Jan. 15, 1957 J. R. BROWN 2,777,914

MAGNETIC SWITCH

Filed Oct. 8, 1953 4 Sheets-Sheet 1

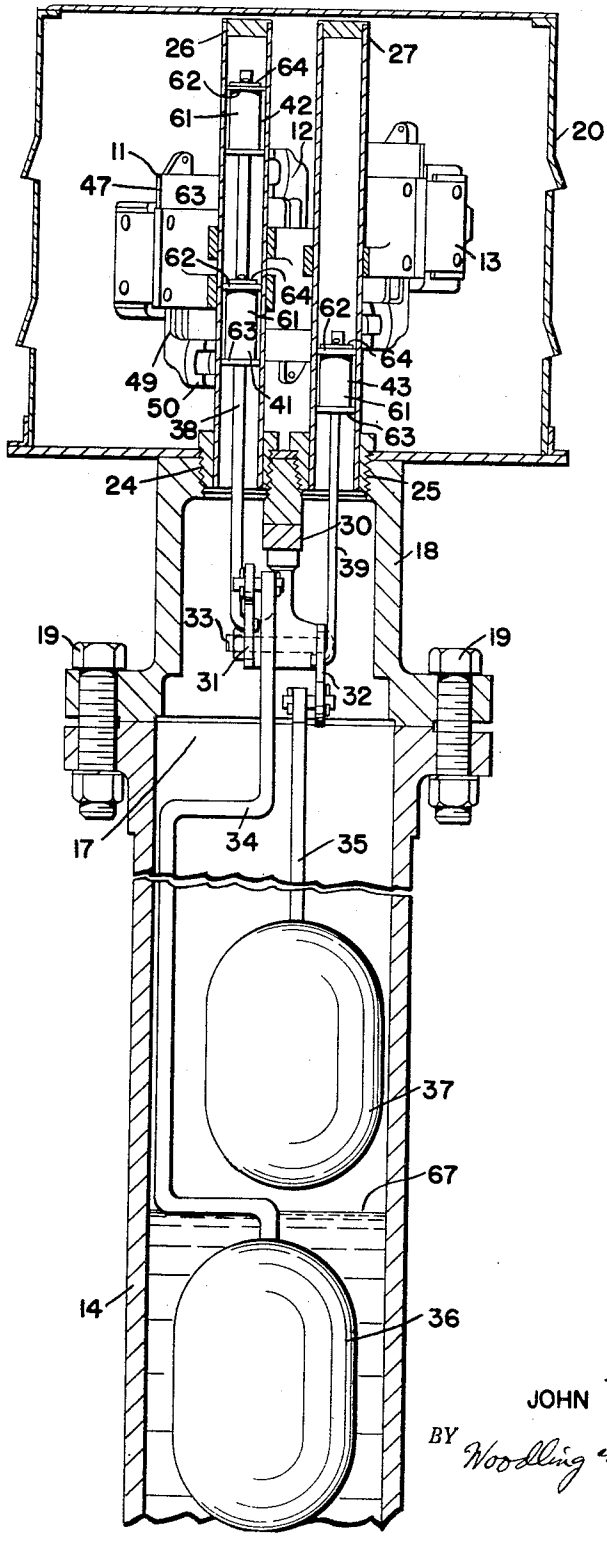


FIG. 1

INVENTOR.
JOHN R. BROWN

BY Woodling and Krost,

ATTYS.

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MAGNETIC SWITCH

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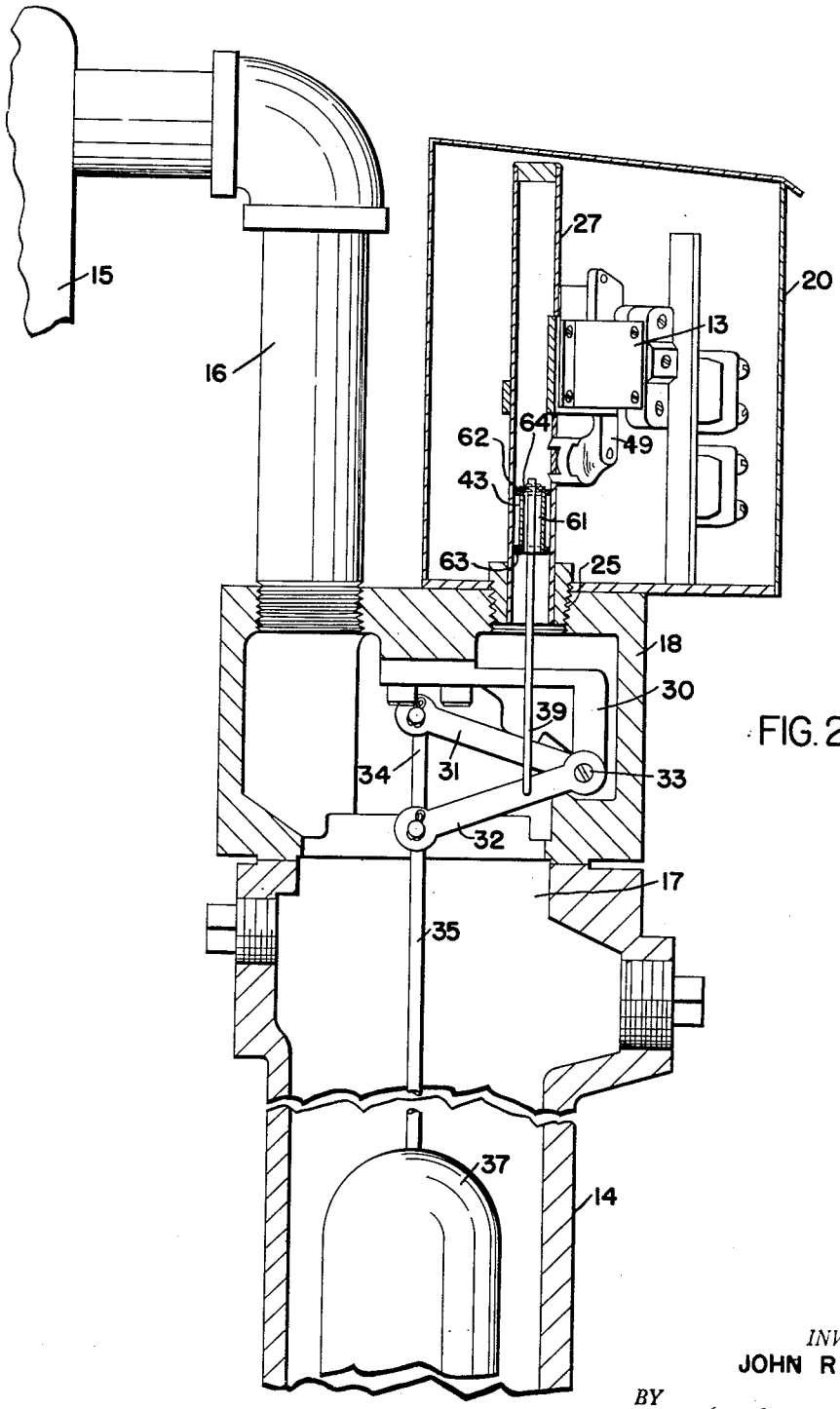


