Dec. 6, 1955 L. P. HANSON ET AL 2,726,296

MAGNETICALLY OPERATED FLOAT SWITCH

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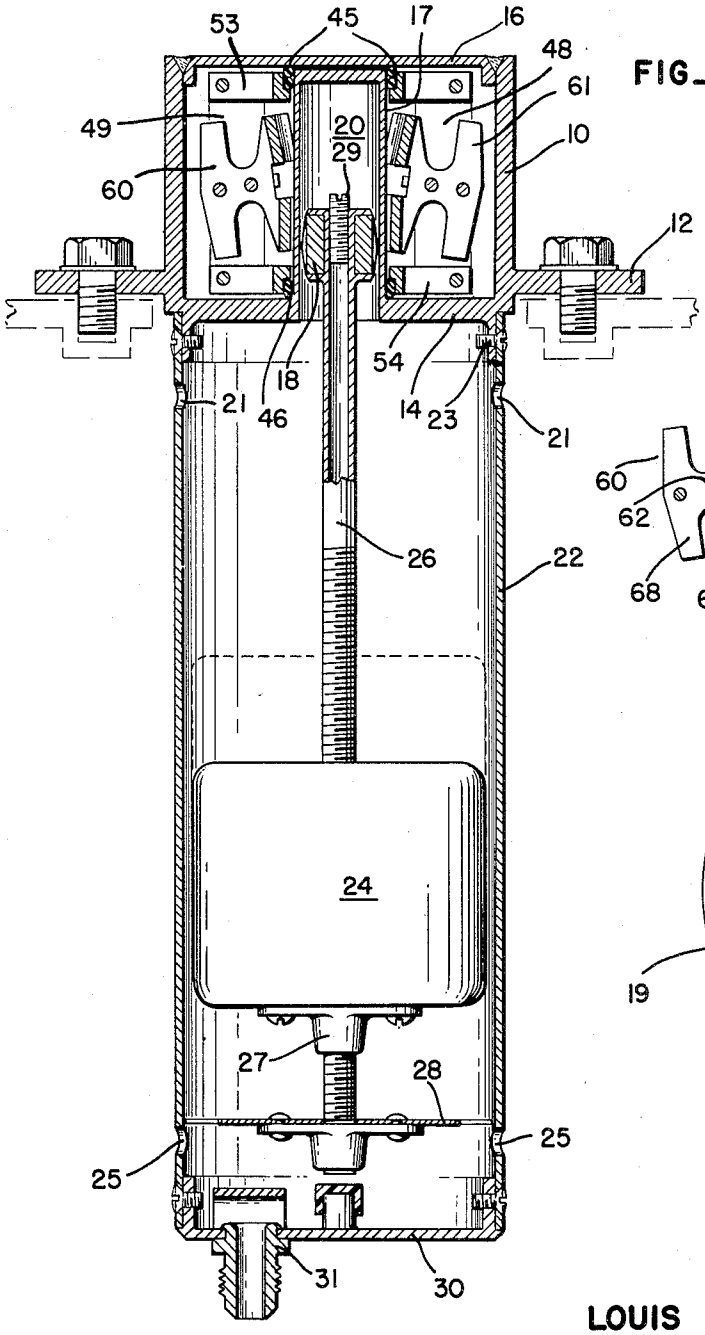
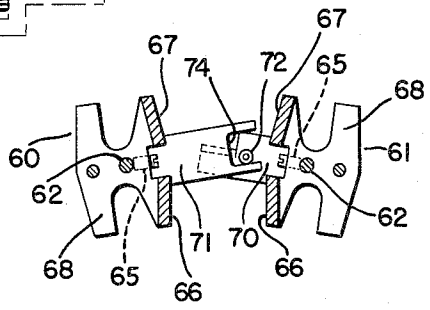



FIG. 1

FIG. 2



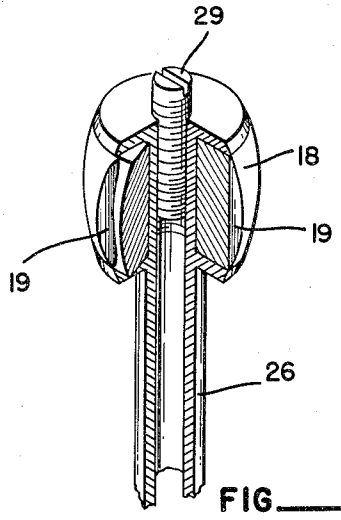




FIG. 3

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MAGNETICALLY OPERATED FLOAT SWITCH

