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 PRESSURE SWITCH HAVING MEANS FOR INCREASING THE
 STROKE OF A BELLOWS PRESSURE SENSING ELEMENT
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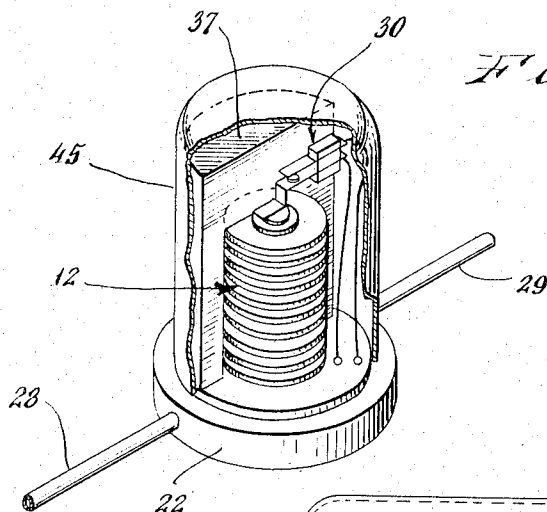


Fig. 1.

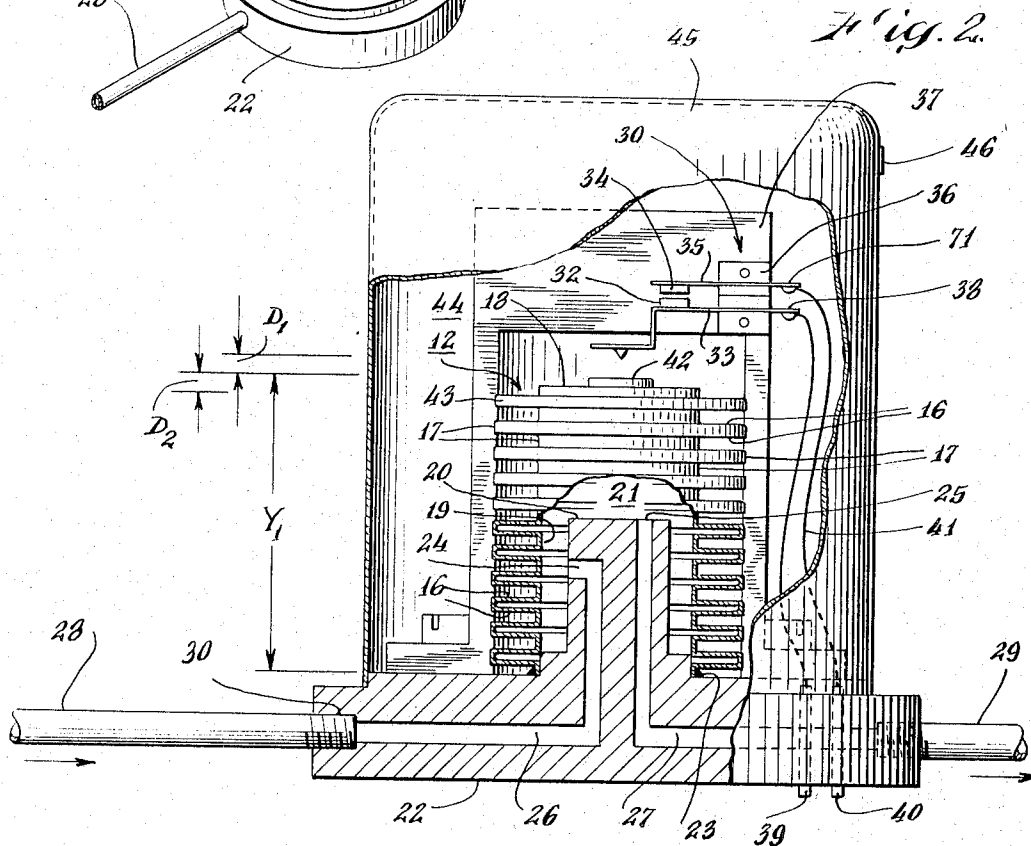
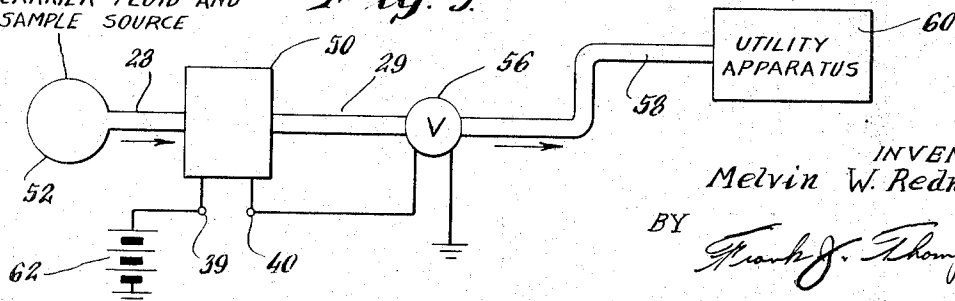


Fig. 2.

