United States Patent

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[54] **ELECTRO-FLUIDIC INTERFACE DEVICE**
8 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **137/625.4,**
251/139, 251/140, 235/201
[51] **Int. Cl.** **F16k 11/02**
[50] **Field of Search** 235/201ME;
137/139, 516.11, 625.48, 625.4; 251/140

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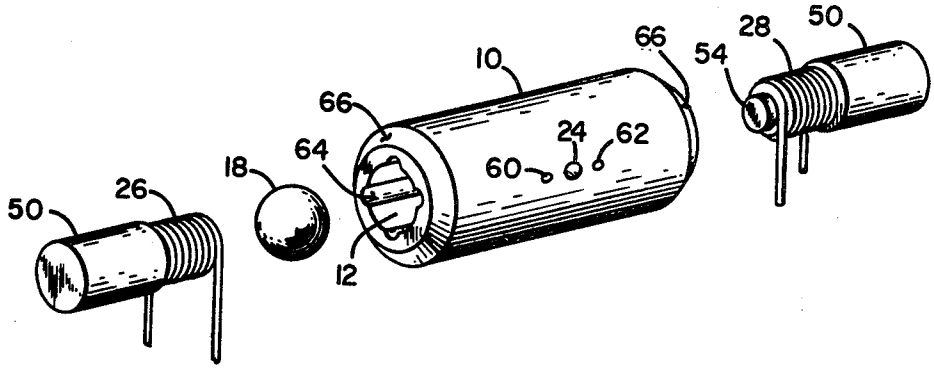
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ABSTRACT: An interface device for providing electrical responses to fluidic signals, and for providing fluidic responses to electrical signals is described. The interface device disclosed has a housing with ports for receiving fluidic signals, and a chamber in which a ball member is movably disposed. A pair of electrically conductive coils in combination with magnetic circuits receive electrical signals for providing fluidic responses by moving the ball to control fluid flow, and for providing electrical signals in response to ball movement caused by the fluidic signals.



