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Nishira

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[54] **PRESSURE SWITCH**

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[30] **Foreign Application Priority Data**

Feb. 18, 1972 Japan 47/20167

[52] **U.S. Cl.** ..... **338/36**, 73/398 AR, 338/32 R, 338/42

[51] **Int. Cl.** **H01c 13/00**

[58] **Field of Search** ..... 338/32 R, 32 H, 36, 338/42; 73/398 AR; 324/45, 46; 323/94 H

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[57] **ABSTRACT**

A pressure switch comprising a housing having an internal cavity which is divided into a high pressure chamber and a low pressure chamber by a flexible diaphragm, a moving yoke which forms part of a magnetic path and moves in accordance with a motion of the said diaphragm, a galvano-magnetro effect device which is provided in said magnetic path and is exposed to a magnetic flux which varies in accordance with movement of the said moving yoke, wherein a switching circuit operates with the function of the said galvano-magnetro effect device.

14 Claims, 7 Drawing Figures

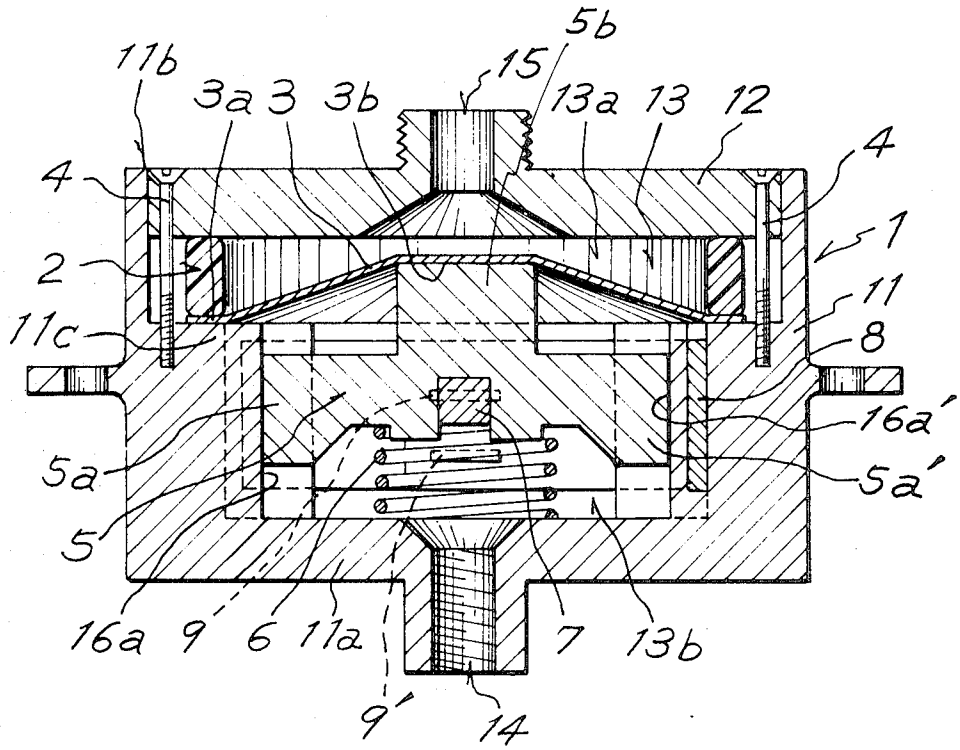

FIG. 1a

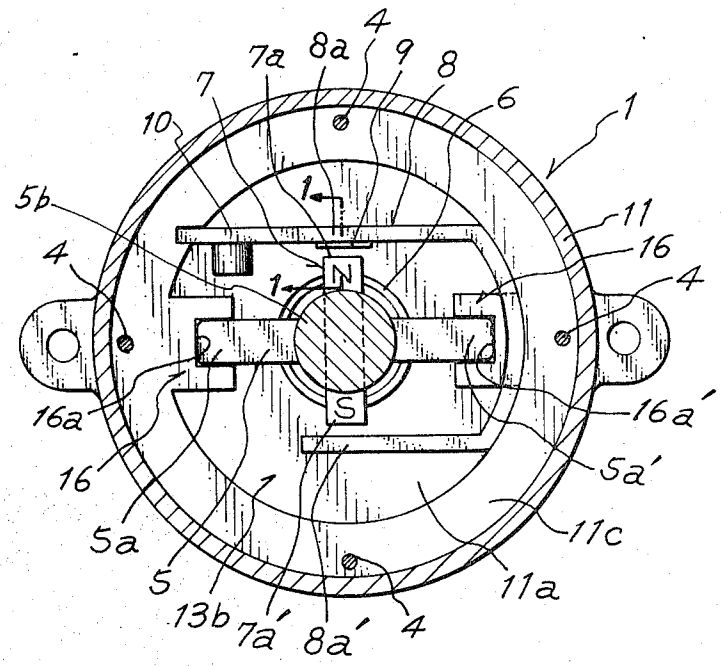
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FIG. 1b