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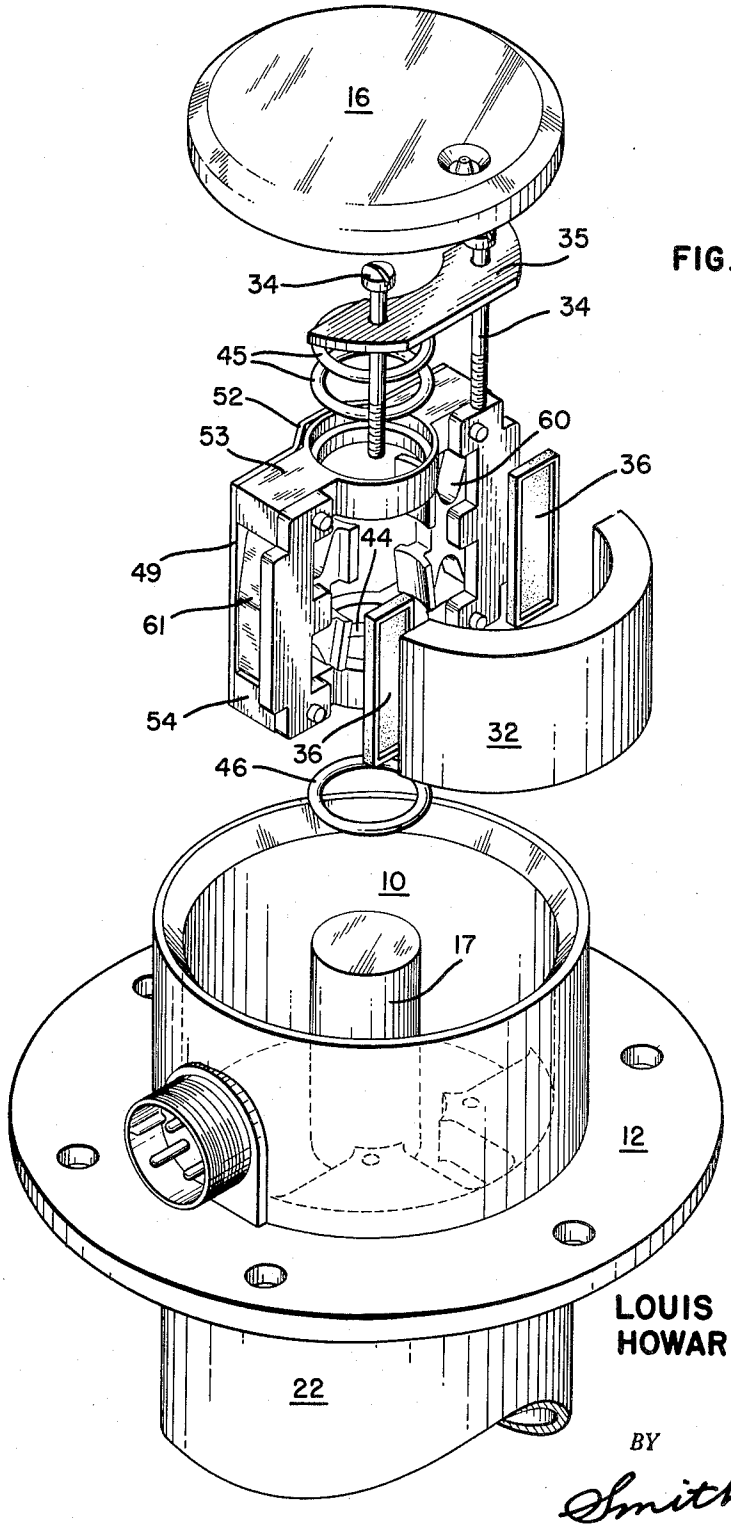



FIG. 4

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MAGNETICALLY OPERATED FLOAT SWITCH

