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PRESSURE ACTUATED SWITCH
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1 Claim

This invention relates to a pressure switch. More particularly, the invention relates to improvements in pressure switches and provides means for constructing pressure switches which will be more accurate, easier to adjust to actuate at critical pressures, and which will have a greatly reduced incident of failure.

One of the difficulties encountered in the manufacturing of pressure switches is the problem of adjusting the switch so that it will actuate at the exact required pressure. Pressure switches ordinarily consist of the movement of a switch actuating rod upon overcoming a spring tension pressure. As the pressure is sufficient to overcome the force exerted by a spring under compression, the switch actuating rod moves to actuate the switch. Adjusting the switch in relation to the movement of the rod so that the switch is actuated repeatedly at precisely the same pressure has been an onerous problem.

It is therefore one object of this invention to provide a micrometer type switch adjustment for pressure switches.

As above mentioned, most microswitches include the use of a spring under tension which must be overcome by the pressure in the system to which the switch is attached. When the spring tension is overcome the movement of the switch rod or other mechanisms actuate the switch. Most springs used in pressure switches are coiled springs which form more or less a cylinder with substantially perpendicular ends. In the formation of a spring, however, it is virtually impossible to provide a finished spring which will have its ends exactly perpendicular. For this reason, when a spring is attached to a rod and the rod moves under fluid pressure, there is usually a tendency to force the rod laterally in one direction or another or to bind the rod so that it does not move freely. Another object of this invention is to provide a ball and socket type mounting arrangement for applying spring compression pressure to a switch actuating rod so that any deformity in the spring will not result in misalignment or binding of the switch actuating rod.

A most commonly used type of gasket for pressure switches, and other mechanical devices wherein gaskets must be used to seal the passage of fluid or gases, is the O-ring type gasket. Under pressure, the O-ring material is deformed to assume the approximate diameter of the openings containing the O-ring. When a parallel sided groove is used wherein the sides of the groove are substantially perpendicular to the axis of the rod on which the O-ring is mounted, and the O-ring gasket is subjected to pressure, the surface tension between the O-ring and the cylinder in which the rod is actuating increases greatly. This results in a tremendous frictional increase in the movement of a piston within a cylinder upon the application of pressure. Another object of this invention is to provide a mounting arrangement for O-rings wherein the application of pressure will not result in a substantial increase of the friction drag of the O-ring against the cylinder's walls.

These and other objects and a better understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the attached drawings in which:

FIGURE 1 is an external view of the completely assembled pressure switch of this invention.

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FIGURE 2 is an enlarged cross-sectional view of the pressure switch of this invention, taken along the line 2—2 of FIGURE 1.

FIGURE 3 is an enlarged view of an O-ring in a typical parallel sided groove showing the approximate configuration the O-ring assumes upon the application of pressure.

FIGURE 4 is a partial cross-sectional view showing the approximate configuration an O-ring will take when subjected to pressure and when the O-ring is positioned in an improved seating groove according to the principles of this invention.

This invention may be described as improvements in pressure switches. More particularly, but not by way of limitation, the invention may be described as a pressure switch having a tubular base, a flexible diaphragm member affixed to said base to seal the tubular opening thereof, a switch actuator rod movably positioned in relation to said base having one end thereof in engagement with said diaphragm, a coil spring adaptable to apply predetermined pressure against said diaphragm, a switch base adjustably lockable to said tubular base, means lockable to said switch base to adjust said spring pressure, said switch base having an opening therein adaptable to slidably receive said switch actuator rod, and a switch affixed to said base having a switch actuator element contractable with said switch actuator rod.

Referring now to the drawings and first to FIGURE 1 the pressure switch of this invention is indicated generally by the numeral 10. The observable external elements of the pressure switch 10 include a base 12, having an integrally formed external threaded portion 14 adaptable to screw into a threaded opening in a vessel, line or other mechanical systems wherein pressure is to be measured, a housing 16 and an electrical connector 18. The pressure switch 10 is shown as cylindrical in configuration but the principles of the invention may be utilized in switches having other geometric configurations.