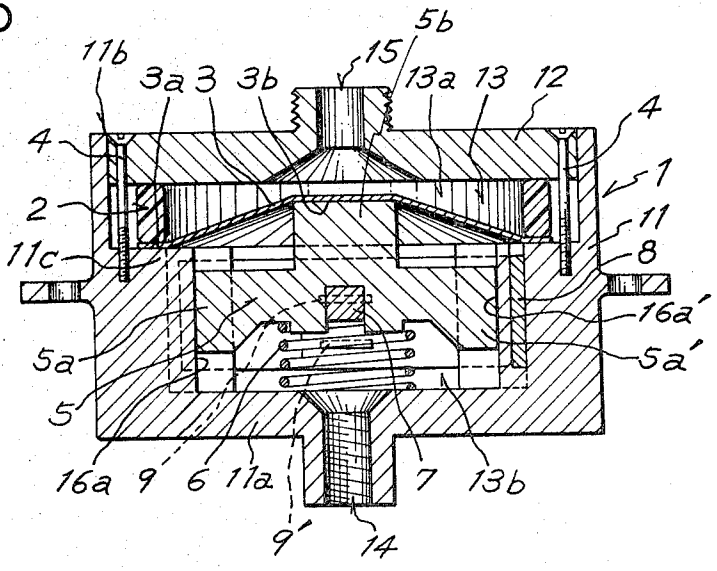
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FIG. 2

