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PRESSURE RESPONSIVE SWITCHING DEVICE

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Att'y
The present invention relates to pressure actuated switching devices, and is particularly concerned with the provision of an improved device of the class described which is sensitive to extreme minute changes of pressure.

One of the objects of the invention is the provision of an improved pressure responsive switch which operates with a minimum amount of friction and which may be embodied in a structure adapted to make the circuit or to break the circuit.

Another object of the invention is the provision of an improved pressure responsive switch of the class described which may be adjusted so that its pressure range or the amount of pressure required for actuation of the switch may be predetermined by means of this adjustment.

Another object of the invention is the provision of an improved device of the class described which may be used to operate upon the application of differential pressures, and which is especially adaptable for use as a safety device for the monitoring of small flows.

Another object of the invention is the provision of an improved switch of the class described, the parts of which are adapted to resist corrosive influences, and the moving parts of which have a minimum amount of mass so that the inertia effects due to mass, will be minimized.

Another object of the invention is the provision of an improved switch structure having an improved diaphragm which has a minimum resistance to movement so that the diaphragm may be operated by very minute pressure differentials, and which is provided with resilient means that may be used in assisting the diaphragm.

Other objects and advantages of the invention will be apparent from the following description and the accompanying drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the single sheet of drawings:

Fig. 1 is a side elevational view of a switch unit embodying my invention, shown in partial section on a line passing through the axis of the diaphragm and push rod;

Fig. 2 is a top plan view of the switch unit;

Fig. 3 is a fragmentary front elevational view, showing the mode of attachment of the spring support;

Fig. 4 is a rear elevational view, partially broken away to show the diaphragm structure;

Fig. 5 is a fragmentary sectional view of a portion of the diaphragm, showing the action which takes place in movement of the diaphragm.

The switch unit, which is shown in plan in Fig. 2, is indicated by the numeral 10, and it preferably is provided with a housing consisting of a pair of housing parts 11 and 12, each of these being preferably formed with an internal recess 13, 14 (Fig. 1). The shape of the housing parts in elevation may vary, but in the embodiment selected to illustrate the invention these housing parts have been made rectangular, and each of the housing parts is provided with an outwardly projecting attaching flange 15, 16 surrounding the recesses 13, 14, and provided with plane seating surfaces 17, 18 to engage the diaphragm.

The housing halves 11, 12 may be secured together by a plurality of screw bolts 19 passing through unthreaded apertures 20 in one flange 16 and threaded into a threaded bore 21 in the other flange 15. The diaphragm also has apertures for passing the screw bolts 19.

The two housing halves 11, 12 preferably comprise metal castings, but in some embodiments of the invention may be molded out of insulating or plastic materials. The housing member 11 is preferably provided on its rear wall 22 with a pair of bosses 23, 24, each of which is provided with a threaded bore 25, 26, and either of which is adapted to be used as an inlet or an outlet.

When the switch is to be made responsive to a differential of pressure between that in the chamber 13 and that of the external air communicating with chamber 14, then one of the threaded bores, such as bore 26, may be plugged with a standard plug 27, and the other may be provided with a suitable pipe 28 for conveying the fluid under pressure to the chamber 13.

The diaphragm is indicated in its entirety by the numeral 29, and it consists of a sheet 29 of extremely flexible and slightly resilient material, such as a fabric sheet impregnated with an artificial rubber, such as neoprene, or a pure sheet of this material. The sheet 29 is rectangular in form so that it may be clamped between the flanges 15 and 16, and it is provided inside the cavities 13 and 14 with a preformed continuous rib or U-shaped bend 30, which extends all the way around the periphery of the sheet 29 inside the recesses 13, 14.

The U-shaped bend 30 may extend toward either side of the diaphragm, but preferably extends toward the side away from the pressure chamber 13. Its resiliency is such that it tends to hold the diaphragm 29 in a middle position, but its flexibility is such that the resilient material of which the diaphragm sheet 29 is made rolls at the U-shaped bend 30 when the diaphragm is moved.

For example, each U-shaped bend of the rib 30 may consist of the sides 31, 32 and the easy bend 33.