FIG. 2

INVENTOR.
JOHN R. BROWN

BY Woodling & Knost,

ATTYS.

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MAGNETIC SWITCH

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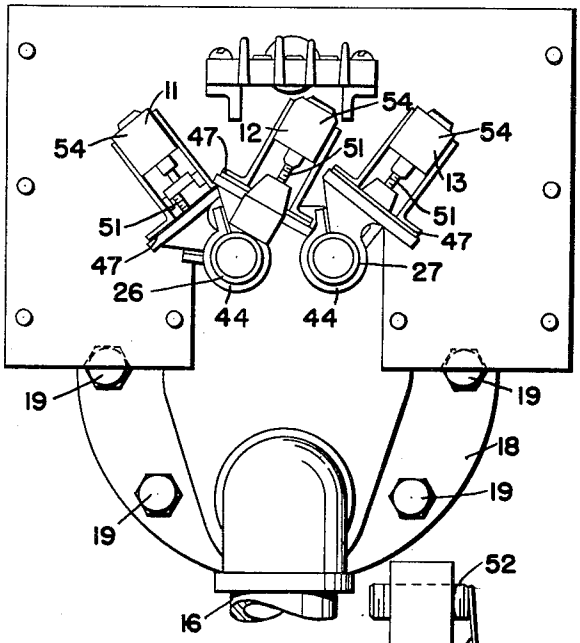
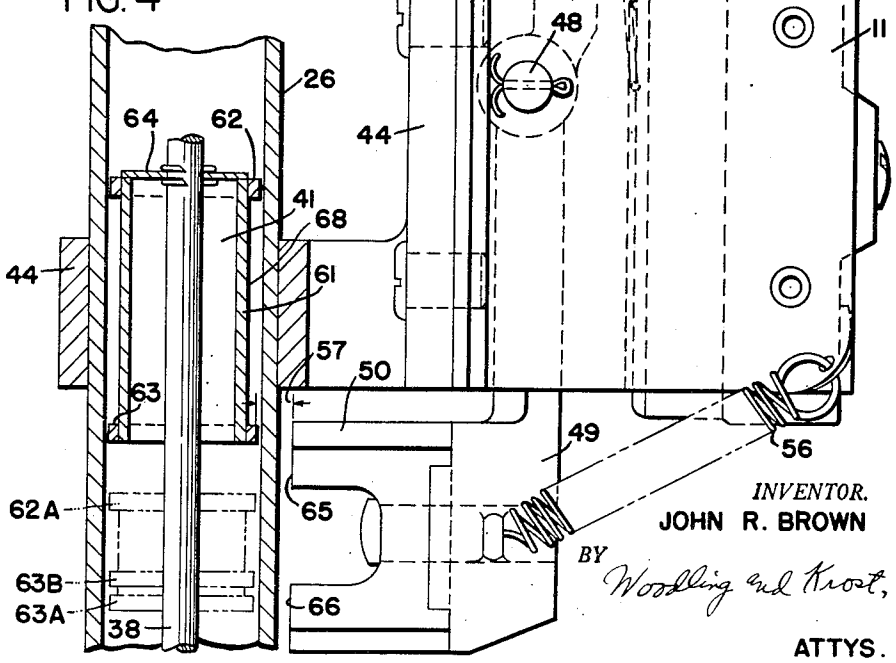


FIG. 3

FIG. 4



INVENTOR.
JOHN R. BROWN
BY Woodling and Kroat,
ATTYS.