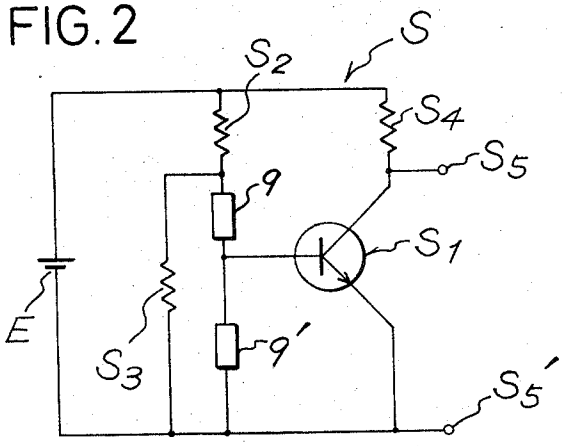


FIG. 3

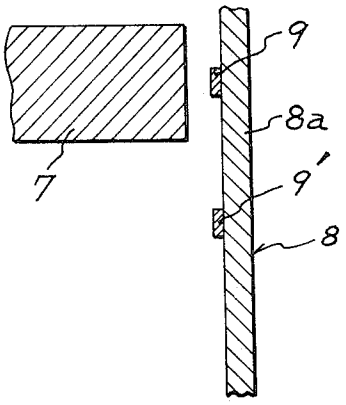


FIG. 4

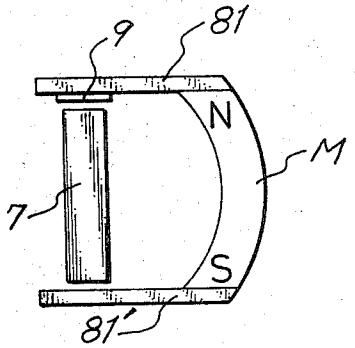


FIG. 5

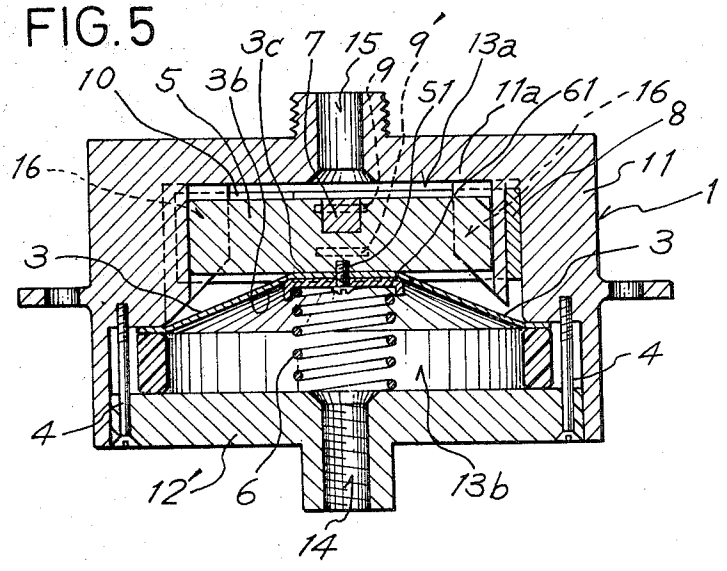
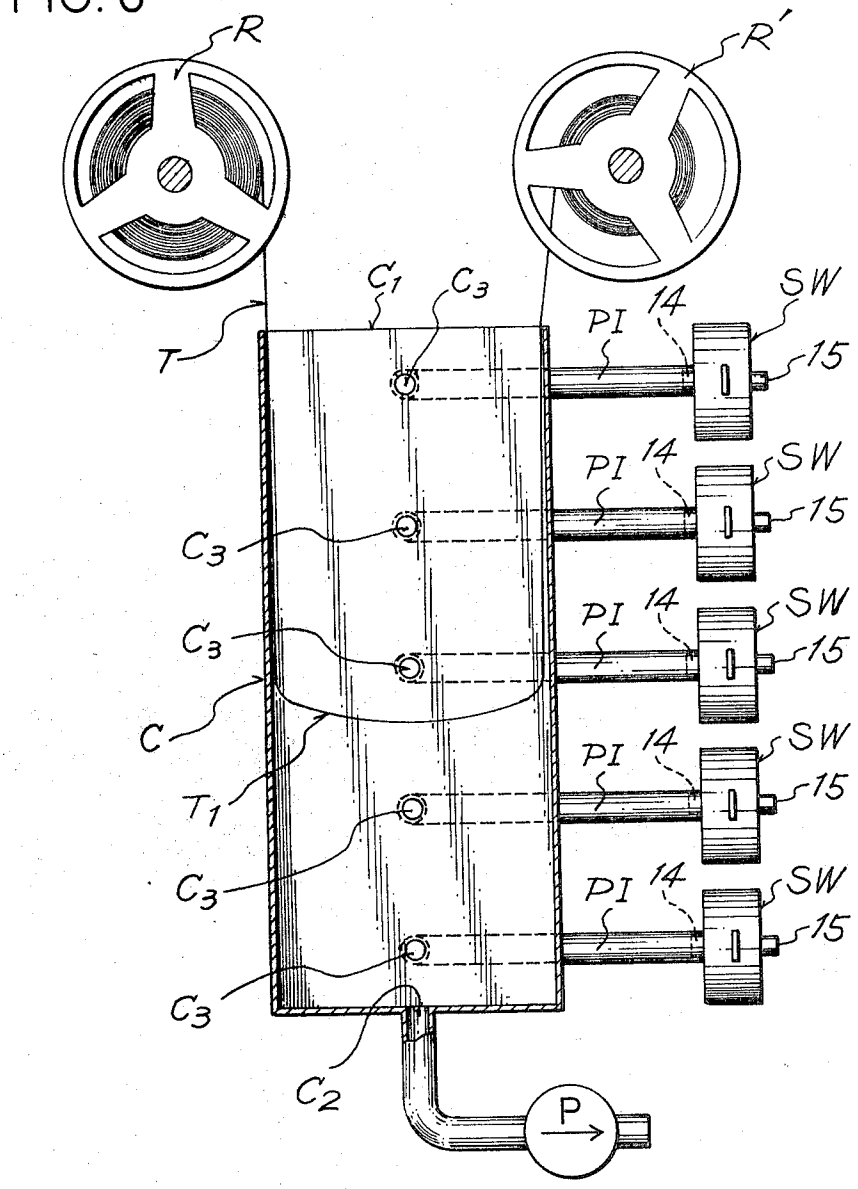


FIG. 6



PRESSURE SWITCH

BACKGROUND OF THE INVENTION

The present invention relates to a pressure switch which operates with a pressure difference of a flowing substance such as, for example, a gas.