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FIG. 5

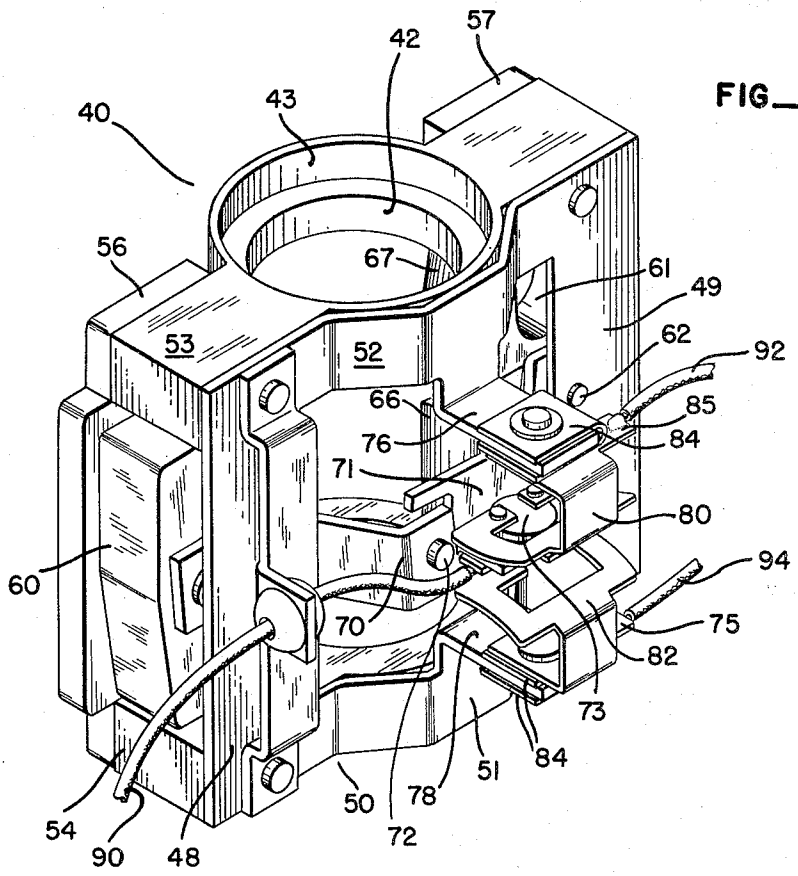
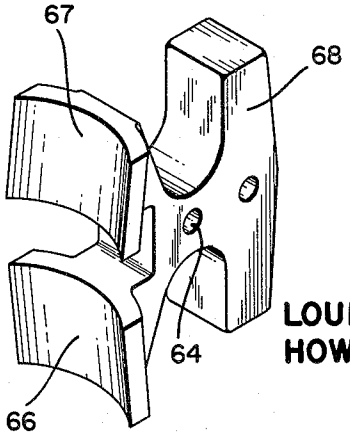



FIG. 6




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Dec. 6, 1955 L. P. HANSON ET AL 2,726,296

MAGNETICALLY OPERATED FLOAT SWITCH

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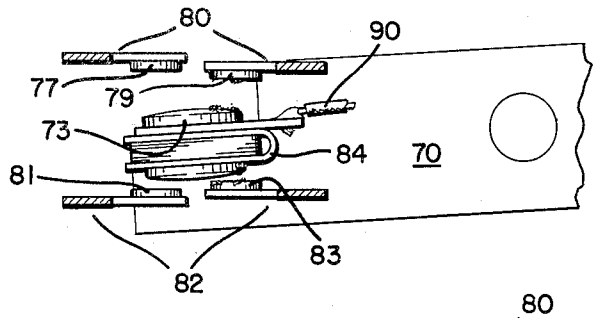



FIG. 7

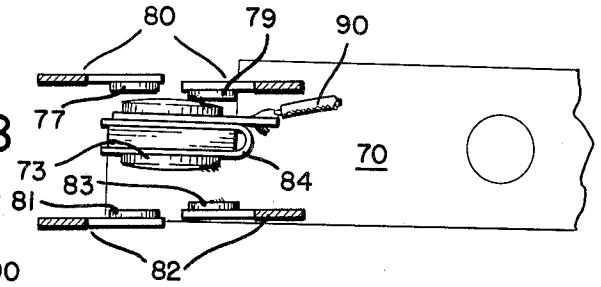



FIG. 8

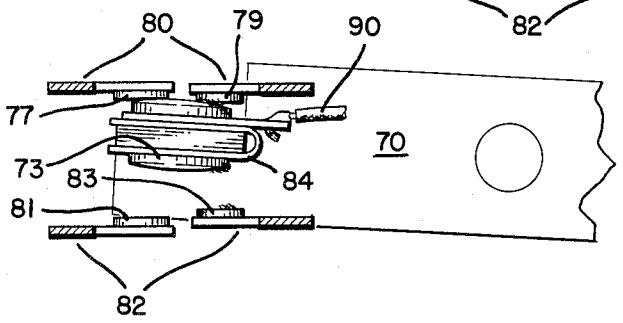



FIG. 9

FIG. 10

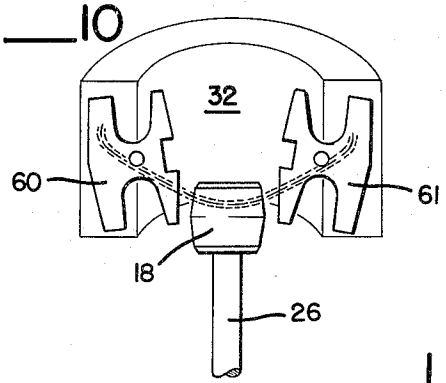
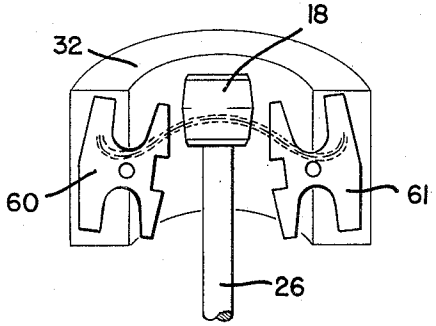