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MAGNETIC SWITCH

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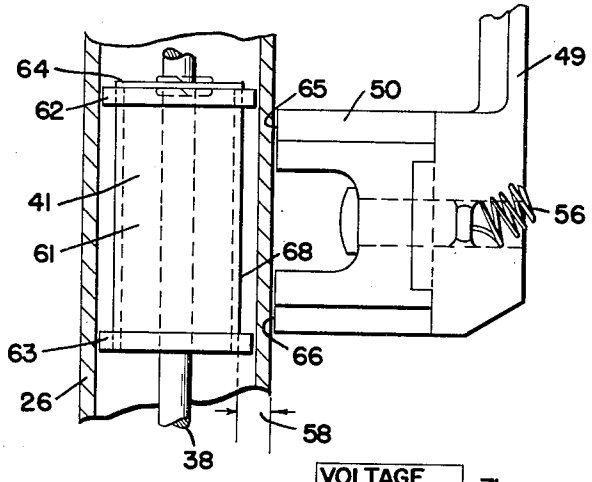
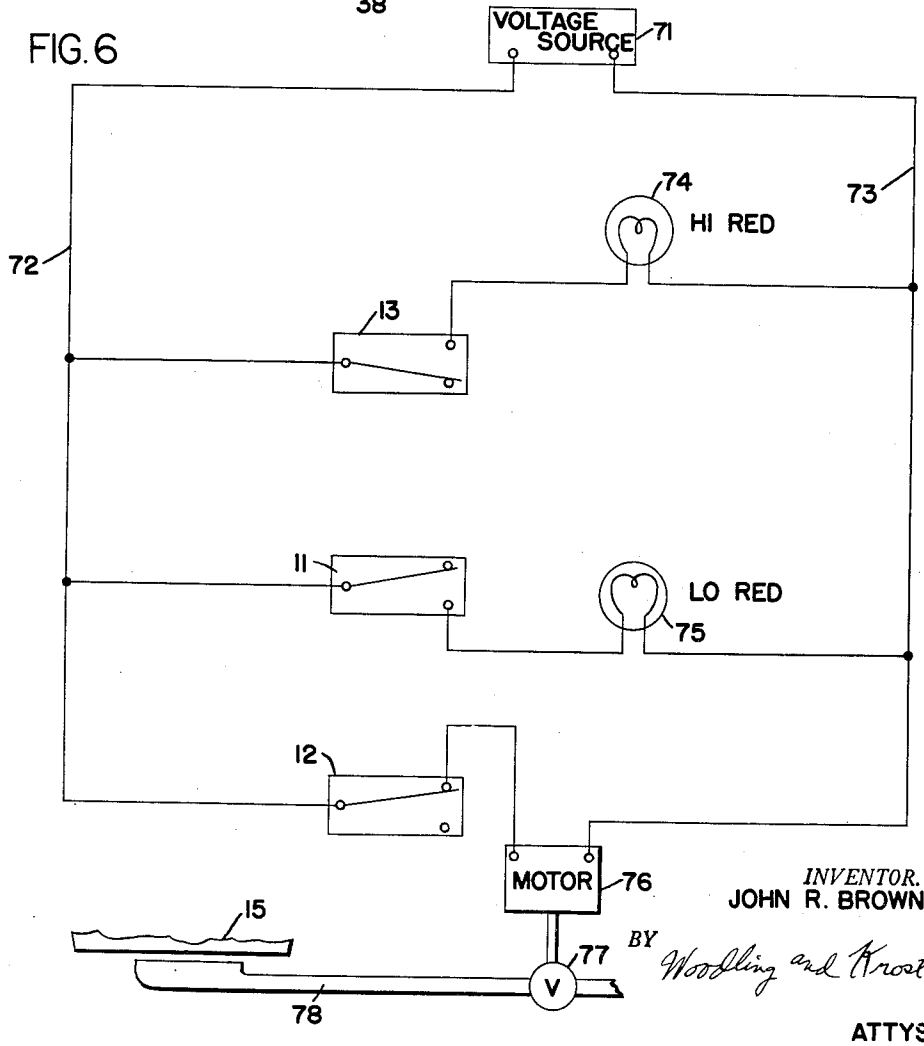


FIG. 5

FIG. 6



INVENTOR.
JOHN R. BROWN

BY Woodling and Krost,

ATTYS.

United States Patent Office

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Patented Jan. 15, 1957

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MAGNETIC SWITCH

John Rowland Brown, Cleveland, Ohio, assignor to The Reliance Gauge Column Company, a corporation of Ohio

Application October 8, 1953, Serial No. 384,895

13 Claims. (Cl. 200—84)

The invention relates in general to magnetically actuated switches and more particularly to sensitive magnetic switches, especially for use with enclosed pressure liquid reservoirs such as steam boilers.

An object of the invention is to provide a magnetically operated switch actuated by a float wherein there is a force multiplication from the float to the magnetic armature.

Another object of the invention is to provide an armature within an enclosed tube which armature cooperates with a permanent magnet and wherein the armature is spool-shaped so that the ends of the spool predominate in the magnetic cooperation with the permanent magnet.

Another object of the invention is to provide an axially movable spool-shaped armature wherein the spool ends are spaced apart farther than the spacing of the pole pieces on the magnet.