Recently, the control system utilizing a pressure has come to be employed along with rapid development of various types of automatic equipment and the pressure switches of high durability and operation accuracy have been generally demanded. On the contrary, conventional switches having electrical contacts are not serviceable for a long period of time and are, furthermore, complicated in the construction with low accuracy since the pressure variation in the analogue type is converted to the operation of contacts in the digital type.

The present invention provides a contactless pressure switch free from the said disadvantages.

SUMMARY

The pressure switch in accordance with the present invention comprises a housing made of a non-magnetic material having an internal cavity, a flexible diaphragm which divides the said internal cavity into a high pressure chamber and a low pressure chamber and moves so as to vary the capacities of the two chambers relatively in accordance with a difference in pressures of the said both chambers, a high pressure side port provided at the said housing to lead to the said high pressure chamber, a low pressure side port provided at the housing to lead to the said low pressure chamber, a non-magnetic moving member provided at one side of the said flexible diaphragm, for example, the side facing the low pressure chamber so that the said moving member moves in accordance with movement of the said flexible diaphragm, guides provided on the said housing to guide the said moving member, a magnetic path containing a moving yoke made of a magnetic material which is fixed on the said moving member, a galvano-magnetro effect device such as, for example, a magnetro-resistance effect device which is provided in the said magnetic path to receive the magnetic flux the density of which varies in accordance with movement of the said moving yoke, and a switching circuit comprised of a switching device which performs the switching in response to the function of the said magnetro-resistance effect device, such as, for example, a switching circuit provided with transistors.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated in detail by the accompanying drawings whereon:

FIG. 1*a* is a cross sectional plan view of the pressure switch of the present invention,

FIG. 1*b* is a cross sectional front view of the said switch,

FIG. 2 is a circuit diagram showing an embodiment of a switching circuit to be employed in the pressure switch in accordance with the present invention.

FIG. 3 is a partly magnified sectional view of the pressure switch as seen along line 1—1 in FIG. 1*a*,

FIG. 4 is a rough plan view illustrating another embodiment of the magnetic path to be employed in the pressure switch in accordance with the present invention,

FIG. 5 is a cross sectional view illustrating another embodiment of the pressure switch of the present invention, and

FIG. 6 is a sketch showing an application example of the pressure switch of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1*a* to 1*b*, there is shown an embodiment of the pressure switch in accordance with the present invention.

Housing **1** is made up by fitting non-magnetic disc type cover **12** to open end **11**b of non-magnetic cylindrical body **11** having bottom **11***a* and has internal cavity **13.** The housing is also provided with low pressure side port **14** at its bottom **11**a and disc cover **12** is provided with high pressure side port **15. 31**

Stepped part **11***c* is provided on the internal circumferential surface of cylindrical body **11,** and O ring **2** made of an elastic material such as, for example, a rubber and periphery **3***a* of disc type flexible diaphragm **3** made of an flexible material such as, for example, rubber are held between the said stepped part and disc cover **12.** The said O ring is depressed by a plurality of bolts **4** fixing disc cover **12** on the said cylindrical body to maintain cavity **13** air-tight. The said flexible diaphragm air-tightly divides cavity **13** into high pressure chamber **13***a* leading to high pressure side port **15** and low pressure chamber **13***b* leading to low pressure side port **14** and is designed to be deflected in accordance with a varying difference in pressures in high pressure chamber **13***a* and low pressure chamber **13***b*, thus varying the capacities of both chambers.

