bearing recess **26**, and the downwardly projecting stop or abutment pin **32**, on its upper surface mounts an upwardly projecting internally threaded tubular stud extension **34**, closed at the bottom by plate **12**. The tubular stud **34** is usually loosely surrounded by a thin washer **35**, such as of nylon or the like, of the same diameter as washer **33**, imposed against the upper surface of the plate **12**. The plate **12** also mounts externally a vertically extending abutment stop stud **37**. Usually and economically this latter stop stud is coextensive with the lower projecting abutment stop **32**, although these can be separate and angularly relatively displaced entities. When preferred, detent recesses **41—41**, or like latches may be formed in the outer face of plate **12**.

The switch is completed by the external master or control assembly **13**. This comprises a formed mass of non-magnetic material having a central aperture **37'**, receiving the stud **34**, and having a pointer end **36**. A screw and washer assembly **39** screwed into threaded stud **34**, axially anchors the master unit to plate **12**, for oscillation about stud **34**. Master unit **13** overlies washer **35** in anti-friction spacing from plate **12**. It will be seen that the axis of the master unit in stud **34** is coextensive with the common axis through the slave unit, and the master unit is oscillatable about its axis between graduations "on" and "off," between the respective detent recesses **41—41**, when the latter are used, as limited by stop pins to be described alternately engaging abutment pin **37**. On the lower surface of the control assembly **13**, concentric with the axis of axial aperture **37'** is a magnet recess **40**, in which is disposed the disc-like washer type magnet **42**, complemental and parallel to the magnet **31** of the slave unit, although spaced therefrom by the non-magnetic plate **12**. If desired a spring-pressed ball detent **43** is disposed for extension beyond the lower surface of the master unit, as in the pointer extension **36**, for alternate seating at

extreme settings in the detent recesses **41—41**. Any other latch or detent organization can be used to hold the master unit in an attained position, augmented by the force of the multiple magnetic flux couples, to be described, incident thereon. The lower surface of the control unit **13** has a peripheral groove **43** in which are disposed stop pins **44** and **45**, in angular spacing *y*. The abutment pin **37** on the upper side of the plate **12** extends into the peripheral groove **43** between the stop pins **44** and **45** to limit the angular motion of the control unit **13**. It is essential that the angular spacing *x* between stop pins **28** and **30**, limiting the angular range of motion of the slave unit, be less than the angular spacing *y* between the stop pins **44** and **45** of the master unit. This insures that the angular motion of the control unit, in moving between "on" and "off" positions, is somewhat greater than that of the slave unit, in its controlled motion between abutment of the depending pin **32** by its respective stop pins **28** and **30**. This is important in the preferred organization and operation of the switch, as will develop.

The magnets **31** and **42** of the respective slave and control units are usually identical, and each has at least four poles, and preferably multiples thereof, in place of the bi-polar bar magnets used in prior art magnetic switches. The magnets are preferably of the ceramic type, in which the thickness and diameter vary inversely as the number of poles desired on each magnet increases from four. Therefore, each magnet has a multiplicity of alternate poles evenly and symmetrically spaced about its peripheral extent. For illustrative purpose let it be assumed that each magnet has eight poles. This is disclosed in the plan views of the respective magnets shown in FIGS. 4 and 5. One organization in its functioning is indicated purely schematically in FIGS. 6, 7 and 8.

It being understood that with the master and slave magnets in parallel spaced planes and concentric about a common axis, the unlike poles of the respective magnets establish flux couples in attraction, indicated in FIGS. 6 to 8 by the generally upwardly vertical arrows pointing toward the control magnet, whereas the flux couples in repulsion between like poles are indicated by the generally downward vertical arrows pointing toward the slave magnet. In FIG. 6 the control magnet has been moved to the right, in FIG. 1, clockwise until in this "off" position abutment stop **37** has been tightly engaged by stop pin **44** of the movable master unit. At the same time slave unit magnet **31** and the mounting unit thereof have been moved counterclockwise until the stop abutment **32** has been tightly engaged by stop pin **28** of the slave unit. This relative angular positioning has been established and maintained by the inclination, relative to the axial, of the force vectors of the flux couples, both in attraction and repulsion, symmetrically distributed about the peripheries of the respective magnets. These force vectors arranged all about the peripheries of the respective magnets exert a torque force of considerable magnitude on both magnets, holding them in their then established attitudes, consonant, illustratively, with the controlled circuit being "off." Owing to the multiplicity of controlling couples in their symmetrical spacing about the peripheries of the magnets, there is no resultant force transverse of the pivots of the slave unit urging the latter out of its journalled freely rotatable disposition, and imposing frictional force thereon making it unbalanced, in the intermediate position of the master unit, as shown in FIG. 7. It will be seen also that the total torque on both units holds them in their established setting, against movement under vibration or impacts, as indicated in FIG. 8.