Another object of the invention is to provide an axially movable magnetic armature which is spool-shaped and which is moved by a float within a sealed tube and cooperates with a horseshoe permanent magnet movable to actuate a switch and wherein the magnet in one position has a first gap relative to the spool end, and the magnet in a second position has a second gap with the spool body with the second gap at least as large as the first gap and preferably of the same value.

Another object of the invention is to provide first and second armatures on a single float actuated rod for cooperation with separate magnetic switches.

Another object of the invention is to provide a magnetically actuated switch which has closely controllable switch closing and switch opening positions.

Another object of the invention is to provide a movable U-shaped magnet having pole pieces and an armature in cooperation therewith which is movable across the pole faces of the magnet to positions wherein the magnet will move to a hold-in position and wherein the distance of movement of the armature for such hold-in position is appreciably greater than the width of a pole face of the magnet.

Another object of the invention is to provide a magnet and armature assembly which is relatively transversely movable and wherein the armature has at least one pole piece to establish an increased air gap when a pole piece of the magnet and a pole piece of the armature are not in registry to thus increase the distance of hold-in of the magnet and to decrease the sliding friction of the armature.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings, in which:

Figure 1 is a sectional front view of magnetic switches mounted on the water column of a boiler;

Figure 2 is a sectional side view of the magnetic switches and top of the water column;

Figure 3 is a top view of the magnetic switches and water column;

Figure 4 is a partially cut away view of the armature and magnetic switch assembly;

Figure 5 is a partially cut away view of the armature in a different position relative to the magnet; and

Figure 6 is a schematic diagram of an electrical circuit usable with the magnetic switches.

The Figures 1, 2, and 3 show three magnetic switch assemblies 11, 12, and 13 which may be used in conjunction with an existing water column 14 on a boiler 15. Such water columns are standard equipment with boilers and are connected to the boiler near the top and bottom thereof as by the pipe 16. These water columns give a relatively stable water level so that a sight gauge, not shown, may be tapped off this water column for visual indication of the water level in the boiler. The water column normally has a top aperture 17 which is usually covered by a closed cap, not shown. The present invention of magnetic switch assemblies is designed to be attached directly to such standard equipment water column 14. To this end a special cap 18 is provided to be bolted to the water column by bolts 19 in a steam tight relationship. The cap 18 has first and second threaded apertures 24 and 25. First and second sealed tubes 26 and 27 have threaded lower ends to be threadably received in the apertures 24 and 25. These tubes 26 and 27 are closed at the upper ends thereof in a manner to withstand the pressure within the boiler 15 which may be considered a closed pressure liquid reservoir. Such boiler may operate at steam pressures of two hundred fifty p. s. i., for example. The tubes 26 and 27 are of some non-magnetic material, and non-magnetic stainless steel is generally satisfactory for most conditions since it will withstand the steam pressure even with thin wall sections; and it will not corrode under the boiler operating conditions.

The cap 18 carries a pivot bracket 30 which pivotally mounts at 33 first and second alarm levers 31 and 32. The alarm levers thus move in a short vertical arc. Figure 2 shows the alarm lever 31 in its upper limit position and the alarm lever 32 in its lower limit position. First and second float rods 34 and 35 are connected to the outer ends of the alarm levers 31 and 32, respectively. First and second floats 36 and 37 are connected to the first and second float rods, respectively. First and second armature rods 38 and 39 are connected to the alarm levers 31 and 32, respectively, at a point giving approximately three to one force multiplication. The first armature rod 38 carries first and second armatures 41 and 42, respectively, and the second armature rod 39 carries a third armature 43. The second armature 42 is near the upper end of the armature rod 38. The first, second, and third armatures cooperate with the first, second, and third switch assemblies 11, 12, and 13, respectively. Each of the switch assemblies has a circular clamp 44 for clamping upon a tube with the first and second switch assemblies mounted on the first tube 26 and the third switch assembly 13 mounted on the tube 27. The switch assemblies may be enclosed within a dust cover 20.

The Figure 4 shows in greater detail the construction of the switch assemblies. All switch assemblies are generally the same; and therefore, the description will be limited to the construction of switch assembly 11. It will be noted in Figure 1 that the switch assembly 12 is inverted relative to the switch assemblies 11 and 13; and a desirable feature of this invention is that such alternative positions are feasible. The switch assembly 11 has a base 47, and the clamp 44 fastens this base in a fixed position to the tube 26. The base 47 carries at a pivot 48 a switch lever 49. This switch lever 49 has a U-shaped permanent magnet 50 at one end thereof, and at the other end thereof has an adjustable abutment 51 which cooperates with the base 47. This second end also carries an adjustable stop 52 to cooperate with a switch actuating

lever 53. The lever 53 is movably carried on an enclosed switch 54 which has an operating plunger 55. Such enclosed switch 54 may be any one of the many makes which utilize a small travel and light pressure on the operating plunger 55 for actuation thereof. A tension spring 56 interconnects the magnet end of the switch lever 49 with the base 47 to urge the magnet 50 counterclockwise as viewed in Figure 4 into a first limit position 57. When the magnet is sufficiently attracted by the cooperating armature, the magnet 50 will move to a second limit position 58. This is shown in Figure 5, and this limit position is established by the magnet contacting or substantially abutting the outer wall of the sealed tube 26.