Moving member **5** made of a non-magnetic material is attached to one surface **3***b* facing the low pressure chamber of flexible diaphragm **3.**

Moving member **5** is constructed so that it moves in accordance with movement of flexible diaphragm **3** while being guided by guides **16** provided on housing **1.**

Guides **16** are comprised of a pair of grooves **16***a* and **16***a'* which are provided on the internal surface of the said cylindrical body to opposed each other in parallel to the axial direction of the cylindrical body and both ends **5***a* and **5***a'* of moving member **5** are slidably fitted into the said grooves respectively. Moreover, projected center part **5***b* of moving member **5** is contacted with the said surface **3***b* of flexible diaphragm **3.**

A resetting means such as, for example, coil spring **6** which pushes up the said moving member toward high pressure chamber **13***a*, that is, provides a resetting force to cause flexible diaphragm **3** to be deflected toward high pressure chamber **13***a* is provided between moving member **5** and bottom **11***a* of cylindrical body **11.**

Hereupon, when the pressure in high pressure chamber **13***a* becomes higher than that in low pressure chamber **13***b*, the deflection amount of flexible diaphragm **3** toward high pressure chamber **13***a* decreases and coil spring **6** contracts in accordance with the difference in the pressures of both high and low pressure chambers, and moving member **5** moves accordingly along the axis of cylindrical body **11.** When the pressures in the said two chambers are equal, moving member **5** is returned to the home position by the resilient force of coil spring **6.** In other words, flexible diaphragm **3** also returns to the home position with original deflection.

Bar type moving yoke 7 made of a magnetic material and magnetized with N and S polarities at its both ends 7*a*, 7*a*′ is fixed on moving member 5 so that the said moving yoke intersects at a right angle to the moving direction of moving member 5. Fixed yoke 8 in combination with moving yoke 7 forms a magnetic path. It is made of a magnetic material in the U-shape and is fixed inside cylindrical body 11 so that its both ends 8*a* and 8*a*′ are opposed to both ends 7*a* and 7*a*′ of the said moving yoke.

A pair of galvano-magnetro effect devices 9 and 9′ are arranged along the moving direction of moving yoke 7, that is, the moving direction of moving member 5, on the surface of one end 8*a* of fixed yoke 8 opposed to end 7*a* of the moving yoke.

The galvano-magnetro effect devices can be the semiconductor devices of which electrical characteristic varies in accordance with variation of the intensity of the magnetic field which acts on the devices. The semiconductor devices can be the magnetro-resistance effect device or Hall effect device made of indium antimony or indium arsenic.

One galvano-magnetro effect device 9 is located at a position where it is opposed to moving yoke 7 when there is no difference in the pressures in high pressure chamber 13*a* and low pressure chamber 13*b*, and other galvano-magnetro effect device 9′ at a position where it is opposed to moving yoke 7 when the moving yoke moves in accordance with the difference in the pressures in both chambers.

Printed circuit board 10 is provided on a line extended from end part 8*a* of said fixed yoke 8 and switching circuit S is formed on this printed circuit board.

Referring to FIG. 2, there is shown an embodiment of switching circuit S which performs switching operation according to the change in electrical characteristic according to variation of the intensity of the magnetic field which acts on galvano-magnetro effect devices 9 and 9′.

There is shown a circuit employing the magnetro-resistance effect device as the galvano-magnetro effect device and NPN type transistor S1 as the switching device.

Resistor S2 and magnetro-resistance effect devices 9 and 9′ are series-connected with power supply E across the positive and negative polarities, resistor S3 is connected across the connecting point between resistor S2 and the magnetro-resistance effect device and the negative polarity of power supply E, and the intermediate connecting point between both magnetro-resistance effect devices is connected to the base of transistor S1. Accordingly, the potential at the said intermediate connecting point is the potential at the base of transistor S1. Furthermore, the collector of transistor S1 is connected to the positive polarity of power supply E through collector resistor S4 and the emitter of the said transistor is connected to the negative polarity of power supply E. Output terminals S5 and S5′ are provided at the collector and emitter.

In the above embodiment, moving yoke 7 is opposed to one galvano-magnetro effect device 9 when the pressures in high pressure chamber 13*a* and low pressure chamber 13*b* are equal and accordingly the magnetic flux is applied to device 9. On the contrary, the magnetic flux is not applied to other galvano-magnetro effect device 9′. Accordingly, the internal resistance value of device 9 is large and that of device 9′ is small. The specified voltage is applied across both ends of the devices which are connected in series. Therefore, the base potential of transistor S1 is so low that transistor S1 is in the on-state and the potential at the collector is high. Thus, the voltage across both output terminals S5 and S5′ is large.