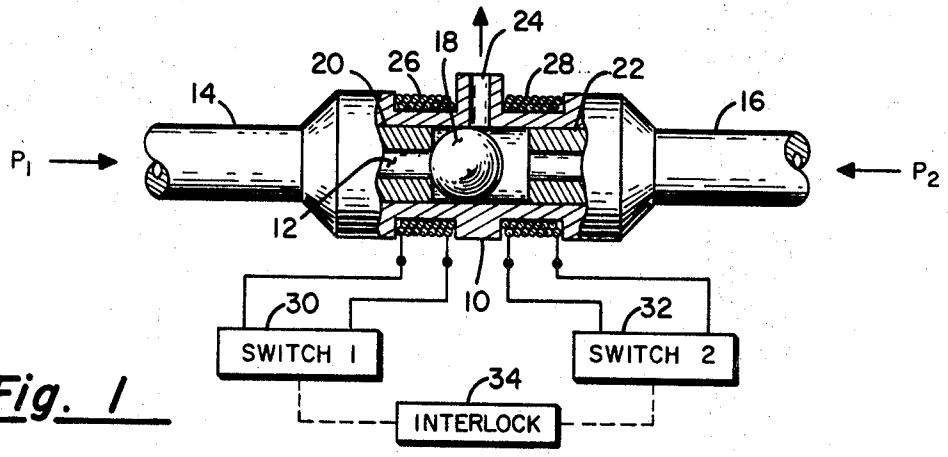


Fig. 1

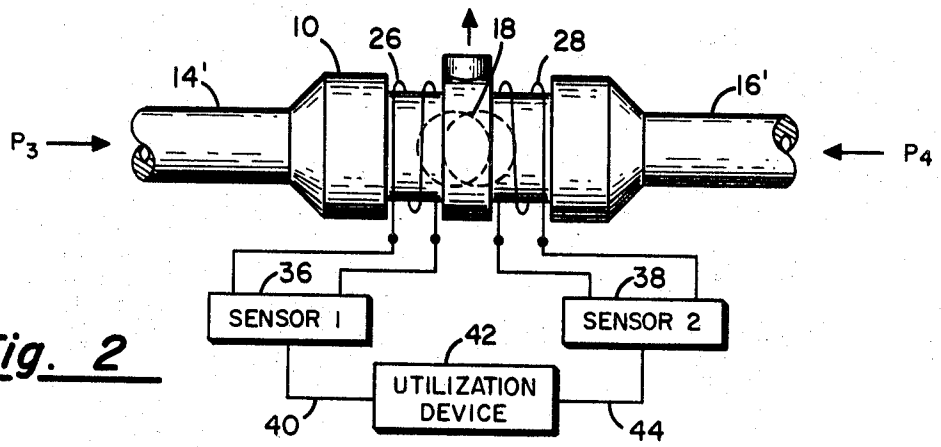


Fig. 2

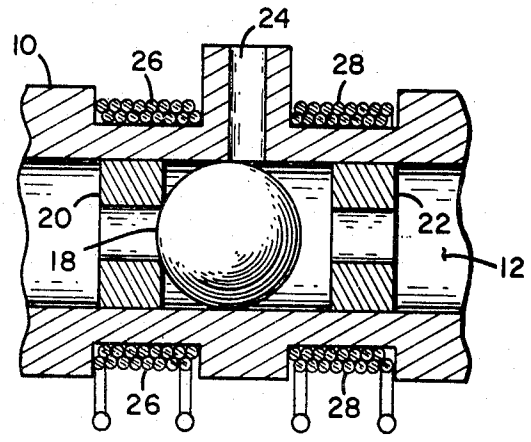


Fig. 3

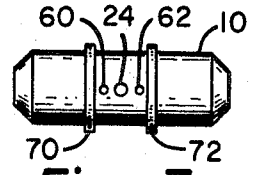


Fig. 7

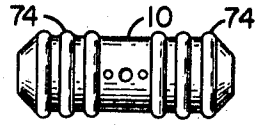
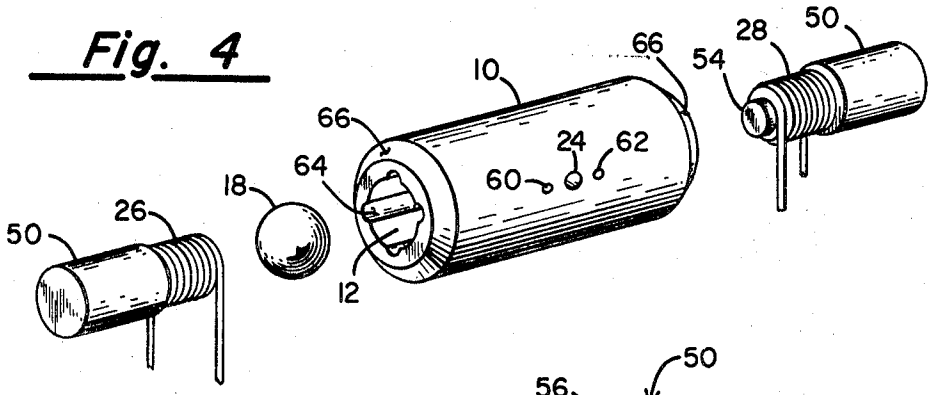