The armature 41 is shown in cooperation with the magnet 50 of the first switch assembly 11. All armatures are constructed the same and each has a body 61 with first and second protruding ends 62 and 63. These are annular ends so that the entire armature is generally spool-shaped. The ends protrude radially and fit closely within the inner bore of the tube 26, and hence, space the body 61 from the inner wall of the tube. A bridge member 64 bridges the open upper end of the armature 41 and connects to the armature rod 38. Preferably, the length of the body 61 between the spool ends 62 and 63 is equal to the overall length of the magnet 50 across the pole faces 65 and 66 thereof. This is shown in Figure 5.

The Figures 1, 2, and 3 show the floats and switch assemblies in the condition thereof when the boiler 15 has normal water level. With this normal water level 67 the float 36 is completely submerged thus causing the alarm lever 31 to be moved upwardly to its upper limit position; and hence, the armatures 41 and 42 will be in their upper limit position. With this normal water lever 67 the float 37 will not be submerged or at least will not be submerged to a condition of flotation. Such flotation condition is generally about three-fourths submerged with the size of float and load as shown herein. If the water level increases, the float 37 will eventually reach a point where it will float to move the armature 43 upwardly, and hence, cause the magnet 50 of the switch assembly 13 to be attracted to actuate the respective enclosed switch. Conversely, if the water level 67 falls, a point will be reached wherein the float 36 will no longer be held in its upper limit position and will floatingly descend with the water level so that the armatures 41 and 42 move downwardly.

The Figure 4 shows the armature 41 approximately in the upper limit position thereof which is the condition under normal water levels. Here it will be seen that the lower spool end 63 is generally opposite the pole face 65 of the magnet 50. As the armature 41 moves downwardly with decreasing water levels, a point 63A will be reached indicated by dotted lines wherein the spool end 63 is generally opposite the pole face 66; and hence, the magnet 50 is sufficiently attracted to be pulled in to thus actuate the enclosed switch 54. If the water level continues on down, the armature 41 may continue to drop, if the linkage to the float 36 so permits, until a point is reached wherein the upper spool end 62 comes into cooperation with the pole face 65. The drop-out point, that is the point wherein the magnet 50 is pulled away from the tube 41 by the spring 56, would be reached when the spool end 62 came to the dotted position 62A. This shows that the armature 41 has a long length of travel during hold-in of the magnet 50 compared to the width of the pole face 65 or 66. This is primarily due to the fact that the spool ends 62 and 63 are spaced apart a distance greater than the spacing of the pole faces 65 and 66 and achieve this hold-in despite the fact that the spool ends 62 and 63 are relatively short in axial length. As the water rises, the spool 41 will rise and the drop-out point of the magnet will be established about at the position indicated by the dotted lines 63B. An important feature of the

invention is that a first gap, shown in Figure 4, established between the pole face 65 or 66 and the spool end 63, when the magnet 50 is in the first limit position 57, is substantially the same as a second gap, shown in Figure 5, between the pole face 66 and a side 68 of the body 61, when the magnet 50 is in the second limit position 58. The fact that this second gap is at least as large as the first gap permits a close control of the pull-in and drop-out points of the switch assemblies and limits the magnetic pull of the magnet on the armature so that the sliding friction of the armature 41 and tube 26 is reduced. This is an important consideration since the size of the floats which may be used within the standard water column 14 is limited. This means that the lift created by the buoyancy of the floats is limited. For example, in a typical boiler four ounces of lift is all that is obtainable from these floats. By utilizing an armature shape which limits the sliding friction of the armature as the armature moves past the magnet and by using a three to one force multiplication of the armature relative to the float, there is no problem of the armatures sticking and failing to operate the switch.

The Figure 6 shows a schematic electrical diagram as to how the switch assemblies 11, 12, and 13 may be utilized. The Figure 6 shows a voltage source 71 energizing leads 72 and 73. The switch assemblies 11, 12, and 13 are connected to these leads. The switch assembly 13 is connected across the leads 72 and 73 in series with a high red lamp 74. The enclosed switch in the switch assembly 13 may be what is termed a normally open switch. The switch may be a single pole, double-throw switch for convenience of the user to electrically connect in whatever manner he desires. As shown in Figure 6, it may be connected as a normally open switch; and when the water level rises to move the armature 43 upwardly, the magnet 50 of the switch assembly 13 will pull in to energize the high red lamp 74. This will give an indication to the boiler operator that the water level in the boiler has reached a dangerously high condition. Such lamp 74 is merely indicative of any form of alarm, either visual or aural.

The switch assembly 11 has an enclosed switch which is wired as a normally open switch in series with a low red lamp 75. The switch of the switch assembly 11 in Figure 6 has been shown as being in a non-actuated condition, as would be the case shown in Figures 1, 2 and 3 wherein the water level is normal; and hence, the lamp 75 is not energized. When the water level falls to a predetermined level, the armature 41 will move downwardly sufficient to attract the magnet of the switch assembly 11, and hence, energize the low red lamp 75.