Referring now to FIGURE 2 the internal elements of the invention are shown in cross-section. Base 12 is of a tubular configuration having a smaller diameter tubular opening 20 in the threaded portion 14. A piston 22 is positioned in the smaller diameter tubular opening 20. Piston 22 has an integrally formed enlarged end portion 24 which is of a configuration to coincide with a recessed area 26 in base 12. End portion 24 positioned in recessed area 26 prevents the piston 22 from sliding out the end of small diameter tubular opening 20. A gasket groove 28 is formed in piston 22 adaptable to receive an O-ring gasket 30. When pressure is exerted in the smaller diameter tubular opening 20, piston 22 is forced upward.

Intersecting the smaller diameter tubular opening 20 of base 12 is a larger diameter tubular opening 32. Larger diameter tubular opening 32 and smaller diameter tubular opening 20 have coincident axis and meet to form a shoulder portion 34 in base 12. A diaphragm 36 is positioned on the shoulder 34 and serves to separate the smaller diameter tubular opening 20 from the larger diameter tubular opening 32. Diaphragm 36 is made of a flexible metal, such as stainless steel, beryllium copper or phosphor bronze, which are not readily attacked by most liquids and gases. Diaphragm 36 serves to seal the small diameter tubular opening 20 from the rest of the pressure switch to prevent the escape of liquids or gases into the upper portion of the pressure switch.

A cylindrical diaphragm seal 38 is provided having integrally formed circular ridge 40 which engages diaphragm 36 and compresses it against the shoulder area 34 to prevent the leakage of fluid past the diaphragm. Diaphragm seal 38 has an opening 42 therein and a lip portion 44.

A switch actuator rod 46 is slideably positioned within pressure switch 10 and has an integrally formed enlarged end portion 48 having engagement with diaphragm 36. Lip 44 extends over end portion 48 to maintain switch actuator rod 46 in its proper relationship with diaphragm 36. Lip 44 is disposed away from diaphragm 36 a sufficient distance to allow axial movement of rod 46 by the action of diaphragm 36.

A spring housing member 50, of a tubular configuration, is provided having a reduced diameter externally and internally threaded end portion 52 adaptable to threadably engage internally threaded larger diameter tubular opening 32 of base 12. End portion 52 engages diaphragm seal 38 and forces it against diaphragm 36 to seal the diaphragm and thereby prevent leakage of fluid past the diaphragm.

A tubular, externally threaded, spring adjusting member 54 is adaptable to threadably engage the internal threaded portion of spring housing member 50. Spring adjusting member 54 is closed at one end, the closed end having an opening 56 therein adaptable to slideably receive switch actuator rod 46. Spring adjusting member 54 encompasses a coiled spring 58. Spring 58 is adaptable to supply compressive tension urging switch actuator rod 46 against diaphragm 36.

Integrally formed on switch actuator rod 46 adjacent enlarged end portion 48 is shoulder portion 60 having rounded shoulder area 62.

A lower spring washer 64 is provided having an opening therein to receive switch actuator rod 46. The function of lower spring washer 64 is to receive the compressive force of spring 58 and transmit it to the shoulder portion 60 of switch actuator rod 46. A rounded shoulder area 66 is formed on lower spring washer 64 to engage rounded shoulder area 62 on the shoulder portion 60 of switch actuator rod 46. The action of the rounded shoulder area 66 of spring washer 64 against the rounded shoulder area 62 of switch actuator rod 46 is substantially that of a ball and socket. This provision means that force applied by spring 58 against switch actuator rod 46 will be applied substantially equal around the total circumference of shoulder portion 60. It is well known that coiled springs are difficult to manufacture wherein their ends terminate exactly perpendicular to the axis of the spring. It is very difficult to produce a coiled spring which will exert equal pressure under compression around the full 360° circumference of the ends. One difficulty which has hitherto interfered with the accuracy of pressure switches is that a compressive spring has a tendency to place the switch actuator rod in a bind, that is, forcing it not only downward but to one side or the other. By the provision of the ball and socket fit of the rounded shoulder area 66 of lower spring washer 64 against the rounded shoulder area 62 of shoulder portion 60 of switch actuator rod 46 an arrangement is achieved wherein any uneven pressure around the circumference of the spring 58 will be eliminated by the ball and socket fit and there will be no tendency to force switch actuator rod 46 into misalignment.

An upper spring washer 68 is provided to support spring 58 in its upper end against the closed end of spring adjusting member 54.