On the other hand, when the pressure in high pressure chamber 13*a* becomes higher than that in low pressure chamber 13*b*, flexible diaphragm 3 is deflected due to the difference in the pressures to cause coil spring 6 to contract whereby moving yoke 7 moves together with the moving member to be away from the position opposing to device 9 and to oppose to device 9′.

Therefore, the internal resistance of device 9′ suddenly increases with application of the magnetic flux to the said device and the internal resistance of device 9 suddenly decreases without application of the magnetic flux to the said device. Accordingly, the potential at the intermediate connecting point between the said both devices rises to result in the rise of the potential at the base of transistor S1. With this potential rise, transistor S1 is in the on-state and the collector potential lowers, that is, the voltage across both output terminals S5 and S5′ becomes low.

The said switching device thus performs the switching operation in response to the pressure difference between the high and low pressure chambers.

Referring to FIG. 4, there is shown a fixed yoke having a magnet.

Since moving yoke 7 and fixed yoke 8 form a magnetic path, moving yoke 7 need not always be magnetized, and fixed yoke 8 can be comprised of magnet M and magnetic yoke pieces 81 and 81′ extended from both poles N and S of the said magnet and moving yoke 7 can be made of a magnetic material which is not magnetized.

Referring to FIG. 5, there is shown flexible diaphragm 3 provided with moving member 5 at surface 3*c* of the high pressure chamber side.

In the embodiment shown in FIG. 5, contrary to the embodiment shown in FIG. 1*b*, disc cover 12′ is provided with low pressure side port 14 and bottom 11*a* of cylindrical body 11 is provided with high pressure side port 15. Low pressure chamber 13*b* is formed between flexible diaphragm 3 and said disc cover 12′ and high pressure chamber 13*a* between flexible diaphragm 3 and bottom 11*a* of the cylindrical body 11.

Low pressure side surface 3*b* of flexible diaphragm 3 is provided with dish-type support member 61 and coil spring 6 is arranged between the said support member and disc cover 12′. Moving member 5 provided at high pressure side surface 3*c* of flexible diaphragm 3 is fixed to support member 61 with screw 51 which passes through flexible diaphragm 3.

In addition, guides 16, moving yoke 7, fixed yoke 8 and galvano-magnetro effect devices 9 and 9′ are constructed as shown in the embodiment of FIG. 1*b*.

It is clear the the pressure switch in the above construction operates as in the embodiments in FIGS. 1*a* and 1*b*.

Referring to FIG. 6, there is shown an application of the pressure switch in accordance with the present invention.

Magnetic tape T is wound on tape reels R and R′ of the data storage unit of the computer. The said tape is

forwarded from reel R and wound on reel R'. Case C is designed so that opening C_1 is formed to be open upwardly, exhaust port C_2 is provided at the lower end and the air is exhausted by vacuum pump P through the said exhaust port. Furthermore, case C is provided with a plurality of detection ports C_3 with specified intervals along a vertical direction. These detection ports C_3 are respectively led to low pressure side ports **14** of pressure switches SW through air duct pipes PI. High pressure side port **15** of each pressure switch is opened in the atmosphere.

Extended part T_1 between two reels R and R' is inserted from opening C_1 of case C, and when vacuum pump P is actuated, extended part T_1 of the tape is pulled to the maximum to the lower part of case C. There occurs a difference of pressures in the spaces at both sides of the tape as the border. The pressure in the upper side of the tape is equal to the atmospheric pressure and the pressure in the lower side is lower than the atmospheric pressure.

The pressure switches connected to the detection ports at the lower side of the tape operates with the difference of pressures in the high and low pressure chambers. On the contrary, the pressure switches connected to the detection ports at the upper side of the tape do not operate since there is no difference of pressures in the high and low pressure chambers.

The pressure switches operate in accordance with the lowering position of the tape and therefore the lowering position of the tape can be detected by the corresponding pressure switch. Accordingly, a fixed delivery allowance of the tape can be maintained at all times by controlling the rotation rate of tape feed reel R with actuation of the pressure switch.

In addition to the above application, the pressure switch in accordance with the present invention can be employed as the control switch for various pressure-applied system such as the air pressure control switch of machine tools.

The pressure switch has the following advantages as compared with the conventional switches.