FIG. 11




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2,726,296

# MAGNETICALLY OPERATED FLOAT SWITCH

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Application June 22, 1953, Serial No. 363,285

8 Claims. (Cl. 200—84)

This present invention relates to the general art of enclosed electrical switches and more particularly to a switch intended for use in an aircraft fuel system for controlling, or indicating, specified fuel levels. The switch is characterized by providing in an hermetically sealed compartment, a permanent magnet and twin armatures adapted to sequentially make or break an electric circuit. The actuating means is a soft iron core, having a barrel-shape, reciprocating in a tube having an opening externally of the switch compartment and which core is actuated by a cork-type float. The soft iron barrel-shaped core directs a magnetic circuit from a permanent magnet through two soft iron armatures which armatures in turn, actuate the electrical contacts.

This present magnetically operated float switch overcomes many of the deficiencies experienced with float switches of the types previously used. Aircraft operation calls for equipment that will assure certainty of operation over long periods even though the mechanism is exposed to a high frequency vibratory environment. These severe operational conditions have been met by isolating portions of the operating mechanism by rubber mounting the same, by providing double-acting counterbalanced armatures of considerable mass which operate the switching mechanism without reliance upon springs and such devices. By arranging the various parts so that vibration and friction can be reduced to a low level, the operational characteristics admit of long periods of satisfactory functioning with an abundance of operational energy available to insure the functioning of the switching mechanism even though it may have been at rest for long periods, thus a dependable switching arrangement is provided which fully meets the requirements of the aircraft industry.

The principal object of this present invention therefore is to provide a magnetically operated float switch for use in an aircraft fuel system for controlling or indicating specified fuel levels.

A further object of this invention is to provide a float switch having hermetically sealed electrical contacts and contact-actuating mechanisms.

A further object of this invention is to provide a cork-type float to which is adjustably connected a soft-iron core which is located in a cylindrical cavity that extends into the hermetically sealed unit and is so arranged that the iron core never leaves the magnetic field of the unit.

A further object is the provision of a dual toggle mechanism employing two armatures and which mechanism, in turn, avoids any dead center position of the switch contact members.

A further object of this invention is to provide a float switch which can be set to indicate either high or low level operational positions.

A further object of this invention is to provide a mechanism having such an over abundance of available energy that it will not be operationally affected by any normal loss of strength in the permanent magnet.

Further objects, advantages and capabilities will be apparent from the description and disclosure in the drawings, or may be comprehended or are inherent in the device.



In the drawings:

Figure 1 is a vertical sectional view through a magnetically controlled float switch made after the teachings of this present invention;

Figure 2 is a fragmentary view in elevation, partly in section, showing the armatures used in this equipment together with certain of the co-related parts;

Figure 3 is a perspective view, partly in section, illustrating the core member used to control the flux flow in this equipment;

Figure 4 is an exploded perspective view of the sealed housing together with the parts normally disposed therein;

Figure 5 is a perspective view on an enlarged scale, showing the switching unit;

Figure 6 is a perspective view illustrating one of the armatures employed in the switching unit;

Figures 7, 8 and 9 are diagrammatic views on an enlarged scale and partly in section illustrating the sequential operation of the switch unit contact members;

Figures 10 and 11 are diagrammatic perspective views illustrating the modification of the flux flow due to the difference in placement of the movable core associated with this switching unit.

Referring more particularly to the disclosure in the drawings, the numeral **10** designates generally the housing which hermetically encloses the switching mechanism. This is provided with a mounting flange **12** having suitable mounting openings and an integral bottom plate **14**, and an upper closure plate **16** which is fixedly secured in place, as by soldering, when the switch mechanism has been fully assembled, tested, and installed. Centrally disposed with respect to housing **10** is a core guide tube **17**, of non-magnetic material, having a closed inner end and an open outer end. This tube completes the hermetic seal for the parts and also provides a path for the soft iron plug or core **18** which is disposed for limited reciprocation within the cylindrical cavity **20** provided by tube **17**. Core **18** is relieved as by grooves **19**, to provide for fluid passage around it. Secured to the outer periphery of the depending ring, formed as part of plate **14**, is a float housing tube **22**. Tube **22** is removably secured to housing **10** as by a plurality of screws **23** and is concentrically disposed with respect to cavity **20** so that float **24** may reciprocate therein. This tube is provided with a plurality of upper holes **21** and a similar set of holes **25** near its lower margin.