Fig. 8

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Fig. 4



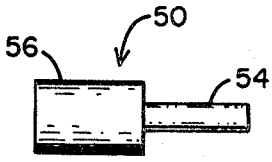


Fig. 5a

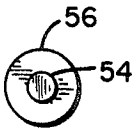


Fig. 5b

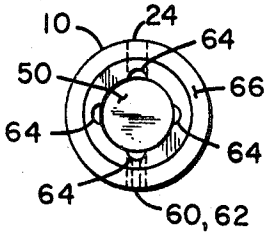


Fig. 6a

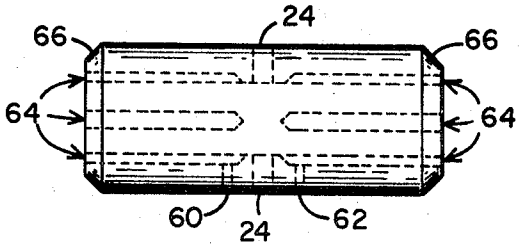


Fig. 6b

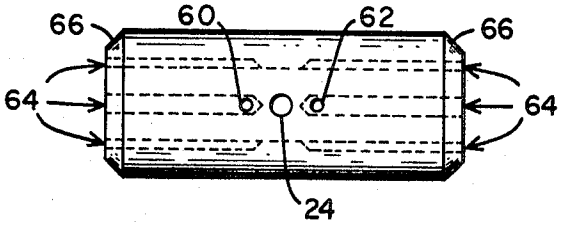


Fig. 6c

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ELECTRO-FLUIDIC INTERFACE DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to electro-fluidic systems, and devices. More specifically, this invention relates to devices that provide fluidic responses to electrical input signals, and electrical responses to fluidic input pressures.

2. Description of the Prior Art

Devices employing fluid as a working medium are finding everwidening uses in process control and data-handling systems. In such systems, it is often desirable to sense for given conditions in the fluid-operated system and to transmit the information indicating the state of the system to some remote location, or to a data processing system. Such transmission can best be accomplished by electrical signals. Accordingly, it is necessary that devices be provided for converting the state of fluidic conditions to electrical signals indicative of these conditions. Such systems also are found to require the provision for entering control signals into the fluid-operated system. Very often these input signals are derived from sensors and data processors that provide electrical signals. In order to respond to these electrical control signals, it is necessary that devices be provided for receiving the electrical control signals and converting these signals to fluidic controls that can be utilized in the fluid-operated system.

In the prior art, various devices have been developed for either providing the fluidic-to-electrical conversion, or the electrical-to-fluidic conversion. These prior devices have not operated with the capability of providing conversion in both directions. Further, the relative complexity of the prior art devices render them relatively expensive to manufacture and tend toward being difficult to maintain. Those prior devices that have recognized the advantage of using magnetic circuits in controlling or sensing fluid flow have not provided arrangements for completely closing magnetic circuits; and, as such, are very inefficient.

SUMMARY

This invention is directed to solving the problem of providing control interface in fluid-operated systems. The invention provides electrical signals in response to fluidic impulses, and fluidic response to electrical control signals. The invention includes a housing having a plurality of ports or channels for cooperating with elements in a fluid-operated system. The housing also includes a chamber for housing a movable member that cooperates with selected ones of the ports for at least partially blocking the fluid flow therethrough. First and second conductive coils and magnetic circuits are used alternately for magnetically moving the member into a cooperative position with the selected ones of the ports, thereby providing a fluidic response to electrical signals applied to the active one of the coils. When fluidic impulses cause the member to be moved with respect to the first and second conductive coils and magnetic circuits their respective magnetic properties are altered generating electrical output signals in response to the fluidic control impulses.

This invention, then, comprises interface devices that solve the problem of a fluidic system communicating with an electrical system and an electrical system communicating with a fluidic system.

Since the moveable member is a magnetizable member and since it contacts one or the other of the magnetic circuits, the interface device has a high degree of efficiency not found in prior art devices.

A primary object of this invention is to provide an improved interface device for use in electro-fluidic systems.

Another object of this invention is to provide an interface device capable of providing fluidic responses to electrical input signals, and electrical responses to fluidic input pressures.

Yet another object of this invention is to provide an interface device having a magnetizable member capable of being moved either fluidically or electrically to alternative operative positions.

Still another object of this invention is to provide an interface device in which magnetic circuits are closed for providing optimum efficiency in responding to electrical signals and fluidic impulses.