When the master unit **13** is turned on its axis to and through a mid-position "C," the unlike poles of the respective magnets are separated, attenuating the attraction flux couples previously existing, while axially straightening the repulsion force vectors so that these are purely vertical and have no torque component on either magnet, but only axial forces. This is indicated in FIG. 7.

Finally, as indicated in FIG. 8 the master magnet having swung from mid-position, to a point at which the new repulsion flux couples are established and inclined, while new inclined attraction flux couples are established between unlike poles, exerting opposite torque on both magnets, causing both units to snap to the final "on" position indicated in FIG. 8, in which the circuit is closed with a snap, and the master unit is forced to engage stop **45** by abutment **37**, and the slave unit is forced to engage abutment **32** against pin **30**. This establishes a snap, arc-reducing movement of the slave unit controlled circuit controlling elements. This same snap action maintains in movement of the master and slave units to the "off" position.

It will be seen that regardless of the speed of angular motion of the master unit, it is subjected to resisting force at the start, decreasing to no resisting force and finally to snap action force in its direction of movement.

An important feature of the invention is to provide the angularly movable master magnetic unit, as broadly disclosed, in conjunction with an angularly restrained but primarily axially movable slave magnetic unit. This is schematically indicated in FIGS. 9, 10 and 11. In this case the master unit **13** is of the same structure as previously described, angularly movable relative to the plate **12**, and the latter, or the lower base **14**, mounts a vertical, fixed, angular stud (or guide) **50**. This stud may be helical when combined vertical and angular movements may be desired. The slave unit **11**, of the same general organization as previously described, has a central angular aperture **51** embracing, and slidable upon, stud **50**. Any desired switching components are provided controlled by slave unit motion which are closed, when the slave unit is forcibly moved downwardly away from the plate **12** under magnetic repulsion forces and which are opened when the slave unit moves upwardly by magnetic attraction, or vice versa. For purely illustrative purposes let it be assumed that the resilient contacts **15** and **16** are mounted in the housing having the floor **14**, and that the slave unit has the same bridging bar or the like, such as an arcuate bar **21'** in its lower surface. FIG. 11 indicates generally the relationship of the slave unit to the angular stud or rod **50**. FIG. 9 indicates the upward positioning of the slave unit when the juxtaposed poles of the master and slave units are unlike. This, illustratively, is the off, or circuit-open position. FIG. 10 indicates the maximum repulsive force of like poles of the complemental magnets, causing maximum axial movement of the slave unit, closing (or opening) the circuit.

It will be understood of the latter form of the invention, FIGS. 9 to 11, that the master or control magnet, movable angularly, has only to move between a position in which unlike poles of the master and slave are axially juxtaposed or a position in which like poles are in axial juxtaposition. The first organization urging the magnets together and raising and holding the slave magnet unit in its highest point on the stud **50**, which point may mark the opening or closing of the circuit controlled thereby, according to the contact arrangement. The second organization uring the magnets apart to cause the slave unit to assume its lowest position on the stud **50**, with appropriate effects upon the contacts and the circuit controlled thereby. It will be seen that the angular movement of the master or control magnet is thus reduced by one-half, with corresponding advantage in attaining small control movements. In this latter type of switch actuator it is preferred that some sort of latch or detent be provided holding the master unit in each of its two positions. Illustratively, it may comprise the spring-pressed detent ball **43** seating alternately in surface recesses previously described. The same sort of detent may be provided, as by a spring-pressed detent ball extending diametrically of the slave unit and movable between detent recesses on the inner surface of the wall of the housing, or the like, juxtaposed thereto. This

minimizes the effects of vibrations and shocks toward dislodging the slave unit or its controlled contacts.

An important modification of the device previously discussed is shown in FIGS. 12 to 16. This form of the invention is simpler to manufacture and has enhanced explosion-proof characteristics. As shown in FIG. 12 in section a unitary molding of suitable plastic is formed comprising a plate **55** having on its upper surface a short open mouthed annular guide **56**, having a lateral opening **57**, and having on its lower surface an open mouthed tubular housing **58**, and suitable stop pins (not shown). In diametric alignment the tubular portion **58** incorporates hollow chuck elements **60** extending from flat faced bosses **59**, and having apertured flattened inner ends **61** within the housing. Within the housing the plate has a journal recess **62**, which may be disposed in a raised vertical short stud (not shown) for maintaining the strength of the plate molding. The open end of the short annular guide is closed, eventually, by a plastic circular disc **63**, bonded to the end of the anular guide **56**, after the insertion of the master unit **64**, within the annular guide. The master unit mounts the master magnet **65**, similar to that previously described, and has a narrow handle extension **66** extending laterally through opening **57**. Opening **57** by its lateral definitions determines the range of motion y of the master unit in a plane close to the outer plane of plate **55**, between "on" and "off." The master unit may have pivotal mounting, but as guided within the confines of the guide **56** and held in by the sealing plate **63**, the general anti-friction mounting of the master unit is secured without an actual pivotal pin.