The armatures 41 and 42 are spaced apart farther than the magnets of the switch assemblies 11 and 12. This means that the armature 42 does not magnetically cooperate with the magnet of the switch assembly 12 until sometime after the low red lamp 75 has been illuminated. The purpose of this is that if the low red alarm is ignored and the water level continues to fall, the switch assembly 12 may come into operation as a fuel cut-off. The switch of the switch assembly 12 is shown as a normally closed switch in accordance with the normal water level as shown in Figures 1, 2, and 3. If the water level falls to a predetermined danger point, the switch assembly 12 will be actuated to an open condition to de-energize a motor 76 in series therewith. The motor 76 when energized will open a fuel valve 77 supplying fuel to a burner 78 for the boiler 15.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, a guide housing on said reservoir, an armature inside said housing, means to move said armature in accordance with said liquid level, a switch assembly cooperating with said armature, said switch assembly including a magnet having a pole piece and movable between first and second limit positions to actuate said switch between first and second positions, said armature being magnetic and having an elongated spool shaped body with first and second end portions projecting outwardly beyond said body, means to urge said magnet away from said housing into said first limit position, positioning of said armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes said urging means to move said magnet to said second limit position, said limit positions being so regulated that a first gap between said magnet pole piece in said second limit position and said armature body is at least as large and generally of the same magnitude as a second gap between said magnet pole piece in said first limit position and one of said armature projecting end portions.

2. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, an alarm lever pivotally carried on said reservoir, a float attached to said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic housing carried on said reservoir, an armature rod extending into said housing and having an end attached to said alarm lever at a point giving a force multiplication from said float, an armature on said armature rod inside said housing, a switch assembly cooperating with said armature in said housing, said switch assembly including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet with pole pieces and carried on said switch lever, a switch carried by said base and cooperating with said switch lever, said armature being magnetic and having an elongated body and first and second end portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of the armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging means to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated that a first gap between a magnet pole piece in said first limit position and an armature projecting portion is no greater than a second gap between said magnet pole piece in said second limit position and said armature body to thus decrease the sliding friction between said armature and said housing, the over-all longitudinal dimension of said armature between said end portions being substantially equal to the dimension across the pole pieces of said magnet.

3. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, an alarm lever pivotally carried on said reservoir, a float attached to said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic housing carried on said reservoir, an armature rod extending into said housing and having an end attached to said alarm lever at a point giving a force multiplication from said float, first and second armatures on said armature rod inside said housing, first and second switch assemblies cooperating with said first and second armatures, respectively, in said housing, each of said switch assemblies including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet with pole pieces and carried on said switch lever, a switch carried by said base and cooperating with said switch lever, each of said armatures being magnetic and having an elongated body and

first and second portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of an armature in the housing substantially adjacent the corresponding magnet establishing a magnetic attraction such that the magnetic force overcomes the urging means to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated that a first gap between said magnet pole piece in said first limit position and an armature prejecting portion is no greater than a second gap between said magnet pole piece in said second limit position and said armature body, the over-all longitudinal dimension of each of said armatures between said radially projecting portions being substantially equal to the dimension across the pole pieces of one of said magnets.

4. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, an alarm lever pivotally carried on said reservoir, a float attached to said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic housing carried on said reservoir, an armature rod extending into said housing and having an end attached to said alarm lever at a point giving a force multipliction from said float, an armature on said armature rod inside said housing, a switch assembly cooperating with said armature in said housing, said switch assembly including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet with pole pieces and carried on said switch lever, a switch carried by said base and cooperating with said switch lever, said armature being magnetic and having an elongated body and first and second portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, a spring to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of the armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated that a first gap between said magnet pole piece in said first limit position and said armature projecting portion is substantially the same as a second gap between said magnet pole piece in said second limit position and said armature body, the over-all longitudinal dimension of said armature between said radially projecting portions being substantially equal to the dimension across the pole pieces of said magnet.

5. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, a bracket on said reservoir, an alarm lever pivotally carried at a first end thereof by said bracket, a float attached to the second end of said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic housing extending upwardly from said bracket, an armature rod having a first end extending upwardly into said housing and having a second end attached to said alarm lever at a point giving approximately three to one force multiplication from said float, first and second armatures on said armature rod inside said housing, first and second switch assemblies cooperating with said first and second armatures, respectively, in said housing, each of said switch assemblies including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet having first and second pole pieces and carried on a first end of said switch lever, an adjustable abutment carried on a second end of said switch lever and cooperating with said base, a switch carried by said base, a stop carried on said second end of said switch lever and cooperating with said switch to actuate said switch between open and closed positions upon pivotal movement of said switch lever, each of said armatures

being magnetic and being generally spool shaped with an elongated body and first and second ends, said ends radially projecting beyond said body and lying closely adjacent the inner wall of said housing, a spring to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of an armature in the housing substantially adjacent the corresponding magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated by said adjustable abutment that a first gap between said magnet pole piece in said first limit position and said armature end is substantially the same as a second gap between said magnet pole piece in said second limit position and said armature body, the over-all dimension across the pole pieces of said magnets being substantially equal to the length of said body between said ends.

6. A float switch for use with a liquid reservoir having a variable liquid level, comprising, a bracket on said reservoir, an alarm lever pivotally carried at a first end thereof by said bracket, a float attached to the second end of said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic housing extending upwardly from said bracket, an armature rod having a first end extending upwardly into said housing and having a second end attached to said alarm lever at a point giving approximately three to one force multiplication from said float, an armature on said armature rod inside said housing, a switch assembly cooperating with said armature in said housing, said switch assembly including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet having first and second pole pieces carried on a first end of said switch lever, an adjustable abutment carried on a second end of said switch lever and cooperating with said base, a switch carried by said base, a stop carried on said second end of said switch lever and cooperating with said switch to actuate said switch between open and closed positions upon pivotal movement of said switch lever, said armature being magnetic and being generally spool shaped with an elongated body and first and second ends, said ends radially projecting beyond said body and lying closely adjacent the inner wall of said housing, a spring to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of the armature in said housing adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated by said adjustable abutment that a first gap between said magnet pole piece in said first limit position and said armature end is substantially the same as a second gap between said magnet pole piece in said second limit position and said armature body, the over-all dimension across the pole pieces of said magnet being substantially equal to the length of said body between said ends.