Compression of spring 58 is adjusted by rotation of spring adjusting member 54. The amount of pressure which must be applied in small diameter tubular opening 20 to force piston 22 upward to move switch actuator rod 46 is thus adjusted by rotating spring adjusting member 54. Switch actuator rod 46 moves, when switch 10 is subjected to sufficient pressure to overcome the compression of spring 58, a relatively short distance, the total movement being limited by lips 44 of diaphragm seal 38.

A switch base 70 is provided having an integrally formed extending externally threaded portion 72 threadably engages an upper internal threaded portion 74 of spring housing member 50. A switch 76 is supported in

switch base 70 by means such as screws 78. Switch 76 includes a protruding switch actuator member 80. Switch 76 is of a type generally found in commercial application and is ordinarily referred to as "microswitch" in that the switch 76 is designed such that a very slight movement of protruding actuating member 80 serves to actuate switch 76.

An opening 82 in switch base 70 is adaptable to slideably receive switch actuator rod 46 and to support it in alignment wherein the end of switch actuator rod 46 engages the protruding actuating member 80 of switch 76.

Affixed to base 12 and surrounding the components of pressure switch 10 is a cylindrical housing 16 which is supported to base 12 by screws 84. Affixed to the upper end of housing 16 is an electrical connector 18 adaptable to receive an electric connector plug (not shown) whereby electrical connection may be made with pressure switch 10. Connector 18 is supported to housing 16 by screws 86. Conductors 88 connect switch 76 with electrical connector 18.

As the pressure switch 10 is assembled and adjusted, in a manner which will be described hereinafter, the components are held in immovable relationship with each other to prevent failure of the switch. A plastic filled small diameter cavity 90 formed in spring housing member 50 engages spring adjusting member 54 so that after the compression force of spring 58 has been adjusted by rotation of spring adjusting member 54 it is secured in position so that the spring adjustment will remain unchanged. In like manner, a plastic filled small diameter cavity 90 positioned in base 12 engages spring housing member 50 to hold it in proper position after it has been adjusted to provide sealing compression on diaphragm seal 38. Allen screws 91 serve to secure switch base 70 in proper position relative to spring housing member 50.

ASSEMBLY AND CALIBRATION

An important novel element of this invention is a means whereby the switch may be very accurately calibrated and wherein the calibration will remain within close limits throughout the life of the switch. During the assembly of the switch, after positioning the diaphragm 36 and diaphragm seal 38 in position supporting switch actuator rod 46, spring housing member 50 is then screwed in engagement with base 12 to force against diaphragm seal 38 and to provide a leak proof seal against the diaphragm 36. Next, lower spring washer 64 is inserted over switch actuator rod 46 and spring 58 is placed in position, followed by upper spring washer 68 and spring adjusting member 54. Hydraulic pressure is applied to the smaller diameter tubular opening 20 of an amount equal to that at which switch 10 is to actuate. Spring adjusting member 54 is adjusted by rotation so that the critical pressure for which the switch is being calibrated overcomes the compression of spring 54 to move switch actuator rod 46.

Next the switch 76 is affixed to switch base 70 and switch base 70 is rotated relative to spring housing member 50 until, with sufficient pressure applied to small diameter tubular opening 20 so that piston 22 and switch actuator rod 46 are in the upward position, protruding actuating member 80 is depressed sufficiently to actuate switch 76. The novel means of mounting switch 76 relative to the switch actuator rod 46 provides a micrometer type of adjustment so that the small movement of switch actuator rod 46 at the critical pressure of the switch can be adjusted to accurately actuate switch 76 to achieve an accuracy in high pressure switches heretofore not obtainable. The micrometer adjusting arrangement permits the adjustment of the switch 76 relative to the predetermined movement of switch actuator rod 46 and permits adjustment to obtain an accuracy independent of the inherent characteristic of switch 76.

