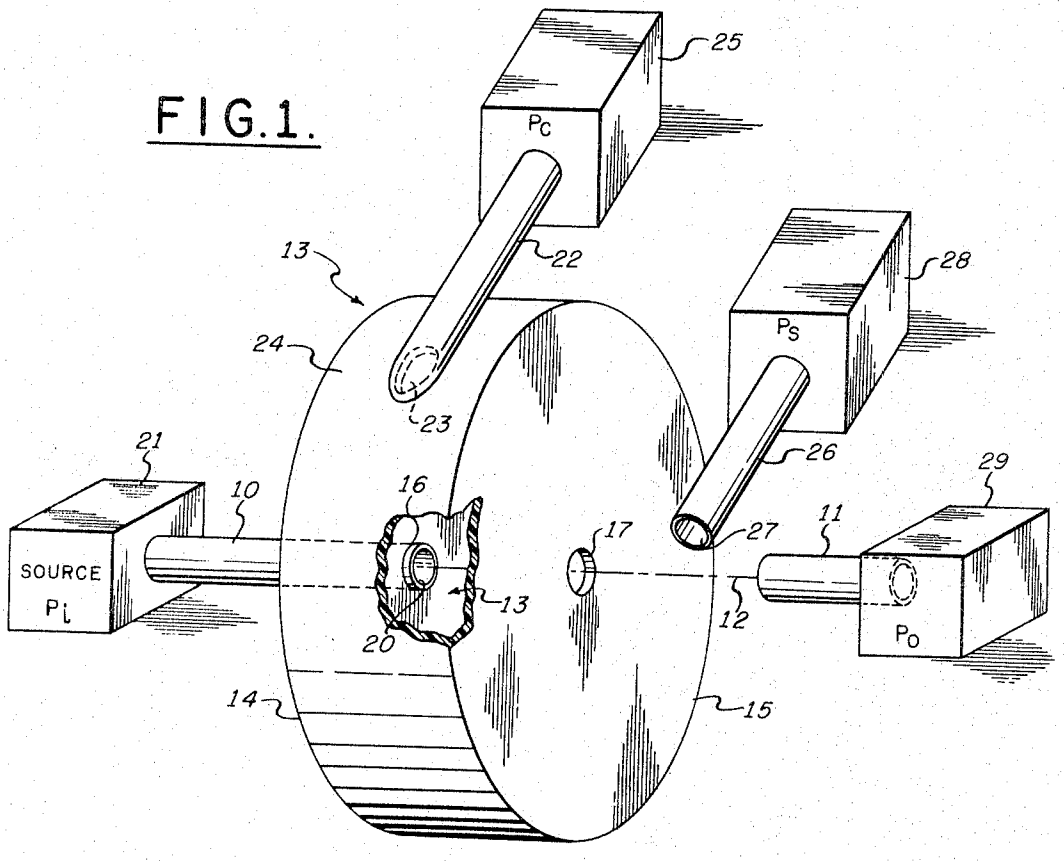
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FLUID LOGIC VORTEX APPARATUS

Filed Sept. 16, 1964

FIG.1.



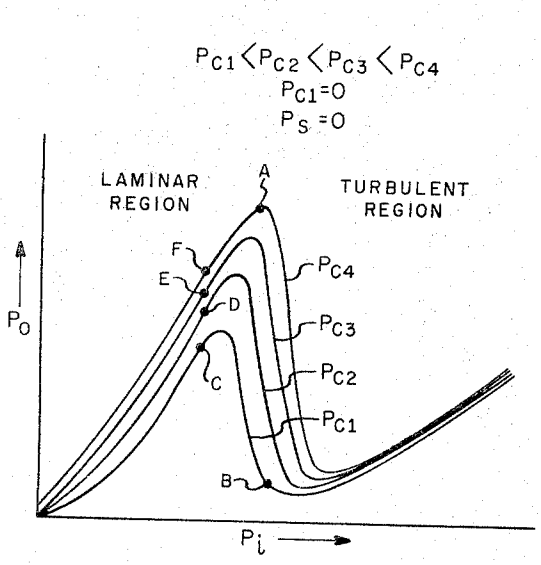


FIG.2.

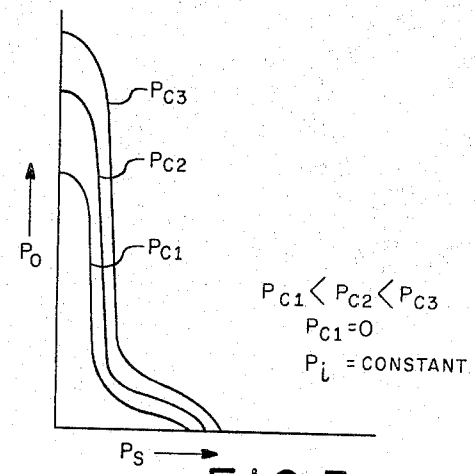


FIG.3.