CARRIER FLUID AND
 SAMPLE SOURCE

Fig. 3.



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PRESSURE SWITCH HAVING MEANS FOR INCREASING THE STROKE OF A BELLWS PRESSURE SENSING ELEMENT

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ABSTRACT OF THE DISCLOSURE

A pressure actuated switching arrangement including an electro-deposited bellows and means for providing a continuous flow path for a fluid through a chamber formed by the bellows. An electrical switching device is positioned with respect to the bellows for actuation thereby when the fluid in the bellows chamber attains a preselected pressure. A static superatmospheric bias pressure is applied to an outer surface of the bellows. This arrangement advantageously provides repeated actuation of the electrical switching device within a relatively small deviation from a preselected mean pressure.

This invention relates to absolute or differential pressure actuated switches.

In various apparatus, a pressure actuated switching arrangement is employed for effecting a desired control function when the pressure exerted by a fluid in the apparatus attains a desired level. The control function, for example, may comprise the interruption of fluid flow. Such a switching arrangement generally includes a pressure sensing means exposed to the fluid and electrical contacts adapted to be actuated by the sensing means.

Various high precision apparatus such as analytical instruments for detecting the presence of trace quantities of elements in a sample require a pressure actuated switching arrangement which can be repeatedly actuated within a relatively narrow deviation range from some preselected pressure level. In addition, it is desirable that the switching arrangement remain relatively clean and free from contaminants between successive samples under investigation.

Accordingly, it is an object of this invention to provide an improved form of pressure actuated switch.

Another object is to provide a pressure actuated switching arrangement which is adapted for relatively clean operation.

A further object of the invention is to provide a pressure actuated switching arrangement which is adapted for repeated operation at a desired pressure level with relatively high precision.

In accordance with a feature of the present invention, a pressure actuated switching arrangement includes a flexible pressure sensing means having a first surface thereof forming a flexible wall portion of a pressure chamber. Means provide a continuous flow path for a fluid through the chamber. Electrical switching means are positioned with respect to a second surface of the flexible wall and are adapted for actuation upon the attainment of a preselected chamber pressure. In accordance with another feature of the invention, the flexible sensing means is generally cylindrically shaped and is adapted for both longitudinal expansion and contraction. A static bias pressure is applied to a second surface of the flexible chamber wall. With this arrangement, the pressure chamber may advantageously be quickly flushed between successive sample investigations and the possibility of contamination from different samples is greatly reduced. In addition, re-

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peated actuation of the electrical switching means within a relatively small deviation from a mean pressure is accomplished.

These and other object of the invention will become apparent from the following specification and drawings wherein:

FIGURE 1 is a perspective view, partly cut away, of the pressure actuated switching arrangement of the present invention;

FIGURE 2 is an elevation view, partly cut away and partly in section, of the pressure actuated switching arrangement of FIGURE 1; and

FIGURE 3 is a schematic of an apparatus utilizing the pressure actuated switching arrangement of FIGURES 1 and 2.

Referring now to FIGURES 1 and 2, a pressure actuated switching arrangement as illustrated comprises a pressure sensing means and an electrical switching means. The pressure sensing means is shown to comprise a bellows, indicated generally as 12, having a flexible wall formed by integral disc segments 16 and integral segments 17. The bellows is generally cylindrical and tubular shaped and includes a first end-closure member 18. This closure member may be an integral part of the bellows or alternatively, a disc which is hermetically sealed to the bellows at this end to form a rigid, flat surface. An inner surface 19 of the flexible wall, the member 18, and a boss 20 extending into the bellows define a pressure chamber indicated generally by 21. The bellows 12 is hermetically sealed to and secured to a base member 22 by any conventional sealing process such as a soft solder seal indicated as 23.

The boss 20, which is shown to extend from and comprise an integral segment of the base member 22 provides an inlet port 24 and an outlet port 25 for the pressure chamber. This arrangement reduces the internal volume of the sample area. An inlet duct 26 and an outlet duct 27 provide a fluid communication path between these ports and a fluid input tube 28 and an output tube 29. The inlet duct 26 may be adapted as indicated, by reference numeral 30, to accept a threaded connector of the type which provides a pressure seal. The outlet duct is arranged similarly.