Float **24** which is preferably formed of resin impregnated cork is adapted for positioning upon an axially disposed tube **26** which tube also carries the iron core **18**. It has been found desirable to employ a tube **26** and closure **29**, preferably of nylon, rather than a solid rod in order to provide the requisite stiffness without excess weight. It is desirable to provide adjusting and securing means so that float **24** can be adjustably positioned on tube **26** as by threading the exterior of tube **26** and provide a self-locking nut arrangement as **27**. On the other hand it may be desirable in certain installations to employ a smooth outer surface of tube **26** and a frictional locking means in lieu of the nut at **27**.

Adapted for locking upon tube **26** is a positioning diaphragm assembly **28**. The periphery of diaphragm **28** is serrated or otherwise provided with fluid passageways but has as a prime object a plurality of bearing surfaces adapted to engage the inner surface of tube **22** and thus provide a guide means which will maintain tube **26** substantially axially aligned with cavity **20**. Considerations of friction and the movement of fluid indicates that diaphragm **28** should not make too snug an engagement with tube **22** but be capable of some floating therein and in order that no binding will occur on plug **18** the outer

periphery of the same where it engages tube 27 is made barrel-shaped with minimum tolerances at the horizontal central plane. This permits a small amount of displacement for the bottom end of tube 26 without in any way building up friction which would tend to lessen the workability of the unit. Float housing tube 22 is provided with a bottom closure member as 30 and is provided with a tubing connector fitting 31.

Disposed within housing 10 are the various elements making up the magnetic switching mechanism, which components are generally shown in the exploded view of Figure 4. These units consist essentially of the permanent magnet 32, fixedly secured to housing 10 by means of a plurality of machine screws 34 and the coacting clamp bar 35. The two ends of magnet 32 are vibration insulated from the switch unit by being enclosed in resilient covers of tray-like form 36.

Disposed within the path of the flux created by permanent magnet 32 is the switch unit 40. This unit which is shown in various views, particularly in Figure 5 is mounted upon tube 17. It is very desirable however that the same be not fixedly mounted and to this end the switching unit 40 is provided with a central bore 42 which encircles tube 17 with reasonable clearance. At each end of the assembly bore 42 is counterbored as at 43 and 44 to accept respectively the resilient rings 45 and 46. These resilient rings provide adequate cushioning to dampen out high frequency vibrations to a very low level, below that which has any effect upon the workability of the unit.

The switching unit is mounted upon its own framework 50 which as viewed in Figure 5 consisting of the two vertical frame portions 48 and 49 and the horizontal portions of the same frame as 51 and 52. This open framework provides for the exact positioning of the various coacting units which are either secured thereto in a fixed relationship or pivotably secured either to the frame or to the members which are fixedly secured to this framework. Fixedly secured to the unit frame are end-bearing members 53 and 54. These members have cut in them respectively the counterbores 43 and 44 in which are seated the resilient washers 45 and 46 respectively. Fixedly secured to bearing members 53 and 54 are the soft iron bars 56 and 57. These bars abut the ends of the permanent magnet 32 except for the imposition of the resilient tray-like members 36, and are used to form part of the switching unit frame and at the same time cut down on the air gap between the magnet 32 and armatures 60–61.

Pivotably disposed between frame portion 48 and bar 56 and frame portion 49 and bar 57 respectively, are the balanced armatures 60 and 61, made of soft iron. These armatures are fixedly mounted upon bearing members 62 which pass through openings 64 in the armature members. Bearing members 62 are secured between the frame portions as 48 and 49 and the opposite bars 56 and 57 which are graphite film coated. To insure that the armatures will continue to operate upon the bearing members without face friction, a lock screw 65 is employed in the armature so as to position the armature in a central position upon the pivot members. The construction of the armatures themselves is probably best illustrated in Figure 6 in which it will be noted that there are two arcuate surfaces as 66 and 67 which are formed to a curve concentric to the outside of tube 17. Further it is to be noted that these two surfaces are not a common one but are angularly disposed with respect to each other to the end that when the armature pivots about openings 64 each of the surfaces alternately will partially encircle but never come in contact with tube 17. Each armature is further provided with a head portion 68 which counterbalances the weight of portions 66 and 67 and disposes the mass of the same to present the same area in the magnetic field.

Fixedly secured to the armatures are the switch operating bars 70 and 71. The two bars are offset away from a plane of the armatures so as to pass around tube 17 and the construction is similar excepting that one as 70 has a metal detent or post 72 while the other has a bifurcated end 74, the opening of which is considerably greater than the diameter of detent 72. This serves a purpose to be stated later. Secured normally to the outer side of arm 70 is the central contact member 73.