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FLUID LOGIC VORTEX APPARATUS

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This invention relates to pure fluid logic devices and particularly to a pure fluid amplifier that can function as an OR device, an AND device, a proportional amplifier or serve to increase the output pressure of a turbulence amplifier NOR device.

Prior art turbulence type fluid amplifiers cannot operate effectively in a proportional mode or as an AND or as an OR device. Further, the maximum output pressure of a turbulence amplifier is only about one-half that of the vortex type amplifier of the present invention.

It is a primary object of the present invention to provide a vortex amplifier device capable of providing a plurality of logic functions.

Another object of the present invention is to provide a pure fluid logic device capable of providing AND, OR, and improved NOR functions.

The above objects are accomplished by combining vortex and laminar-turbulent flow by utilizing a vortex amplifier in combination with a turbulence amplifier.

FIG. 1 is a schematic diagram in perspective of a combination vortex and turbulence amplifier;

FIG. 2 is a graph showing characteristic curves of output pressure P_o versus input pressure P_1 at constant control pressure P_c; and

FIG. 3 is a graph showing characteristic curves of output pressure P_o versus control pressure P_s at constant control pressure P_c and constant input pressure P_i.

Referring to FIG. 1, two collinear conduits **10** and **11** are spaced by approximately 1 inch with the inside diameter of the conduits **10** and **11** being about 30 mils, for example. The collinear conduits **10** and **11** are coaxial along the axis of symmetry **12** of a hollow cylindrically shaped vortex chamber **13**. The inside height of the cylinder **13** may be approximately ⅜ inch with the inside diameter being approximately 1 inch. Spaced end walls **14** and **15** of the cylinder **13** have a centrally disposed input opening **16** and output port **17**, respectively, located therein concentric with the axis **12**. The input conduit **10** projects into the opening **16** with the end **20** of the conduit **10** protruding slightly into the interior of the chamber **13**. The other extremity of the conduit **10** is connected to a source **21** of constant input pressure fluid P_i. One or more control fluid conduits **22** terminate in respective ports **23** in the peripheral wall **24** of the vortex chamber **13**. A source **25** of control pressure fluid P_c is connected to the other extremity of the control conduit **22**. A control conduit **22** may have an inside diameter of, for example, about 30 mils and serve to provide a control flow emanating from the port **23** which is tangential to the peripheral wall **24** of the cylinder **13** thereby creating a fluid cortex within the chamber **13**.

One or more control conduits **26** are arranged with their axes of symmetry perpendicular to the axis **12** and disposed between the end wall **15** of the chamber **13** and the output conduit **11** so that the control fluid flow emanating from the output port **27** of the conduit **26** intersects the flow between the conduits **10** and **11**, in a manner to be more fully explained. The other extremity of the control conduit **26** is connected to a source **28** of control signal fluid flow P_s. The distal extremity of the output conduit **11** with respect to the chamber **13** is connected to a signal utilization device **29** which is responsive to the output pressure flow P_o from the output conduit **11**.

It will be appreciated that the dimensions given above are not critical but merely serve as typical examples. For an optimized vortex amplifier, the dimensions will vary depending upon the pressure, temperature, and type of fluid used. The restriction of dimensions is such that the inside diameters of the conduits **10** and **11** and their distance of separation are restricted to values that define a laminar flow to be established between conduits **10** and **11** in the absence of interference from the control signal source P_s.

In operation, an input flow is applied to conduit **10** from source **21** at an input pressure P_1. The flow continues along the axis **12** through the hollow cylinder **13** exiting through the port **17**. A portion of this flow is captured by the output conduit **11** at a pressure P_o sufficient to be useful in the utilization apparatus **29**. With a control signal applied from the control source **25** at a control pressure P_c, control fluid flow emanates from the control port **23** that is tangential to the cylinder wall **24**. This control flow produces a vortex within the vortex chamber **13** and provides a control flow which follows a spiral path that exits through the output port **17** along with the flow from the input conduit **10**. The angular momentum is conserved as the control flow spirals inwardly so that the angular velocity of the control flow increases. The flow from the conduit **10** is trapped in the center of the rapidly spinning control flow emanating from the control port **23**. The effect is to make the fluid flowing from the output port **17** more laminar and thus more easily captured by the output conduit **11** thereby providing a greater output signal P_o to the utilization apparatus **29**.

Referring now to FIG. 2, characteristic curves of output pressure P_o versus input pressure P_i at constant control pressure P_c with control signal P_s absent is shown. The lowermost curve is with control signal P_c absent and corresponds to the curve for a conventional turbulence amplifier, i.e., two collinear conduits such as **10** and **11** with no hollow cylinder **13** therebetween. The curve rises in the laminar region until a peak is reached and then falls as transition to turbulent flow occurs after which the curve again rises as the turbulent flow increases.