PISTON MEMBER

Referring now to FIGURES 3 and 4, another important element of this invention providing improved gasketing of piston 22 is shown. FIGURE 3 discloses a typical gasket groove 28 arranged wherein the groove sides 92 are parallel to each other and substantially perpendicular to the axis of piston 22. With pressure applied from the bottom of the view attempting to force piston 22 upward in the tubular opening 20 of base 12, O-ring 30 deforms to assume the approximate shape shown. It is noted that such deformation forces a large area of contact between the O-ring 30 and the side walls of tubular opening 20. This large area of contact increases the frictional resistance to the movement of piston 22 with reference to base 12 such that pressure must overcome this increased frictional drag in order to move piston 22 and thereby move switch actuator rod 46. Most materials of which O-rings 30 are formed are temperature sensitive and have a greater degree of flexibility with different temperatures. When a high temperature is encountered more flexibility of O-ring 30 occurs causing more flow of the material against the side of tubular opening 20, which in turn increases the frictional resistance. An ultimate objective of the design of a pressure switch is to achieve an arrangement whereby the pressure switch is not sensitive to temperature changes. Therefore, the utilization of the typically used parallel sided groove 28 of FIGURE 3 results in a variation in the frictional drag of piston 22 according to the temperature of O-ring 30 which results in inconsistency of pressures at which the switch will actuate.

One of the novel features of this invention is the design of an O-ring groove 28 shown in FIGURE 4. In this arrangement the forward groove side 94 is sloped in the direction opposite the direction from which pressure is being applied. In this arrangement as hydraulic pressure is applied from the bottom, tending to force piston 22 upward relative to base 12, the major portion of the O-ring 30 flows under pressure into the tapered recessed area of the groove 28 instead of towards the wall of opening 20. This reduced area of contact reduces the friction between piston 22 and base 12. Sufficient contact is maintained between O-ring 30 and the wall of opening 20 to provide a seal but the provision of flow of O-ring 30 under pressure away from the wall reduces the frictional drag, thereby maintaining increased accuracy. The temperature in which O-ring 30 is operating therefore does not drastically effect the frictional resistance of the movement of piston 22 since under higher temperatures, when greater flow of the O-ring 30 occurs, most of the flow is away from the side walls of opening 20. The frictional drag remains relatively constant and the accuracy of the pressure switch is maintained.

Rearward groove side 96 is shown sloping in the same direction as forward groove side 94, that is, in the direction from which pressure is being applied. This is considered the optimum arrangement. Since O-ring 30 will be forced by pressure primarily against forward side 94, the design of rearward side 96 is not critical and rearward side 96 may be perpendicular to the axis of piston 22 as is shown in FIGURE 3.

SUMMARY

The novel features of this invention result in the provision of a pressure switch adaptable for high pressure detection, such as required on missiles and other modern developments, which provides greatly increased accuracy and dependability. These novel elements include the provision of a pressure switch using a minimum number of parts; the provision of a ball and socket arrangement be-

tween lower spring washer 64 and shoulder portion 60 of switch actuator rod 46 to eliminate any effect of misalignment of spring 58; the micrometer-type adjustment obtainable by switch base 70 whereby the actuation of switch 76 by the movement of switch actuator rod 46 may be very accurately and easily adjusted; the provision of means whereby all of the switch adjustments may be secured so that they will remain in the desired positions and not be loosened by vibration and temperature changes; and the improved design of groove 28 of piston 22 whereby the frictional resistance of the movement of piston 22 remains relatively constant under varying temperature changes.

Although this invention has been described with a certain degree of particularity, it manifests that many changes may be made in the details of construction and arrangement of components without departing from the spirit and scope of this disclosure.

What is claimed is:

1. A pressure switch having a tubular base, a flexible diaphragm member affixed to said base to seal the tubular opening thereof, a switch actuator rod movably positioned in relation to said base having one end thereof in engagement with said diaphragm, a coil spring to apply predetermined pressure against said diaphragm, a switch base adjustably lockable to said tubular base, means lockable to said switch base to adjust said spring pressure, said switch base having an opening therein adaptable to slideably receive said switch actuator rod, and a switch affixed to said base having a switch actuator element contactable with said switch actuator rod; a piston slideably positioned in the tubular opening of said base, said piston engageable against that side of said diaphragm opposite that side engaged by said switch actuator rod, said piston having an annular groove formed therein to receive a gasket member, said groove defined in part by a forward side sloped in a direction opposite the direction from which pressure is applied to said piston, said gasket being a deformable O-ring positioned in said groove to contact said tubular opening of said base whereby said O-ring under pressure is disposed to deform primarily toward the interior of said groove whereby the area of contact between said O-ring and said tubular opening is not materially increased by increase of pressure within said tubular opening, yet provides a seal between said diaphragm and said pressure.

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