Since it is the contactless switch, it excels in mechanical durability. Also, since the pressure variation is converted to the intensity of magnetic flux to be applied to the galvano-magnetro effect device and the switch performs switching according to the change in the electrical characteristic of the said device, it is unnecessary to convert the analogue type pressure variation to the digital type mechanical operation and therefore high accuracy is obtained.

The condition for the switching operation can be set as desired by setting the conditions of the switching circuit. The pressure necessary for the switching operation can be freely selected by properly selecting the thickness of the flexible diaphragm and the material.

The operating point of the pressure switch can be easily changed by setting the position of the galvano-magnetro effect device.

Thus, the pressure switch in accordance with the present invention finds a wide range of applications in many various fields.

What is claimed is:

1. A pressure switch comprising:

a. a housing made of a non-magnetic material having an internal cavity,

b. a flexible diaphragm which divides said cavity into a high pressure chamber and low pressure chamber and causes the capacities of said both chambers to vary relatively,

c. a high pressure side port which is provided in said housing so as to lead to said high pressure chamber,

d. a low pressure side port which is provided in said housing so as to lead to said low pressure chamber,

e. a moving member made of a non-magnetic material which is provided on one of high pressure and low pressure chamber side surfaces of said flexible diaphragm so that said moving member moves in accordance with displacement of said flexible diaphragm,

f. guides provided on said housing to guide the said moving member,

g. a magnetic path comprised of a magnetic moving yoke which is fixed on said moving member,

h. at least one galvano-magnetro effect device provided in said magnetic path, and

i. a switching circuit which is provided with a switching device and is connected to said galvano-magnetro effect device and performs the switching operation in accordance with actuation of said galvano-magnetro effect device,

wherein the intensity of magnetic flux to be applied to said galvono-magnetro effect device through said magnetic path varies in accordance with movement of said moving yoke.

2. A pressure switch according to claim **1**, wherein a printed circuit board is provided inside said housing and said printed circuit board is formed with said switching circuit.

3. A pressure switch according to claim **1**, wherein said magnetic path is comprised of said moving yoke and a magnetic fixing yoke fixed inside said housing, the fixed yoke opposes to both end faces in parallel with the moving direction of the moving yoke, and one of the fixed yoke and moving yoke contains a magnet.

4. A pressure switch according to claim **3**, wherein said galvano-magnetro effect device is fixed at a position opposing to said moving yoke on the fixed yoke.

5. A pressure switch according to claim **3**, wherein said moving yoke is made of a magnet, both poles of which are respectively opposed to said fixed yoke.

6. A pressure switch according to claim **3**, wherein said fixed yoke contains a magnet.

7. A pressure switch according to claim **1**, wherein a resetting means is provided which depresses said flexible diaphragm so that said flexible diaphragm deflects towards said high pressure chamber when there is no difference of pressure between the high pressure chamber and the low pressure chamber and which has a resetting force against displacement of said flexible diaphragm causing the capacity of said high pressure chamber to increase.

8. A pressure switch according to claim **7**, wherein said moving member and said resetting means are provided in the low pressure chamber.

9. A pressure switch according to claim **8**, wherein said resetting means makes said moving member contact at all times said low pressure chamber side surface of said flexible diaphragm.

10. A pressure switch according to claim **7**, wherein said moving member is provided in the high pressure chamber and said resetting means in the low pressure chamber.

11. A pressure switch according to claim **7**, wherein a coil spring is employed as said resetting means.

12. A pressure switch according to claim 1, wherein a pair of magnetro-resistance effect device are employed as said galvano-magnetro effect device.

13. A pressure switch according to claim 12, wherein one of said both magnetro-resistance effect devices receives the magnetic flux when there is not a great pressure difference of pressures in said high and low pressure chambers and does not receive the magnetic flux when there is a great pressure difference, and the other magnetro-resistance effect device receives the magnetic flux when there is a great difference of pressures in said both chambers and does not receive the magnetic flux when there is not a great pressure difference.

14. A pressure switch according to claim 13, wherein a transistor is employed as said switching device, said both magnetro-resistance effect devices are connected in series, the specified voltage is applied across both ends of said devices in series connection, and the voltage across both ends of one device is applied as the base bias voltage of said transistor.

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