7. A magnetic switch assembly for use with an enclosed liquid reservoir having a variable liquid level, comprising, a cap on said reservoir to close same, said cap having an upper wall, a first threaded aperture in said upper wall, an alarm lever pivotally carried at a first end thereof by said cap and disposed below said aperture, a float attached to the second end of said lever to move said lever in an arc upon flotative movements of said float, a non-magnetic generally cylindrical tube extending upwardly from and threadably engaging said threaded aperture, an armature rod having a first end extending upwardly into said tube and having a second end attached to said alarm lever at a point giving approximately three to one force multiplication from said float, an armature on said armature rod inside said tube, a switch assembly cooperating with said armature in said tube, said switch assembly including a base fixed relative to said tube, a switch lever pivotally carried in said base, a permanent magnet carried on a first end of said switch lever, an adjustable abutment carried on a second end of said switch lever and cooperating with said base, an enclosed switch having an actuating lever and carried by said base, an adjustable stop carried on said second end of said switch lever and cooperating with said switch actuating lever to actuate said enclosed switch between open and closed positions upon pivotal movement of said switch lever, said armature being magnetic and being generally spool shaped with a generally cylindrical body and first and second annular ends, said annular ends radially projecting beyond said cylindrical body and lying closely adjacent the inner wall of said tube, a spring to urge said permanent magnet pivotally away from said tube into a first limit position corresponding to a first position of said enclosed switch, longitudinal positioning of the armature in said tube adjacent said permanent magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said permanent magnet to a second limit position corresponding to a second position of said enclosed switch, said limit positions being so regulated by said adjustable abutment that a first gap between said permanent magnet pole piece in said first limit position and said armature annular end is substantially the same as a second gap between said permanent magnet pole piece in said second limit position and said armature cylindrical body, the over-all dimension across the pole pieces of said permanent magnet being substantially equal to the length of said cylindrical body between said annular ends.

8. A magnetic switch assembly for use with an enclosed liquid reservoir having a variable liquid level, comprising, a cap on said reservoir to close same, said cap having an upper wall, a first threaded aperture in said upper wall, an alarm lever pivotally carried at a first end thereof by said cap in a generally horizontal position and disposed below said first aperture, a float attached to the second end of said lever to move said lever in a vertical arc upon flotative movements of said float, a non-magnetic generally cylindrical closed tube extending generally vertically upwardly from and threadably engaging said first threaded aperture, an armature rod having a first end extending upwardly into said tube and having a second end attached to said alarm lever at a point giving approximately three to one force multiplication from said float, first and second armatures on said armature rod inside said tube, first and second switch assemblies cooperating with said first and second armatures, respectively, in said tube, each of said switch assemblies including a base fixed relative to said tube, a switch lever pivotally carried in said base, a permanent magnet carried on a first end of said switch lever, an adjustable abutment carried on a second end of said switch lever and cooperating with said base, an enclosed switch having an actuating lever and carried by said base, an adjustable stop carried on said second end of said switch lever and cooperating with said switch actuating lever to actuate said enclosed switch between open and closed positions upon pivotal movement of said switch lever, each of said armatures being magnetic and being generally spool shaped with a generally cylindrical body and first and second annular ends, said annular ends radially projecting beyond said cylindrical body and lying closely adjacent the inner wall of the respective tube, a spring to urge said permanent magnet pivotally away from said tube into a first limit position corresponding to a first position of said enclosed switch, vertical positioning of an armature in the tube substantially adjacent the corresponding permanent magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said permanent magnet to a second limit position corresponding to a second position of said enclosed switch, said limit posi-

tions being so regulated by said adjustable abutment that a first gap between said permanent magnet pole piece in said first limit position and said armature annular end is substantially the same as a second gap between said permanent magnet pole piece in said second limit position and said armature cylindrical body, the over-all vertical dimension across the pole pieces of said permanent magnets being substantially equal to the vertical length of said cylindrical body between said annular ends.

