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SWIRL INPUT FLUID AMPLIFIER

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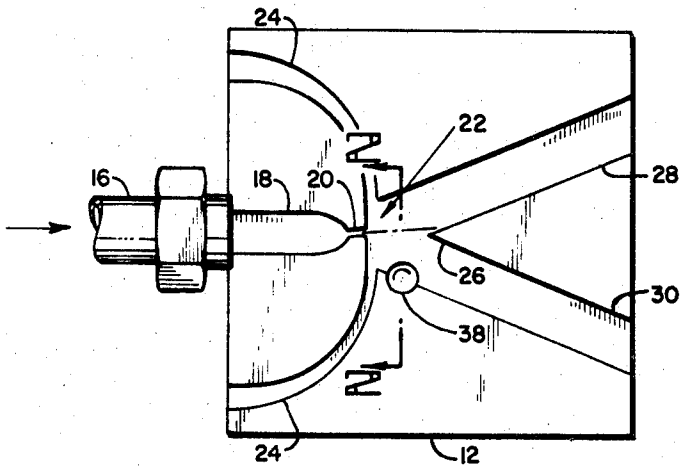


FIG. 1

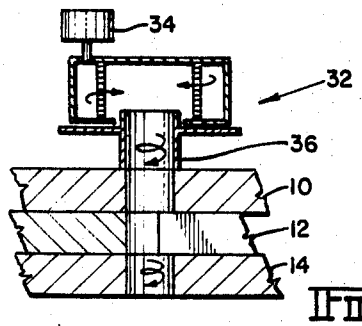


FIG. 2

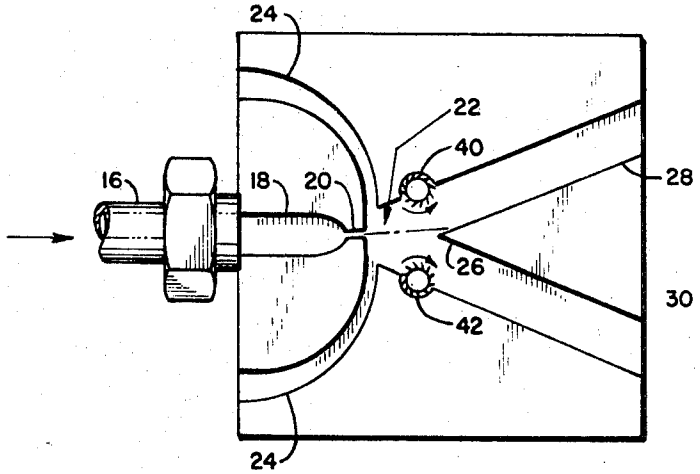


FIG. 3

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SWIRL INPUT FLUID AMPLIFIER

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U.S. Cl. 137—81.5 8 Claims

ABSTRACT OF THE DISCLOSURE

A fluid control device wherein an angular rate sensor is combined with a fluidic amplifier, the rate sensor providing or generating a rotational fluid stream which is injected substantially tangentially to the power stream in the interaction chamber of the device.

This invention relates to fluid control devices. More particularly, this invention is directed to a pure fluid system which employs only a moving fluid to perform the operations of amplification and switching. Accordingly, the general objects of this invention are to provide new and improved apparatus of such character.

In recent years, renewed interest in the Coanda effect has resulted in the development of pure fluid systems which employ only moving fluids and require no moving mechanical parts to perform computation and control functions. Typical of these recently developed pure fluid systems are the devices disclosed in U.S. Patents Nos. 3,016,066 and 3,024,805.

The typical fluid control device comprises a block of material or sandwich structure in which channels have been cut for the passage of fluid. A high energy stream of fluid, commonly called the power stream, is injected through an inlet at one end of the device. Downstream of the inlet, the power stream arrives at a fork consisting of two outgoing channels separated by a pointed structure called the flow splitter. If the power stream has not been disturbed and hits the flow splitter head on, the stream will be divided in two, half of the fluid passing to one outlet channel and half into the other. Flow splitting is, of course, generally not desired. Thus upstream of the flow splitter, channels are provided for the injection of one and usually two control jets. In the prior art, the control jet channels were arranged such that the control stream would hit the power stream from the side with a certain linear momentum. The control jet or jets thus deflected the power stream to one or the other of the outlet channels. The stream passing through the outlet channel has a net momentum that is the sum of the original momentum of the power stream and the control stream, taking direction into account.

As will now be obvious, the output stream represents an amplification of the energy applied by the control stream and the gain or the amplification of the device is equal to the ratio between the output stream's momentum and the momentum of the control jet. The degree of deflection of the power stream is proportional to the momentum of the control stream. Obviously, the input signal to the fluid amplifier (the control stream) can be measured in terms of either momentum or pressure. That is, if the control stream nozzle is placed close to the power stream, the main factor deflecting the power stream will be pressure rather than momentum.