An oscillatable slave unit **64**, similar to that already described, mounting the magnet **65**, is provided concentric with a shaft **66'**, and in its lower surface mounts an arcuate or linear contact strip **67**. In assembling the switch the slave unit **64** is dropped into the open mouth of the tubular housing **58** with the end of shaft **66** entered into the bearing opening **62**. Then spring contact elements **70** and **71** are mounted on the flat ends of the chuck elements **60**, by screws or the like **72**, forcing the ends of the contacts against the lower surface of the slave unit. Finally the open end of the tubular member **71** is closed and hermetically sealed by the cover plate **73** having the journal recess **74**, into which the juxtaposed end of shaft **66** is fitted. This establishes free anti-friction rotation of the slave unit within the housing **58**, only reduced by the friction of the spring contact members **70** and **71**, which is minimal. Any suitable stop or detent means are provided to limit the oscillation of the slave unit through a range x.

Part of the problem in explosion-proofness is the creation of a spark-free organization for the lead-in wire, such as wire **85**. To this end the chuck **60** is axially bored with a wire receiving passage **74** and has a threaded tapered end **75** formed with axial slots **76** so that the end is subject to constriction toward the axial passage **74**. A plastic constricting nut **77** is provided having an internal tapering threaded surface **78** leading into an axial wire-receiving bore **80** merging into a flaring or internally sloping terminal end surface **81**. The constricting nut **77** has suitable angularity for wrench-tightening and has an externally threaded shank **82**. A resilient externally tapered washer **83** is provided formed, for instance, of neoprene, having an axial opening **84** such as to slidably receive the lead-in wire **85**. This may be relatively solid, or formed with a dished external surface **89**. Finally an internally threaded nut **86** having a shoulder **87** and wire-receiving bore **88** is provided for threaded movement on threaded shank **82**. A resilient O-ring or the like washer **90** is imposed against the surface of boss **59**, for contact and constriction by the advancing end of constricting nut **77**.

To minimize the establishment of a leakage path, a recess **91** is provided across which the impinging contact **71** relatively passes in the motion of the slave magnet.

With the threaded portions and the O-ring **90**, more or less loosely engaged and the tapering resilient washer **83** juxtaposed in one direction to the tapering terminal sur-

face **81**, and to the shoulder **87** of nut **86** in the other, the lead-in wire **85** is pushed axially inward through the bore **88** of the nut, through the axial aperture **84** of the washer, through bore **88** and into bore **74** in the chuck element **60** in the uncompressed chuck element. The plastic constricting nut **77** is then tightened against the O ring **90** by movement on tapered threaded portion **76**, forcing the tapered end of the chuck element into tight constriction on the wire, anchoring the wire. The nut **86** is then tightened on shank **82** compressing the tapered washer axially between the shoulder **87** and the tapered surface **81** and forcing the washer into tight hermetic seal against the wire.

It will be seen that within the broad purview of the invention many changes and modifications may be made without departing from the spirit of the invention, and all such are to be construed as within the scope of the invention as recited in the appended claims.

I claim as my invention:

1. A magnetic switch comprising a slave unit, means journalling the slave unit for rotative oscillation only on an axis, said slave unit comprising an annular slave magnet concentric with said axis and having multiple poles evenly distributed about the periphery of the magnet, switch means controlled by motions of the slave unit, a master control unit in juxtaposed proximity to said slave unit having an axis co-extensive with the axis of said slave unit, said master unit comprising an annular master magnet concentric with said axis and having multiple poles evenly distributed about its periphery and having the same diameter and the same number of poles as the slave magnet, said master unit being rotatably oscillatable only whereby flux magnetic couples are established between the poles of the master magnet and the poles of the slave magnet in attraction and repulsion respectively to effect snap action of the slave unit in closing and opening the circuit through the switch means.

2. A magnetic switch comprising a support, master and slave planar magnet units each having the same diameter and the same number of multiple poles coaxially journalled in the support in effectively confronting axial registration for parallel axially fixed respective rotative oscillations, circuit controlling means on the support in operative relation to said slave unit operated between open and closed functionally with positioning of said slave unit, stop means on the support respectively limiting the rotative oscillations of said master and said slave unit to ranges of the latter within which the circuit controlling means is opened and closed, whereby with the master unit at one limit of its oscillation first flux couples between poles of the respective units creates torque on the slave unit forcing it to one limit of its oscillation while simultaneously forcing the master unit toward its said one limit, and whereby rotation of the master unit towards its other limit disrupts the first flux couples and after passing a neutral no-torque-juxtaposition of poles of the respective units develops second flux couples establishing torque on the respective units forcing the master unit against its said other limit while forcing the slave unit toward and against its other limit establishing a snap action of both units in both directions of oscillation.

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