BRIEF DESCRIPTION OF DRAWINGS

Other and more detailed objectives of this invention will become apparent upon consideration of the following description when considered in light of the drawings, in which:

FIG. 1 is a diagrammatic view of an interface device used for controlling fluidic flow in response to electrical control signals;

FIG. 2 is a diagrammatic view of an interface device used to provide electrical signals in response to fluidic impulses;

FIG. 3 is a sectional view of one embodiment of the interface device;

FIG. 4 is an exploded perspective view of another embodiment of the interface device;

FIG. 5*a* and FIG. 5*b* are side and end views, respectively, of plugs used in one embodiment of the interface device;

FIGS. 6*a*, 6*b* and 6*c* are end, side, and bottom views of one embodiment of the interface device;

FIG. 7 is a view of one embodiment having stop-members on the housing; and

FIG. 8 is one view of the housing having conduit-retaining ridges on the housing.

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. 1 is a diagrammatic view, with a portion cut away, of an interface device that is utilized to control fluid flow by the application of electrical signals. The interface device includes a housing **10** comprised of a nonmagnetic material, and having an axial chamber therethrough. The housing **10** is adapted to be coupled to a fluid conduit **14** for carrying a fluid under pressure P1 from a source (not shown), and a second conduit **16** for carrying fluid from a second source (not shown) at a pressure P2. The fluid flow is in the direction of the arrows respectively. Located within the chamber **12** is a moveable member, such as ball **18**. Ball **18** is comprised of a magnetic material such as mu-metal or ferrite, or any other magnetizable material that has a low coercivity and high permeability such that there will be little or no residual magnetism in the absence of applied magnetic fields. Also located within chamber **12**, is a pair of stop-members **20** and **22**. These stop-members are made of a magnetizable material such as mu-metal, ferrite, or the like. These stop-members **20** and **22** are cylindrical in shape and are constructed to cooperate respectively with the fluid flow from conduits **14** and **16** respectively. Finally, the chamber **12** is provided with an exhaust port **24** for allowing the fluid flow to be evacuated from chamber **12**. In a closed system, exhaust port **24** could be coupled to another conduit (not shown) and returned to the fluid pressure source. Alternatively, the exhaust port **24** can be left open to the atmosphere for many types of operations and merely allow the fluid to exhaust from the chamber **12**. The dimension of exhaust port **24** will be determined by whether or not it is a closed system, and it will depend upon the volume of fluid flow in conjunction with the pressures P1 and P2. Located on housing **10** is a pair of electrically conductive coils **26** and **28**. The turns of coil **26** are electrically coupled to switch **1**, labeled **30**. The terminals of coil **28** are electrically coupled to switch **2**, labeled **32**. Switch **1** and switch **2** can be manual switches that are operative to alternatively apply or remove voltage to the terminals of coils **26** and **28**. It should be understood, of course, that switches **1** and **2** can also be relay switches, electronic switches, or any other well-known switching devices that can be utilized to apply or remove voltage from the terminals of the respective coils. In an automatic system wherein electronic switching would be utilized, it may be desirable to provide an interlock **34** intercoupling switches

1 and 2, so that when one switch is operative the other switch is inoperative. This will ensure that only one coil is receiving a voltage; and, accordingly, will ensure that the ball 18 is under definite control.

In operation, then, when switch 1 is operative to apply a voltage to coil 26, it can be seen that a magnetic field will be created such that ball 18 will be drawn to stop-member 20. When ball 18 is in physical contact with stop-member 20, the magnetic circuit is closed and the ball will be retained in that position as long as voltage is applied to coil 26. In this position, it can be seen that the path of fluid flow in conduit 14 is blocked off, and a high pressure in that conduit will result. At the same time, the fluid flow in conduit 16 is allowed to proceed through exhaust port 24. Whether or not there is a pressure drop at P2, will depend upon the fluid source and the amount of restriction to the fluid flow that is accomplished by exhaust port 24. In a similar manner, if switch 1 is altered such that no voltage is applied to coil 26, and switch 2 is operated to provide a voltage at coil 28, a magnetic field will be set up for drawing ball 18 to the right into contact with stop-member 22. The result will be similar to that just described in that the flow in conduit 16 will now be restricted, and the fluid in conduit 14 will be allowed to proceed to exhaust port 24.