In many fluid control systems, angular rate sensors are either employed or their utilization would be desirable. Present pure fluid rate sensors use changes in swirl to indicate changes in rate. These swirl changes are sensed as pressure changes and it is these pressure

changes which are or may be used as the input signals to other fluid devices. As indicated by the brief description of the prior art fluid amplifier above, present devices cannot use swirl directly as an input signal. Rather, present techniques require that swirl be sensed and a linear control flow proportional thereto be developed and used for the control stream.

The present invention overcomes the aforementioned deficiency of the prior art by providing a fluid control device which uses swirl directly as the input.

It is therefore an object of this invention to provide a fluid control device using swirl directly as an input.

It is another object of this invention to provide a pure fluid amplifier having greater gain than prior art devices of like character.

It is yet another object of this invention to eliminate the need for intermediate pressure sensing for converting swirl to a linear control stream for a fluid control device.

These and other objects of this invention are accomplished by using the change in swirl of a control stream as an input signal. The swirl input is injected substantially tangentially to the power stream upstream of the flow splitter or, alternatively, means for generating a swirl input is positioned in the device upstream of the flow splitter.

This invention may be better understood and its numerous advantages will become apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in various figures and in which:

FIGURE 1 is a top cross-sectional view of a fluid control device employing a single swirl input.

FIGURE 2 is a partial cross-sectional view along line 2—2 of FIGURE 1, of the fluid control device of FIGURE 1.

FIGURE 3 is a top cross-sectional view of a fluid control device employing two swirl input signals.

Referring now to FIGURES 1 and 2, the pure fluid system of this invention is generally formed by a plurality of flat plates **10**, **12** and **14** which are sandwiched together and sealed fluid tight one to another by adhesives, machine screws, clamps or other suitable means. The middle plate **12** is etched or stamped out to form channels for the power streams and output streams. Thus, with the exception to be described below, top plate **10** and bottom plate **14** are sealed fluid tight to plate **12** so as to provide essentially planner top and bottom walls for confining the flow in the configuration formed in the middle plate **12**. The power stream is injected via a tube or conduit **16** connected at one end so as to communicate with the power stream channel **18**. Channel **18**, as is common in the art, tapers to a nozzle **20** and thereafter opens into a widened chamber indicated generally at **22**. Branching off at chamber **22** are a plurality of vent passages **24**. Passages **24** prevent the build up of pressure in chamber **22**. The power stream passes across widened chamber **22** and arrives at a flow splitter **26**. Flow splitter **26** in part defines a pair of output channels **28** and **30**. In the embodiment of FIGURE 1, flow splitter **26** is skewed with relation to the axis of nozzle **20** and thus the power stream has a natural tendency to pass into and out through output channel **28**.

As may best be seen from FIGURE 2, means which generates a swirl or vortex when subjected to an outside influence is positioned externally of the sandwich structure comprised of plates **10**, **12** and **14**. In the FIGURE 2 embodiment, this swirl generator comprises a vortex rate pressure sensor indicated generally at **32**. Sensor **32** may be of a type similar to that disclosed in U.S. Patent No. 3,240,060. As is well known in the art, vortex rate pressure sensors comprise inner and outer chambers sep-

arated by a porous wall. A fluid under pressure is supplied from a source, such as shown at **34**, to the outer chamber. Upon being subjected to an outside influence, for example an acceleration induced force, the sensor rotates about its axis. A slight degree of rotation of the sensor imparts a swirl to fluid defusing through the porous dividing wall into the inner chamber and, as the fluid swirls inwardly, a vortex is generated. Aligned with the axis of sensor **32** is a conduit **36**. The swirling fluid or vortex generated by sensor **32** escapes from the inner chamber via conduit **36** which communicates with chamber **22** as shown through a vertical passage through plate **10**.

As may be seen from a consideration of FIGURES 1 and 2 together, the wall of chamber **22** defined by an extension of the outer wall of output passage **30** is provided with a semi-circular groove **38**. Conduit **36** communicates with the similarly shaped passage in plate **10** which in turn is aligned with groove **38** as shown. The swirl input signal discharges from the passage in plate **10** into chamber **22** and groove **38**.

In chamber **22** the swirl input tangentially contacts the power stream. In the embodiment of FIGURE 1, the input stream is swirling clockwise as shown. This clockwise swirl creates, in a manner well known in the art, an attractive force which pulls the power stream away from output channel **28** and into channel **30**. This attractive force will provide an output proportional to the input swirl.

It is to be noted that the geometry of the device is designed so that with a particular reference rotation of the input or control flow the power stream will be in the null or flow divided position. If is increased, the power stream will then be deflected to outlet channel **30** and if is decreased, the power stream will be deflected into outlet channel **28**. Thus, the output from the device will vary with changes in swirl thereby resulting in a modulating control. By proper design of channels **28** and **30** it is also possible for the device to operate in a bistable mode. That is, an on-off output signal would be dependent upon the magnitude of input swirl.