9. A magnetic switch assembly for use with an enclosed pressure reservoir having a water column at one side thereof with a top aperture therein, comprising, an inverted cup shaped cap cooperating with said aperture to close same, said cap having an upper wall, second and third threaded apertures in said upper wall, low and high alarm levers pivotally carried at a first end thereof by said cap in a generally horizontal position and disposed below said second and third apertures, respectively, low and high level floats attached to the second ends of the respective levers to move said levers in a vertical arc through a first limited range upon floative movements of said floats, first and second nonmagnetic generally cylindrical closed tubes extending generally vertically upwardly from and threadably engaging said second and third threaded apertures, respectively, first and second armature rods each having a first end extending upwardly into said first and second tubes, respectively, and having a second end attached to said low and high alarm levers, respectively, at a point giving approximately three to one force multiplication from said floats, first and second armatures on said first armature rod inside said first tube, a third armature on said second armature rod inside said second tube, a dust cover enclosing said tubes, first, second, and third switch assemblies carried inside said dust cover and cooperating with said first, second, and third armatures, respectively, each of said switch assemblies including a base fixed relative to the respective tube, a switch lever pivotally carried in said base, a permanent magnet carried on a first end of said switch lever, an adjustable abutment carried on a second end of said switch lever and cooperating with said base, an enclosed switch having an actuating lever and carried by said base, an adjustable stop carried on said second end of said switch lever and cooperating with said switch actuating lever to actuate said enclosed switch between open and closed positions upon pivotal movement of said switch lever, each of said armatures being magnetic and being generally spool shaped with a generally cylindrical body and first and second annular ends, said annular ends radially projecting beyond said cylindrical body and lying closely adjacent the inner wall of the respective tube, a spring to urge said permanent magnet pivotally away from said tube into a first limit position corresponding to a first position of said enclosed switch, vertical positioning of an armature in a tube substantially adjacent the corresponding permanent magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said spring to move said permanent magnet to a second limit position corresponding to a second position of said enclosed switch, said limit positions being so regulated by said adjustable abutment that a first gap between said permanent magnet pole piece in said first limit position and said armature annular end is substantially the same as a second gap between said permanent magnet pole piece in said second limit position and said armature cylindrical body, the over-all vertical dimension across the pole pieces of said permanent magnets being substantially equal to the vertical length of said cylindrical body between said annular ends, said first armature rod having a second limited range of movement corresponding to said first limited range of said low alarm lever, the magnets of said first and second switch assemblies being spaced apart a distance greater than said second range of movement, said first and second armatures being spaced apart on said first armature rod a distance greater than

the spacing of the magnets of said first and second switch assemblies whereby the magnet of said first switch assembly cooperates with said first armature but not with said second armature and the magnet of said second switch assembly cooperates with said second armature but not with said first armature.

10. In a magnetic switch assembly having a switch operable by a movable magnet mounted outside a housing, said magnet having pole pieces, the provision of a spool shaped magnetic armature longitudinally movable in said housing, said armature having an elongated body and first and second ends, said ends radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet away from said housing into a first limit position corresponding to a first position of said switch, longitudinal positioning of the armature in said housing adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging of said urging means to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated that a first gap between a magnet pole piece in said first limit position and an armature end is substantially the same as a second gap between said magnet pole piece in said second limit position and said armature body, the over-all dimension across the pole pieces of said magnet being substantially equal to the length of said body between said ends.

11. A magnetic switch assembly, comprising, a nonmagnetic housing, an armature movable inside said housing, a switch assembly cooperating with said armature in said housing, said switch assembly including a switch having first and second conditions and carried relative to said housing, switch actuating means, a magnet with pole pieces and carried on said switch actuating means, said armature being magnetic and having an elongated body and first and second end portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet away from said housing into a first limit position corresponding to said first condition of said switch, positioning of the armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging means to move said magnet to a second limit position corresponding to said second condition of said switch, said limit positions being so regulated that a first gap between a magnet pole piece in said first limit position and an armature projecting portion is no greater than a second gap between said magnet pole piece in said second limit position and said armature body, the over-all longitudinal dimension of said armature between said end portions being substantially equal to the dimension across the pole pieces of said magnet.

12. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, a non-magnetic housing carried on said reservoir, an armature inside said housing, float means connected to move said armature, a switch assembly cooperating with said armature in said housing, said switch assembly including a switch lever pivotally carried relative to said housing, a magnet with pole pieces and carried on said switch lever, a switch cooperating with said switch lever, and having first and second positions, said armature being magnetic and having an elongated body and first and second end portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet pivotally away from said housing into a first limit position corresponding to said first position of said switch, longitudinal positioning of the armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging means to move said magnet to a second limit position corresponding to said second position of said switch, said limit positions being so regulated that a first gap between a magnet pole piece in said first limit

position and an armature projecting portion is no greater than a second gap between said magnet pole piece in said second limit position and said armature body to thus decrease the sliding friction between said armature and said housing, the over-all longitudinal dimension of said armature between said end portions being substantially equal to the dimension across the pole pieces of said magnet.

13. A magnetic switch assembly for use with a liquid reservoir having a variable liquid level, comprising, a float operable in said reservoir, a non-magnetic housing carried on said reservoir, an armature rod extending into said housing and having an end operable by said float, an armature on said armature rod inside said housing, a switch assembly cooperating with said armature in said housing, said switch assembly including a base fixed relative to said housing, a switch lever pivotally carried in said base, a magnet with pole pieces and carried on said switch lever, a switch carried by said base and cooperating with said switch lever, said armature being magnetic and having an elongated body and first and second end portions radially projecting beyond said body and lying closely adjacent the inner wall of said housing, means to urge said magnet pivotally away from said housing into a first limit position corresponding to a first position

of said switch, longitudinal positioning of the armature in the housing substantially adjacent said magnet establishing a magnetic attraction such that the magnetic force overcomes the urging means to move said magnet to a second limit position corresponding to a second position of said switch, said limit positions being so regulated that a first gap between a magnet pole piece in said first limit position and an armature projecting portion is no greater than a second gap between said magnet pole piece in said second limit position and said armature body to thus decrease the sliding friction between said armature and said housing, the over-all longitudinal dimension of said armature between said end portions being substantially equal to the dimension across the pole pieces of said magnet.

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