Referring to Fig. 1, this view shows the diaphragm at its medial position. When pressure is exerted upon the diaphragm from the chamber 13, the leg 31 of the U-shaped bend tends to become shorter, while the leg 32 of this bend tends to become longer, as shown in Fig. 5.
During this action material previously forming the leg 31 rolls outward to form the yoke 33, while the material previously forming the yoke rolls outward to form the flange or leg 32. This involves some stretching of the material; but, as the amount of movement of the diaphragm is very minute, it may be actuated by very minute forces.

The diaphragm sheet 29 is preferably provided with a pair of stiffening sheets 34, 35 of light material, such as sheet aluminum, and these sheets are preferably rectangular and of sufficient size to cover both sides of the diaphragm to a border line, which is in proximity to the U-shaped bend 30. The stiffening sheets 34, 35 and the diaphragm sheet 29 are all provided with registering apertures 36 centrally located and adapted to receive the reduced end 37 of a push rod 38, which may have an annular shoulder 39 engaging the stiffening sheet 35 and may have its end portion riveted over at 40 to clamp the stiffening sheets on the flexible sheet 29 and to secure the push rod in place.

The push rod 38 is provided with a threaded end portion 41, which engages the slots from 28 the housing member 14 through an aperture 42, and is preferably provided with four lock nut assemblies 43–46. These lock nut assemblies may be identical in construction, and each may consist of a nut member 47 having a partially spherical bearing surface 48 for engaging the switch arm 49 or the spring 50.

In addition to this, each nut assembly has a relatively thin nut 51 of conventional shape, locking the ball nut 48 in place. Thus, when adjusted, the nut assemblies 43–46 are adapted to be locked permanently in adjusted position.

The housing member 14 is preferably provided with an integral laterally projecting supporting flange of angular shape, as indicated at 52 (Fig. 2), provided with apertures 53 for a threaded member. One of the apertures 53 is preferably a horizontally elongated slot, as shown in Fig. 1, thus permitting an adjustment of the unit to a vertical position, where it is clamped by the supporting screws or bolts.

The housing member 14 is preferably provided at one end with an outwardly projecting lug 54, which is rectangular in elevation and provided with a plane supporting surface 55, having a pair of threaded bores 56.

The bores 56 are adapted to receive the screw bolts 57, which pass through unthreaded bores in a supporting plate 58, spring 59, and a pair of columns 59, which are provided with V grooves 60 on their upper surface for receiving the knife edge pivot members 61 that are carried by the switch arm 49.

Thus the assembly, comprising the boss 54, columns 59, spring 59, plate 58, and screw bolts 57, form a U-shaped member, within which the switch arm 49 is confined; but this arm is provided with a clearance with respect to the outwardly projecting columns 59, as indicated at 62 (Fig. 3).

The only contact of the switch arm 49 with its support is by way of the knife edge members 61.

The switch arm 49 may consist of a cast metal member provided with the integral laterally projecting V-shaped knife edge members 61. The angularity of these knife edge members is, of course, greater than that of the V-shaped grooves 60 so as to provide a sufficient freedom of movement, but friction is thus reduced to a minimum, since the switch arm rests only upon the relatively sharp line contact provided by the knife edge members 61.

At its lower end the switch arm 49 may be provided with a U-shaped socket 63, having frictional engagement with a U-shaped permanent magnet 64 located in the socket, and having its pole faces 65 facing outwardly. This permanent magnet may be made of any desired material, but is preferably a magnet of high coercive force, made of material such as that known as "Alnico."

The switch arm 49 hangs vertically and maintains its position by gravity, and the switch unit 67 should be supported in vertical position. The switch arm 49 is provided with a through bore 68 for passing the push rod 38, and the ball nut assemblies 43, 44 engage with their partially spherical surfaces on each of the plane surfaces 67, 68 on the front and back of the switch arm 49.

The nut assemblies 43, 44 may be adjusted to provide a lost motion action between the diaphragm and the switch arm 49 in either direction, or they may be adjusted into relatively close contact so that the arm 49 is actuated as soon as the spring 50 is compressed.