The bifurcated end 74 which is provided to engage detent 72 is designed to apply the pressure of bar 71 to the switch contact with manufacturing limitations in mind. While it is possible to interlock the two bars 70 and 71 by various means we have found it desirable to place the interlocking detent 72 away from a plane intermediate the two armatures and nearer armature 61 so as to avoid the central contact member 73. Since the angular movement of bars 70 and 71 are the same, the vertical travel of detent 72 is less than a point on arm 71 which contacts detent 72. Therefore a relatively wide slot 74 is provided to compensate for this difference in vertical travel while retaining fixed angular relationship.

The horizontal bar portions 51 and 52 of the main switch unit frame have outwardly extending lug portions 76 and 78. To these lugs are fixedly secured two point electrical contact members 80 and 82. The construction of these members is best illustrated in Figure 5 and the three Figures 7, 8 and 9. A U-shaped insulating washer arrangement is provided at 84.

Soldering lugs as 75 and 85 are normally formed as part of contact members 80 and 82 and to these are connected electrical conductors that lead outside the case through glass bead insulators.

*Method of operation*

After a float switch of this order is placed in service, the switching mechanism is not available for adjustment or servicing. Consequently its various components must be fully tested before assembling. Prior to being placed in service for most purposes the evacuation equipment is applied to an opening in cover 16 and when evacuation has been completed, the chamber is filled with an inert gas, as dry nitrogen, and then sealed as by soldering the evacuation opening. There are certain uses when a suitable damping oil may be employed instead of the inert gas. The next step to be completed before placing the unit in service is to adjust the position of float 24 upon stem 26. The positioning will be determined by experience and will be different for a high or a low level operation. Certain conditions will dictate the over-all length of tube 22 and this in turn will call for a similar change in the length of tube 26. In this operation it is very desirable that the soft iron plug 18 be positioned within tube 17 and also within the limits of the armature plates 66 and 67. It therefore follows that the length of tube 22 will control the downward limit of the movement of the core 18 and should therefore be of the proper length to achieve this desired result. By insuring that the plug 18 never leaves the magnetic field, the armatures are at all times acted upon by a large magnetic force, which holds them in either the actuated or de-actuated position. No springs need be employed for this operation.

As viewed in Figure 1 the lower armature surfaces 66 are being acted upon by the increased flux lines passing through plug 18 and this force, through arms 70 and 71, move the central contact member 73 into engagement with the two upper contacts forming part of member 80. When under action of float 24, plug 18 is moved to the upper position opposed to the armature contact surfaces 67, both armatures pivot about their pivot axis 64 so that surfaces 67 are in close proximity to tube 17. This action through arms 70 and 71 moves the centrally disposed contact 73 downwardly to contact the lower contact member 82. It is to be noted that the central contact member is one large contact surface sufficient in extent

so that the two spaced contact points 77—79 and 81—83 of either member 80 or 82 respectively can both engage this large central contact. It is desirable however that both contact points of the same contact member either 80 or 82 do not engage the central contact at the same time. An optimum arrangement is where one point will contact followed shortly by the second contact of the same unit. This means that the current starts to flow through a single contact point, more important however, is the action when the current is broken. Members 80 and 82 are both of resilient construction and likewise the two contact points being on separate prongs of the member also have a degree of resiliency. However, experience shows that the contact points, as 79 or 83, that first engages the central contact will, because of the placement and resiliency of the metal, be the last one to leave. Therefore, it assumes the full burden of the arcing incidental to breaking the circuit and as this arcing continues from various making and breaking of the circuit, it is common to have a high electrically resistant carbon deposit built up at this point. This is a desirable condition in that it means longer life for the paired mating contact points, as 77 or 81. The mating contact point of the pair of a single contact member is of course usually left clean of all carbon deposits as it has made contact after the initial contact has been made by the companion point and it leaves, or breaks its contact, before the carbonized point has broken the contact and accepted the results of the arcing which normally ensues. The uncarbonized contacts 77 and 81 then offer a low resistance path for electrical current flow. The sequential operation of these members is probably best shown in the three diagrammatic Figures 7, 8 and 9. It is desirable to point out that such niceties of operation are achieved only by a well balanced design which avoids the usual interference caused if vibration is experienced by these parts, it then follows that the desirable arrangement is one in which the mass of the magnet and its associated parts are entirely isolated from the switch unit as by means of the resilient rings 45 and 46 and pads 36. This is no doubt a contributing factor to the long life of these units and the certainty of their operation. The absence of high frequency vibration assured by the resilient mounting of the switching unit permits the smooth functioning of the double acting, counterbalanced armatures 60 and 61 and permits them to oscillate without interference on their respective pivots under urgence of the flux flow from permanent magnet 32. The low friction armature pivot bearings 62 again contribute to the smooth functioning of this device and permit the functioning of the device even though after long periods of use, the flux flow of the permanent magnet should be greatly decreased. It is further desirable to point out that a design of this order can be made in small size and the components are such that weight has been conserved to a remarkable degree, a very desirable attribute in a piece of equipment designed for airplane use. The output of this device is carried through the central contact conductor 90 and the two conductors 92 and 94 which are alternately energized to provide control circuits which find many uses in aircraft fuel systems for controlling or indicating specified fuel levels.