Turning briefly to a consideration of FIG. 3, which is a sectional view of the interface device just described, it will be seen that the various elements discussed have the same reference numerals. This figure illustrates that the movable member 18 is of a size to have a relatively close fit in chamber 12, it being desired to have minimum friction, but maximum fluid control. The arrangement is such that coils 26 and 28 surround the major portion of stops 20 and 22 respectively, and also overlap a portion of ball member 18 for both of its operative positions. As illustrated, with ball 18 to the left, it can be seen that a substantial portion of the ball is included within the windings of coil 26. Since both stop 20 and ball 18 are of a magnetizable material, the magnetic field generated by current flowing in coil 26 will result in the materials becoming magnetized in a manner to force them into physical contact. Once they are in physical contact, the magnetic circuit is closed and the efficiency is markedly increased. For those prior art devices discussed above, it can be seen that there has been no way of having a movable member come in direct physical contact with the elements in the magnetic circuit and, as such, there is a considerable inefficiency in the prior art devices. It will be noted also, that with the ball 18 to the left some of the coils of coils 28 still are in an operative relation with the portion of ball 18. Therefore, when the voltage is removed from coil 26 and applied to coil 28 there will be the magnetic action in ball 18 and stop-member 22 which will tend to cause ball 18 to move to the right into contact with stop-member 22. The number of windings on coils 26 and 28 and the level of voltage necessary to be applied to the terminals thereof will be determined by the pressures P1 and P2 that are to be controlled, the mass of ball 18, and the distance that ball 18 will have to traverse between its two operative positions.

In FIG. 2 there is shown a diagrammatic view of the interface device utilized to provide an electrical signal in response to fluidic control signals. The physical arrangement of the interface device is identical to that described in FIGS. 1 and 3, but the operation is inverse of that described. In such a configuration, the terminals of coils 26 are coupled to Sensor 1, labeled 36, and the terminals of coil 28 are electrically coupled to the Sensor 2, labeled 38. When utilized in this manner, the ball 18 will be moved to the left when pressure P4 in conduit 61 exceeds pressure P3 in conduit 14'. For this condition, the ball will change the reluctance of the magnetic circuit and will provide a signal that can be sensed by Sensor 1. Sensor 1 in turn provides an output signal on conductor 40 to utilization device 42. When pressure P3 exceeds pressure P4 the ball 18 will be forced to the right in a manner to cooperate with coil 28, and changes the magnetic characteristics of its associated circuit and provide a signal to sensor 2. Sensor 2 in turn will provide a signal over conductor 44 to utilization device 42 indicating that pressure P3 exceeds pressure P4.

For maximum operational rates, it is desirable that the movement distance for ball 18 be minimized while still maintaining a physical arrangement such that exhaust port 24 is in a condition to cooperate with one side or the other of chamber 12.

FIG. 4 is an exploded view of another configuration of the interface device. Items that are the same or similar to items previously discussed will bear the same reference numeral. In this configuration, ball 18 moves back and forth within chamber 12 between plug members 50. The side and front views of these are illustrated in FIG. 5*a* and 5*b*, respectively. It can be seen that each plug has a neck portion 54 and a sealing portion 56. The outside dimension of the sealing portion 56 is adapted to cooperate with the surface of chamber 12. The neck portion 54 is arranged for supporting the windings of the coils. In this configuration, the plugs 50 are comprised of mu-metal, ferrite, or the like. Again, it should be pointed out that the material must be magnetizable but have a low coercivity and high permeability such that little residual magnetism will result when the voltage is removed from the associated coil. In this configuration, it can be seen that the outer shell of housing 10, which is a nonconductive material, surrounds the windings of coils 26 and 28. Apertures 60 and 62 are provided for bringing the terminals of coils 26 and 28, respectively, outside of housing 10. Chamber 12 is provided with a plurality of channels 64 along which the fluid can pass around the plug portion 56 of the plugs 50. The ends of neck portions 54 of plugs 50 operate as the stop-member. Each end of housing 10 has a beveled surface 66 to facilitate inserting the housing 10 within conduits 14 and 16.