A second embodiment of this invention is shown in FIGURE 3. The FIGURE 3 embodiment differs from the device of FIGURE 1 in two particulars. First, the FIGURE 3 embodiment employs two swirl or control inputs. Secondly, and more significant, the inputs to the embodiment of FIGURE 3 are mechanical. That is, in the FIGURE 3 embodiment, the vortex rate pressure sensor of FIGURE 2 has been eliminated and direct mechanical inputs to the fluid control device are employed. These mechanical inputs may comprise a pair of rotatable shafts **40** and **42** having buckets thereon as shown. Thus, the inputs to the embodiment of FIGURE 3 comprise a pair of turbines which, in response to the outside influence to be sensed, rotate thus providing a rotating boundry or viscous effect which influences the power stream.

While preferred embodiments have been shown and described, various modifications and substitutions thereof may be made without departing from the spirit and scope of this invention. For example, the vortex rate pressure sensor of FIGURE 2 may be utilized in place of the mechanical shaft inputs of FIGURE 3 and vice versa. Similarly, the flow divider in the embodiments of FIGURES 1 and 3 may be either skewed or centered as desired. Accordingly, it is to be understood that this invention has been described by way of illustration rather than limitation.

What is claimed is:

1. A fluid control device comprising:

means defining a chamber having at least a main fluid input channel and a plurality of fluid output channels communicating therewith;

means positioned at least partly exterior of and vertically displaced from said chamber defining means for producing a relative rotational motion when subjected to an outside influence; and

means for transmitting said rotational motion into said chamber, said motion transmitting means being positioned so as to generate a rotating stream in said chamber, said rotating stream exerting a force on a stream of fluid flowing into said chamber through said main input channel, said force exerted on said fluid stream directing said stream into a particular output channel.

2. The apparatus of claim **1** wherein said chamber defining means comprises:

a pair of oppositely disposed side walls, said walls constituting extensions of the outer walls of at least two of said output channels, at least one of said side walls having a groove therein, said rotating stream being generated adjacent said groove.

3. A fluid control device comprising:

means defining a chamber having a main fluid input channel and a plurality of output channels communicating therewith, the outer walls of at least two of said output channels extending into and forming oppositely disposed side walls of said chamber;

means positioned at least partly exterior of and vertically displaced from said chamber defining means for producing a swirling stream of fluid when subjected to an outside influence; and

means communicating with said swirl producing and chamber defining means for delivering said swirling fluid to said chamber, said delivery means being positioned so as to discharge said swirling fluid stream into said chamber adjacent one of said oppositely disposed side walls thereof and in a direction normal to the direction of flow of fluid passing into said chamber via the main input channel, said swirling fluid exerting a force on said main channel fluid to direct said main channel fluid into a particular output channel.

4. The apparatus of claim **3** wherein said swirl producing means comprises:

a vortex rate pressure sensor; and

means for supplying fluid under pressure to said sensor.

5. The apparatus of claim **4** wherein said delivery means comprises:

a first conduit communicating between said sensor and said chamber.

6. The apparatus of claim **5** further comprising:

discharge means communicating with said chamber and having its axis aligned with the axis of said first conduit, said discharge means being positioned as to permit that portion of said swirling stream which is not added to the main input fluid stream to pass out of said chamber.

7. The apparatus of claim **6** wherein said chamber defining means comprises:

a pair of oppositely disposed side walls, said walls constituting extensions of the outer walls of at least two of said output channels, at least one of said side walls having a groove therein, said groove defining in part a path for said swirling stream through said chamber between said first conduit and said discharge means.

8. A fluid control device comprising:

means defining a chamber having a main fluid input channel and a plurality of fluid output channels communicating therewith, the outer walls of at least two of said output channels extending into and serving to define oppositely disposed side walls of said chamber, at least one of said side walls having a semicircular groove therein, said groove extending the width of said chamber;

means positioned exterior of said chamber for producing a relative rotational motion when subjected to an outside influence;

means including a rotatable shaft for transmitting said motion into said chamber; and

means in said chamber and at least partly disposed in said groove for generating a rotating stream, said rotating stream generating means being operatively connected to said shaft, said rotating stream exerting a deflecting force on a stream of fluid injected into said chamber via said main input channel.

References Cited

UNITED STATES PATENTS

3,158,166	11/1964	Warren	137—81.5
3,193,197	7/1965	Bauer	137—81.5 XR
3,216,439	11/1965	Manion	137—81.5
3,228,602	1/1966	Boothe	137—81.5 XR
3,233,522	2/1966	Stern	137—81.5 XR
3,244,189	4/1966	Bailey	137—81.5
3,266,512	8/1966	Turick	137—81.5
3,276,463	10/1966	Bowles	137—81.5
3,311,987	4/1967	Blazek	137—81.5 XR
3,342,198	9/1967	Groeber	137—81.5

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