The electrical switching means comprises a switch, indicated generally as 30, having a contact 32 mounted on a resilient swinger arm 33 and a contact 34 mounted on a rigid stationary arm 35. The arms 33 and 35 are spaced apart and supported by a block of insulating material 36. A support bracket 7 supports the switch 30 with relation to the bellows for actuation thereby. The switch 30 also includes a pair of terminals 71 and 38 which are electrically coupled to hermetically sealed feed-through insulating terminals 39 and 40 by wires 41. When the bellows extends longitudinally, a contact plate 42 which is mounted on the end member 18 by any convenient method, such as soldering will contact swinger arm 33 and cause the contacts 32 and 34 to make electrical contact. Contraction of the bellows will cause these contacts to separate. Various arrangements of normally open and normally closed contacts may be employed in this electrical switching means.

A static bias pressure is established on the outer surface 43 of the bellows wall by hermetically sealing the atmosphere surrounding the bellows, indicated generally as 44, and by maintaining this atmosphere at a desired pressure level. In FIGURES 1 and 2, an enclosure 45 is hermetically sealed to the base member 22 by any conventional means. This enclosure 45 thereby provides the sealed atmosphere surrounding the bellows. This atmosphere is pressurized by introducing a fluid through a tubulation, not shown, which is later tipped-off in a known manner. The tubulation tip off is indicated

as 46. Alternatively, the atmosphere 44 within the enclosure 45 may be evacuated.

In operation, a difference in fluid pressure between the pressures of the chamber 21 and the atmosphere 44 exerts a force on the bellows wall and causes it to elongate or compress longitudinally from a zero differential pressure position with respect to the base member 22, indicated as Y_1 . In one form of operation the bias pressure of the atmosphere 44 is established at a pressure level, P_2 , midway between an initial relatively lower pressure level, P_1 , and a final relatively higher pressure level, P_3 , to be measured in the pressure chamber 21. Thus, when the chamber pressure is at the initial pressure level, P_1 , the bellows will be compressed to the position $(Y_1 - D_2)$. As the chamber pressure increases the bellows elongates from this initial position through Y_1 and finally to $(Y_1 + D_1)$ when the chamber pressure attains its final level.

In an analytical instrument, a sample having elements which are to be detected is transported by a carrier fluid of the apparatus through the duct 26 into the chamber 21 and from the chamber 21 via the duct 27 to other parts of the instrument. The pressure of the carrier fluid causes the bellows to extend from the level $(Y_1 - D_2)$. As the pressure of the carrier gas attains some preselected value, the bellows will elongate from $(Y_1 - D_2)$ to $(Y_1 + D_1)$ causing the contact plate 42 to actuate the switch 30 and generally initiate a desired control function. This preselected level will be established by the composition and associated characteristics of the bellows along with the magnitude of the fluid pressures in the atmosphere surrounding the bellows. Upon completion of an analysis of a sample, a cleansing fluid will be introduced into the pressure chamber 21 via the tube 28 and the inlet duct 26. Thus, the cleansing fluid maintains not only clean piping but also advantageously cleans the interior of the pressure chamber.

An arrangement of this type in addition to providing relatively clean operation is particularly suited for reliable repeatability of actuation of the switch 30 within a relatively narrow deviation range from some nominal pressure. For example, when it is desired to actuate the switch 30 at a final chamber pressure, P_3 , of two atmospheres of fluid pressure, then one form of the bellows illustrated may operate with a bias atmosphere having a pressure P_2 within the enclosure 45 of one and one half atmospheres. Hence a bellows movement resulting from a pressure change of one atmosphere from an initial chamber pressure P_1 of one atmosphere to a final pressure P_3 of two atmospheres will actuate the switch.

A particular form of bellows which may be employed with the arrangement of FIGURES 1 and 2 comprises an electro-deposited bellows which is conveniently formed in a known manner from nickel or nickel cobalt alloy. A bellows of this type, which may be used in an extension or compression through many operations while maintaining its operational characteristics provides nearly double the allowable bellows stroke and this substantially increases the resolution of the level of actuation by a factor of two. Repeatable accuracy of actuation with a pressure switch employing this form of bellows has been held to an error of .1% or less of the actuation pressure.