Another factor contributing to the certainty of operation is the calculated balance of the forces applied by the float due to an increase or decrease of liquid displacement and the attraction of the core by magnet 32. The magnet tends to hold the core in place until the delayed movement of the float creates an overbalancing force which then takes control and gives a quick throw to the switch mechanism.

It is believed that it will be clearly apparent from the above description and the disclosure in the drawings that the invention comprehends a novel construction of a magnetically operated float switch.

Having thus disclosed the invention, we claim:

1. A magnetically operated float switch, comprising: a hermetically sealed housing adapted to house and fixedly support a bar magnet and resiliently support an electrical switching means; an axially disposed cylindrical cavity extending into said housing and open at its lower end; a barrel-shaped iron core disposed for reciprocation within said cavity and to thus change the path of the flux flow of the magnet; a liquid buoyant float disposed in substantial axial alignment below said core; means operatively and adjustably connecting said core and said float and enabling the float to position the core within said cavity; means for guiding the lower end of said connecting means to maintain it in substantial alignment with said cavity; an electrical switching means having two opposed resiliently mounted, two contact switch members and a movable single contact switch member disposed between the resilient members; said bar magnet being arcuate in form to partially encircle said switching means; a pair of counterbalanced iron armatures, mounted on horizontal pivots, and disposed in the flux path of said magnet; an arm secured to each of said armatures and operatively connected to said movable single contact switch member; said armature having vertically spaced, arcuate contact surfaces adapted to substantially contact the outer wall of said cavity, alternately, as said core is moved into the horizontal plane of said contact surfaces; and vibration damping means adapted to yieldably support the armature and switch members from said housing.

2. A magnetically operated float switch, comprising: a hermetically sealed housing adapted to house and fixedly support a bar magnet and resiliently support an electrical switching means; an axially disposed cylindrical cavity extending into said housing and open at its lower end; a barrel shaped iron core disposed for reciprocation within said cavity and to thus change the path of the flux flow of the magnet; a liquid buoyant float disposed in substantial axial alignment below said core; means operatively and adjustably connecting said core and said float and enabling the float to position the core within said cavity; means for guiding the lower end of said connecting means to maintain it in substantial alignment with said cavity; an electrical switching means having two opposed, resilient, two contact, switch members and, a movable single contact switch member disposed between the resilient members; said bar magnet disposed to partially encircle said switching means; a pair of counterbalanced iron armatures, mounted on horizontal pivots, and disposed in the flux path of said magnet; an arm secured to each of said armatures, one arm having an outwardly extending detent and the other having a bifurcated end adapted to engage the same, and to thus operatively connect the armatures to said movable single contact switch member; said armature having vertically spaced, arcuate contact surfaces adapted to substantially, but not quite, contact the outer wall of said cavity alternately as said core is moved in the horizontal plane of said contact surfaces; and vibration damping means adapted to yieldably support the armature and switch members from said housing.

3. A magnetically operated float switch, comprising: a housing adapted to be hermetically sealed and having flange means for mounting the switch in a gas tank; means forming an axially disposed cylindrical cavity extending into said housing and open at its lower end; an iron core disposed for reciprocation within said cavity; a liquid buoyant float disposed in substantial axial alignment below said core; a tube operatively connecting said core and said float; a ventilated disc secured to said tube for guiding the lower end of the tube to maintain it in substantial alignment with said cavity; an electrical switching means having two opposed, two contact, switch members which are resilient but fixedly mounted and, a movable double faced contact switch member disposed between

the resilient members; a curved permanent bar magnet adapted to energize said switching means; a counterbalanced soft iron armature, mounted on a horizontal pivot and disposed in the flux path of said magnet; an arm secured to said armature and operatively connected to said movable switch member; said armature having vertically spaced, angularly disposed arcuate contact surfaces adapted to come into close proximity with the outer wall of said cavity, alternately as said core is positioned in the horizontal planes of said contact surfaces; attaching means for fixedly securing said magnet to said housing and vibration damping means adapted to yieldably support the armature and switch members from said housing and magnet.