The spring 50 comprises a resilient sheet metal member which may be made of beryllium copper, phosphor bronze, or other noncorroding, resilient material, and this spring is likewise provided with an aperture adjacent its lower end for passing the threaded portion 41 of the push rod.

The spring 50 is preferably of full width, engaging both of the columns 59 at the top, but it tapers downwardly toward its lower end, and this reduces the force necessary to bend the spring, and increases its flexibility.

The lock nut assemblies 45, 46 are arranged to bear on the opposite plane surfaces of the spring 50. These nuts may also be adjusted to accomplish various results, and may permit a lost motion action between the spring and the push rod and diaphragm, or the nuts may be adjusted to permit the spring to act in either direction.

Ordinarily the spring 50 is arranged to resist pressure on the diaphragm 28, but it may be arranged so as to assist the diaphragm, and thus make the diaphragm responsive to still lower pressures.

The lower end of the switch arm 49 and the supporting bracket 67 may be provided with any desired form of movable and fixed contacts, but the bracket 67 preferably supports a mercury switch unit of the type indicated at 68.

This switch unit has a pair of leads 69, 70 sealed into a glass envelope 71, and one of the leads 70 extends downward into contact with a mercury globule 72. The shape of the envelope 71 may vary, but is preferably round and elongated and provided with a partially spherical recess 73 at its lower end for receiving the mercury globule 72.

The other lead 69 communicates with a depending internal conductor 74 in the envelope 71, which preferably carries a spiral spring 75 and a depending arm 76. The depending arm 76 may be a wire which has its lower end 77 dipping in the globule of mercury 72, but depending arm 76 also supports a magnetic vane 78. The magnetic vane comprises a sheet of paramagnetic material, such as anode. Laterally is provided a wall of the envelope so that it may move sufficiently to move the contact finger 77 out of the globule 72 of mercury.

Such a switch unit is very sensitive, and it may be used without danger of electric sparks causing explosions. The mercury switch unit 68 may be
supported by one or more spring clips 79 carried by a sheet metal attaching flange 80, which is riveted to the upwardly projecting flange of the bracket 67 by rivet 81.

The operation of my pressure responsive switch is as follows: When the spring 50 is so arranged relative to the nuts 45, 46 that the spring resists movement toward the right, the spring increases the resistance of the diaphragm toward movement. Under such conditions, when the chamber 13 is provided with fluid under pressure, this pressure builds up until the total thrust exerted on the diaphragm 28 is sufficient to move the diaphragm and to move the spring, and then the push rod 38 is moved toward the right, moving the switch arm 49 toward the right.

The permanent magnet 64 then comes into closer proximity to the mercury switch unit 68, and the field surrounding the vane 18 becomes strong enough so that the vane is drawn toward the magnet, causing a breaking of the circuit with a snap action. Upon reduction of pressure there is a corresponding reverse action, permitting a making of the circuit with snap action.

I declare it to be understood that in some embodiments of the invention the spring 50 may be omitted. In other embodiments of the invention the spring may be arranged to assist the diaphragm so that the spring is adapted to overcome almost all of the resistance of the diaphragm, and the diaphragm is thus responsive to still more minute pressures.

Under these conditions, however, it may be necessary to reset the diaphragm to the initial position by hand.

It will thus be observed that I have invented an improved pressure responsive switch which is adapted to be actuated by very minute differentials of pressure. The material of which the diaphragm is made is not subject to deterioration by grease or other chemicals to which it may be subjected, and the present switch may be used in many places where other switches would be unsafe.

The friction of the moving parts is reduced to a minimum, and the present switch may be actuated by as small a differential of pressure as 0.01 inch of water.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of a minute pressure differential exerted on the opposite sides of said diaphragm, the said circuit making and breaking means comprising a mercury switch unit having an enclosed contact engaging a globule of mercury and a magnetic vane carried by said contact for moving the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane.

2. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of a minute pressure differential exerted on the opposite sides of said diaphragm, the said circuit making and breaking means comprising a mercury switch unit having an enclosed contact engaging a globule of mercury and a magnetic vane carried by said contact for moving the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane.

3. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of a minute pressure differential exerted on the opposite sides of said diaphragm, said housing also supporting a resilient sheet metal member having an aperture for passing said actuating member, and the actuating member having threaded members on opposite sides of said resilient member for permitting adjustment of the range of action of said switch.

4. A pressure responsive switch adapted to be actuated responsive to very minute pressure changes, comprising a housing having a pair of recessed members bordered by clamping flanges, one of said recesses having an inlet, a thin, flexible, resilient sheet clamped between said clamping flanges and forming part of a diaphragm, an actuating member secured centrally to said sheet and projecting through one of said housing members, said housing having a pair of horizontally projecting supporting arms, a switch arm hanging by gravity in substantially vertical position from said arms, by means of a pair of knife edge members, and means on said actuating member for engaging said arm to move the switch arm to make or break a contact upon movement of said diaphragm, said horizontally extending arms also supporting a depending spring, said spring being tapered toward its lower end, and said lower end being located in proximity to said actuating member, and means on said actuating member for engaging one side of said spring when the diaphragm is actuated by a differential of pressure.

5. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch
arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of a minute pressure differential exerted on the opposite sides of said diaphragm, the said circuit making and breaking means comprising a mercury switch unit having an enclosed contact engaging a globule of mercury and a magnetic vane carried by said contact for moving the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane, said diaphragm including a sheet of resilient flexible material carried between a pair of stiff sheets of light metal, the edges of which are spaced from said housing to leave an intermediate flexing portion between said plates and the housing.

6. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of a minute pressure differential exerted on the opposite sides of said diaphragm, the said circuit making and breaking means comprising a mercury switch unit having an enclosed contact engaging a globule of mercury and a magnetic vane carried by said contact for moving the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane, said diaphragm including a sheet of resilient flexible material carried between a pair of stiff sheets of light metal, the edges of which are spaced from said housing to leave an intermediate flexing portion between said plates and the housing, and said diaphragm flexing between the metal sheets and said housing.  

7. In a pressure actuated switch, the combination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane, said diaphragm including a sheet of resilient flexible material carried between a pair of stiff sheets of light metal, the edges of which are spaced from said housing to leave an intermediate flexing portion between said plates and the housing.
bination of a housing member provided with a pressure chamber and a diaphragm carried by said housing, said diaphragm closing the pressure chamber and being provided with an outwardly projecting actuating member, a depending switch arm carried by said housing and supported upon knife edges, said switch arm having its position determined by gravity, and circuit making and breaking means controlled by the end of said switch arm and adapted to be actuated by the application of minute pressure differential exerted on the opposite sides of said diaphragm, the said circuit making and breaking means comprising a mercury switch unit having an enclosed contact engaging a globule of mercury and a magnetic vane carried by said contact for moving the contact, and said switch arm having a magnet adapted to be moved to bring its field into position to actuate said vane, said diaphragm having a pair of relatively stiff metal sheets arranged on its opposite sides and engaged by said actuating member, a resilient member carried by said housing and extending substantially parallel to said switch arm, said actuating member being provided with adjustable shoulders for engaging said resilient member and adjusting the range of action of said switch arm.

13. A pressure responsive switch adapted to be actuated responsive to very minute pressure changes, comprising a housing having a pair of recessed members bordered by clamping flanges, one of said recesses having an inlet, a thin, flexible, resilient sheet clamped between said clamping flanges and forming part of a diaphragm, an actuating member secured centrally to said sheet and projecting through one of said housing members, said housing having a pair of horizontally projecting supporting arms, a switch arm hanging by gravity in substantially vertical position from said arms, by means of a pair of knife edge members, and means on said actuating member for engaging said arm to move the switch arm to make or break a contact upon minimum movement of said diaphragm, said horizontally extending arms also supporting a depending spring, said spring being tapered toward its lower end, and said lower end being located in proximity to said actuating member, means on said actuating member for engaging one side of said spring when the diaphragm is actuated by a differential of pressure, and a magnet carried by said switch arm and a switch unit comprising a mercury switch having a movable arm provided with a magnetic vane to be moved by said magnet, said movable arm provided with a magnetic vane to be moved by said magnet, said movable arm carrying a contact for engaging a globule of mercury.

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