In FIGURE 3, an apparatus is shown utilizing the pressure switch arrangement of the present invention and illustrating its operation in the control of the flow of a carrier fluid. In FIGURE 3, components similar to those components previously described in FIGURES 1 and 2 bear the same reference numerals. The apparatus includes the pressure switch arrangement of FIGURES 1 and 2, indicated in FIGURE 3 generally by a block bearing the reference numeral 50. The switch arrangement 50 is coupled to a source of carrier fluid and sample 52 by the inlet tubing 28 and to a flow valve 56 by the outlet tubing 29. The flow valve 56 is further coupled by tubing 58 to a utility apparatus 60. A positive terminal of a

source of electrical potential 62 is coupled to a feed-through terminal 39 while a negative terminal of the source of electrical potential 62 is coupled to the feed-through terminal 40 via a series circuit path including a common ground connection and an electrical control element of the flow valve 56 such as a solenoid winding, not illustrated. When the pressure of the carrier fluid exceeds a preselected level, it is desirable to interrupt the fluid flow. To this end, the valve 56 is connected in series in the fluid line. As the pressure attains the preselected level, for example, the bellows will expand and the contact plate 42 will cause the switch 30 to close and actuate the solenoid to thereby actuate the valve and interrupt fluid flow.

Various arrangements of means for establishing desired pressures and vacuums may be employed to provide other desired switching values. In addition, the bias atmosphere 44 may be coupled to a source of varying pressure. The switch 30 will then be actuated at some preselected differential varying pressure level.

Thus, there has been described a pressure actuated switching arrangement which is particularly adapted for repeatedly operating at an absolute pressure within a narrow deviation from a preselected pressure level and which includes a pressure chamber flow-through fluid path thereby providing a facility for quickly removing contaminants.

While I have illustrated and described a particular embodiment of my invention, it will be understood that various modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. An analytical instrument, a pressure actuated switching device comprising:
 - a metal bellows having a flexible wall with inner and outer surfaces,
 - means including said inner wall surface defining a pressure chamber,
 - said bellows adapted to have a maximum stroke of length D_0 over a usable pressure range within the elastic limit of said bellows where $D_0 = D_1 + D_2$ and where $D_1 = D_2$,
 - means for establishing a constant bias pressure P_1 independent of atmospheric variations on said outer surface of said bellows in a manner for causing an initial displacement of length D_2 of the bellows as a result of a differential pressure existing between said surfaces,
 - means including an inlet duct and an outlet duct for conveying a fluid in a continuous flow path under pressure through said pressure chamber, and electrical switching means arranged for actuation by said bellows when the pressure within said chamber attains the value $2 \cdot P_1$.
2. In an analytical instrument, a pressure actuated switching device comprising:
 - a generally cylindrically shaped tubular metal bellows having a flexible wall,
 - said bellows adapted to have a stroke of length D_0 over a usable pressure range within the elastic limit of said bellows where $D_0 = D_1 + D_2$ and where $D_1 = D_2$,
 - a closure member positioned at a first end of the said bellows for traversing a longitudinal path upon elongation or compression of said bellows,
 - an electrical switching means having a pair of contact surfaces and positioned with respect to said closure member for actuation of said contacts by said closure member,
 - means for establishing a constant bias pressure P_1 independent of atmospheric variations on said outer surface of said bellows in a manner for causing an initial displacement of length D_2 of the bellows as

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a result of a differential pressure existing between said surfaces, and

means including a second closure member positioned at a second end of said bellows having an inlet and an outlet port for said bellows for conveying a fluid under pressure in a continuous flow path through said bellows. 5

3. The pressure actuated switching device of claim 2 wherein said bellows comprises an electro-deposited metal bellows. 10

4. In an analytical instrument, a pressure actuated switching device comprising:

a generally cylindrically shaped tubular electro-deposited metal bellows having a flexible wall, said bellows adapted to have a stroke D_0 over a variable pressure range within the elastic limit of said bellows where $D_0 = D_1 + D_2$ and where $D_1 = D_2$, 15

a closure member at a first end of said tubular bellows adapted to move in a longitudinal direction a distance D_2 upon an elongation or a distance D_1 upon compression of said bellows, 20

an electrical switch having a pair of contacts and positioned with respect to said bellows for actuation of said contacts by said closure member,

a boss extending into said tubular bellows from a second end thereof and forming an end member, said latter end member having a fluid inlet port and fluid outlet port, 25

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inlet and outlet ducts communicating with said inlet and outlet ports for conveying a fluid in a continuous flow path through a pressure chamber formed by said flexible wall and closure member,

means hermetically enclosing said bellows and switching means, and

a fluid located within an atmosphere defined by said hermetical means and establishing a super atmospheric bias pressure P_1 on said bellows having a magnitude for causing an initial displacement D_1 of the bellows as a result of differential pressure existing between said surfaces.

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