FIG. 6*a* is an end view of the configuration shown in FIG. 4, FIG. 6*b* is a side view, and FIG. 6*c* is a bottom view. In this configuration, it will be noted that the channels 64 terminate in the vicinity of exhaust ports 24, and that plural exhaust ports are utilized. The channels 64 are terminated so that when the ball is adjacent the stopping end of one of the plugs 50, the channels will be virtually sealed off and fluid will be permitted to flow only along the unrestricted channels. It should be pointed out, of course, that in this arrangement it is normally unnecessary to provide an absolute seal and that a certain amount of leakage can be tolerated within the tolerance of the switches or sensors that the interface device is used with.

FIG. 7 illustrates a pair of stop-members 70 and 72 surrounding housing 10. These stop-members allow the conduits 14 and 16 tp be slipped over the outer surface of housing 10 up to the stop-members 70 and 72, and will prevent the conduits from interferring with the coil leads that will protrude through aperture 60 and 62 and will not be allowed to block exhaust port 24. In this arrangement, the interface device is supported and mounted right in the conduit line and forms a very compact physical structure. Clamps can be used to hold conduits 14 and 16 in place in housing 10.

An alternative configuration to the shape of housing 10 is shown in FIG. 8. A plurality of ridges 74 can be formed in the outer surface of housing 10. When the conduits 14 and 16 are comprised of stretchable material the conduits can be inserted over the housing 10 and will tend to be held in place by the ridges 74.

It can be seen, then, that an interface device has been disclosed and described that will permit fluidic control signals to be transformed into electrical output signals, and alternatively, will provide fluidic responses to applied electrical control signals. Having described the operation and preferred embodiments, various modifications will become apparent to those skilled in the art without departing from the spirit and scope of the invention, and what is intended to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. An interface device for use in electro-fluidic systems comprising:

housing means having a chamber therein with an outlet port and first and second inlet ports for cooperating with respectively associated first and second sources of pressurized fluid;

first and second plug means disposed in said chamber and associated with said first and second inlet ports, respectively;

first and second electrically conductive coil means disposed in said chamber and associated with said first and second plug means, respectively;

a movable magnetizable means disposed in said chamber intermediate said first and second plug means and cooperating with said first or second plug means for directing fluid flow from said second or first inlet port, respectively, into said outlet port.

2. An interface device as in claim 1 wherein said chamber in said housing means is substantially circular in cross section said chamber further including a plurality of channels extending into said chamber from said first and second inlet ports.

3. An interface device as in claim 2 wherein each of said plug means has a plug portion of a shape to substantially conform to said circular cross section of said chamber, thereby permitting fluid flow past said plug means in said respective ones of said plurality of channels, and each of said plug means further including magnetizable support means for supporting said respectively associated one of said conductive coil means.

4. An interface device as in claim 3 wherein said moveable magnetizable means is capable of alternatively contacting each of said plug means for at least partially blocking fluid flow in the ones of said plurality of channels associated with the contacted one of said plug means.

5. An interface device as in claim 4 wherein said moveable magnetizable means comprises a spherically shaped member having a dimension to substantially conform to said circular cross section of said chamber.

6. An interface device as in claim 4 wherein said first and second electrically conductive coil means includes a conductive wire wound on the associated one of said support means.

7. An interface device as in claim 6 and further including signaling means coupled to each of said conductive wires for alternatively applying an electrical signal to a selected one of said conductive wires for providing a magnetic field for urging said moveable magnetizable means into contact with the one of said plug means associated said selected one of said conductive wires, thereby at least impeding fluid flow in the associated ones of said channels.

8. An interface device as in claim 6 and further including sensor means coupled to each of said conductive wires for sensing changes in the parameters of the magnetic circuit caused by said moveable magnetizable means being forced by fluid pressure into contact with one of said plug means.