As control pressure P_c is increased with the input pressure P_i held constant, the output pressure P_o rises. Further, the maximum output pressure P_o increases as the control pressure P_c is increased. The amount that P_o is increased diminishes as higher values of P_c are reached.

FIG. 3 shows a plot of output pressure P_o versus control pressure P_s at constant control pressure P_c and constant input pressure P_i. P_i and P_c are such that the flow is laminar. When P_s is applied, the laminar flow is disrupted and becomes turbulent. The lowermost curve is for P_c absent and corresponds to the curve for a turbulence amplifier as explained above.

For the operation of the present invention as an OR device or an AND device, refer again to FIG. 2. Assume that the pressures are adjusted so that the vortex amplifier is operating at point A on curve $Pc4$. If the control pressure is removed, the operating point falls to point B on curve $Pc1$. There is an output only when a control signal is present. Multiple control inputs can be provided to supply control pressure P_c, the presence of any one of which causes an output pressure P_o thus giving the OR function. If the vortex amplifier is operated so that two or more control signals are required for an output pressure P_o, then the AND function results.

For operation as a proportional amplifier, a constant input pressure P_i is supplied to the vortex amplifier. If the amplifier is operating at point F on curve $Pc4$ of FIG. 2 and the control pressure P_c is reduced to zero, the output pressure falls to a value given by point C on curve

Pc1. The output pressure P_o varies proportionally with the control pressure P_c.

Operation of the vortex amplifier as an improved turbulence amplifier may be understood from FIG. 3. The lowermost curve results from the absence of a control pressure P_c and corresponds to the curve for a turbulence amplifier. The presence of P_c increases the output pressure P_o so a higher working pressure can be used. When control pressure P_s is applied, laminar flow from the output port 17 is disrupted and the flow remains turbulent, thus providing no input into utilization apparatus 29 until P_s is removed. One or more control conduits 26 can be provided to supply P_s resulting in a NOR device. Larger diameter input and output conduits can be used as the spinning flow P_c makes the flow to the output conduit more laminar.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than of limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.

What is claimed is:

1. A fluid device comprising
(a) vortex chamber means having first and second spaced openings concentric with its axis of symmetry,
(b) a first source of pressure fluid connected to said first opening for providing a first fluid flow,
(c) output conduit means in spaced relation to and cooperative with said second opening,
(d) a first source of control pressure fluid connected to a control port adapted to provide a first control stream for providing a vortex within said chamber cooperative with said first fluid flow for providing a second fluid flow from said second opening along said axis of symmetry,
(e) utilization apparatus connected to said output conduit means responsive to pressure fluid flow captured by said output conduit means,
(f) a second source of control pressure fluid, and
(g) a second control port connected to said second source and disposed between said second opening and said output conduit means and adapted to provide a second control stream for impacting against said second fluid flow to prevent said second flow from being effective in said utilization apparatus.

2. A pure fluid logic device comprising
(a) a cylindrically shaped chamber defined by a peripheral circular wall bounded by first and second end wall members concentric with respect to an axis of symmetry,
(b) a first input opening centrally disposed in said first wall member and concentric with said axis,
(c) a source of input pressure fluid connected to said first opening for providing a first laminar fluid flow,
(d) a second output opening centrally disposed in said second wall member and concentric with said axis,
(e) a first source of control pressure fluid,
(f) a first conduit responsive to said first control source and terminating in a control fluid port in said circular wall and adapted to provide a first control stream tangentially to said circular wall for producing a vortex within said chamber enhancing said first fluid flow for providing a second fluid from said second opening along said axis of symmetry,
(g) output conduit means in spaced relation to and cooperative with said second opening,
(h) utilization apparatus connected to said output conduit means responsive to pressure fluid flow captured by said output conduit means,
(i) a second source of control pressure fluid, and
(j) a second control port connected to said second source and disposed between said second opening and said output conduit means and adapted to provide a second control stream for impacting against said second fluid flow to prevent said second flow from being effective in said utilization apparatus.

3. A pure fluid logic device comprising
(a) a hollow cylindrically shaped chamber having first and second spaced end wall members concentric with respect to its axis of symmetry and a peripheral circular wall,
(b) first and second openings centrally disposed in said first and second spaced end wall members respectively and concentric with said axis of symmetry,
(c) a first source of pressure fluid connected to said first opening for providing a first fluid flow,
(d) output conduit means in spaced relation to and cooperative with said second opening,
(e) a source of control pressure fluid connected to a control port in said wall adapted to provide a control stream for producing a vortex within said chamber cooperative with said first fluid flow for providing a second fluid flow from said second opening along said axis of symmetry,
(f) utilization apparatus connected to said output conduit means responsive to pressure fluid flow captured by said output conduit means,
(g) a second source of control pressure fluid, and
(h) a second control port connected to said second source and disposed between said second opening and said output conduit means and adapted to provide a second control stream for impacting against said second fluid flow to prevent said second flow from being effective in said utilization apparatus.

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