4. A magnetically operated two position switch, comprising: a housing and a pair of soft iron armatures mounted in said housing freely pivotal about two parallel, spaced apart axes, a magnetic source in said housing disposed to form a strong flux field passing between the armatures, each armature being substantially balanced about its axis and said magnetic source exerting a force considerably in excess of the forces of gravity acting upon the armatures, a soft iron core member positioned in said housing movable between a first and a second position on a path of travel between the armatures lateral to the plane common to said axes; each armature having its side portion adjacent said path of travel divided into two large, independent sections and said first position of said core member being closer to one section and said second position of said core member being closer to the other section whereby said armatures pivot so that the adjacent section assumes the position closest to the core member, said armatures having a first electrical contact moving therewith and there being two other electrical contacts positioned in said housing arranged so that said first contact abuts one when the armatures have pivoted to one position when said core member is in said first position and abuts the other when the armatures have pivoted to another position when said core member is in said second position; and operating means for moving said core member between its positions thereby operating the switch.

5. The subject matter of claim 4 in which each armature has an arm extending therefrom and one of said arms carries said first electrical contact, and one of said arms having an opening therein and the other of said arms having a detent positioned in said opening forming a loose connection therebetween so that the arms move generally together.

6. A float switch, comprising: a housing having a passageway, an external liquid buoyant float having secured thereto a magnetically susceptible core disposed for movement in said passageway responsive to movement of said float between a first and a second position along said passageway, a pair of juxtaposed counterbalanced magnetically susceptible armatures supported in said housing alongside said passageway and each having its face toward said passageway bifurcated forming two large face portions separated in a direction parallel to the axis of said passageway and each armature being pivotally mounted to pivot between a first position in which one face portion is closer to said passageway and a second position in which the other face portion is closer to said passageway, magnetic means in said housing directing a flux flow through the area of the face portions of said armatures with the flux flow being disposed and being of such strength to pivot the armatures between their first and second positions responsive to the movement of said core between its first and second positions, the first position of said core being closer to one face portion of each armature and the second position of said core being closer to the other face portion of each armature whereby the flux flow passes through the face portions of the armatures closest to the core and thereby pivots the armatures toward the core, said armatures having linkage means therebetween so as



to pivot generally together, and electrical switching means connected to said armatures and responsive to the pivoting of said armatures between their first and second positions to switch contacts.

7. A float switch, comprising: a housing having a passageway, an external liquid buoyant float having secured thereto a magnetically susceptible core disposed for movement in said passageway responsive to movement of said float between a first and a second position along said passageway, an armature supported in said housing alongside said passageway and having its face toward said passageway divided into two face portions which are separated in a direction parallel to the axis of said passageway and the armature being pivotally mounted to pivot between a first position in which one face portion is closer to said passageway and a second position in which the other face portion is closer to said passageway, magnetic means in said housing directing a flux flow through the area of the face portions of said armature with the flux flow being disposed and being of such strength to pivot the armature between its first and second positions responsive to the movement of said core between its first and second positions, the first position of said core being closer to one face portion of said armature and the second position of said core being closer to the other face portion of said armature whereby the flux flow passes through the face portion of the armature closest to the core and thereby pivots the armature toward the core, and electrical switching means connected to said armature and responsive to the pivoting of said armature between its first and second positions to switch contacts.

8. A switch, comprising: supporting means and a magnetically susceptible core supported by said supporting means for movement, responsive to externally applied force, along a path of travel between a first and a second position, an armature supported by said supporting means alongside said path of travel and having its face toward said path of travel divided into two face portions which are separated in a direction parallel to said core path of travel and the armature being pivotally mounted to pivot between a first position in which one face portion is closer to said core path of travel and a second position in which the other face portion is closer to said core path of travel, magnetic means supported by said supporting means directing a flux flow through the area of the face portions of said armature with the flux flow being disposed and being of such strength to pivot the armature between its first and second positions responsive to the movement of said core between its first and second positions, the first position of said core being closer to one face portion of said armature and the second position of said core being closer to the other face portion of said armature whereby the flux flow passes through the face portion of the armature closest to the core and thereby pivots the armature toward the core, and electrical switching means supported by said supporting means and connected to said armature and responsive to the pivoting of said armature between its first and second positions to switch contacts.


**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 803,486 | Hill | Oct. 31, 1905 |
| 1,216,420 | Dodgson | Feb. 20, 1917 |
| 1,891,568 | Morris et al | Dec. 20, 1932 |
| 1,958,685 | Tevander | May 15, 1934 |
| 2,068,093 | Terjesen | Jan. 19, 1937 |
| 2,069,641 | Bold et al | Feb. 2, 1937 |
| 2,142,680 | Shrode | Jan. 3, 1939 |
| 2,204,161 | Shepherd | June 11, 1940 |
| 2,467,073 | Binford | Apr. 12, 1949 |
| 2,544,491 | Davis | Mar. 6, 1951 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 593,315 | Germany | Feb. 24, 1934 |