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PRESSURE RECOVERY FROM BISTABLE ELEMENT

Filed June 17, 1963

2 Sheets-Sheet 1

FIG. 1

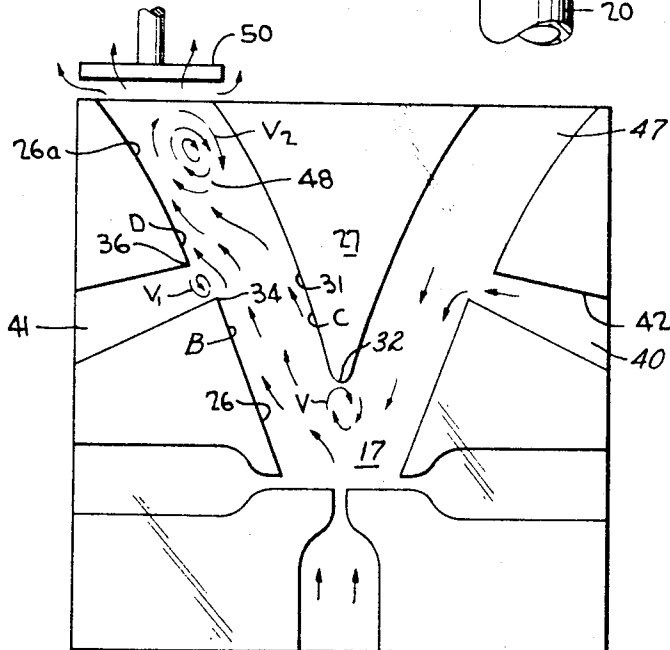
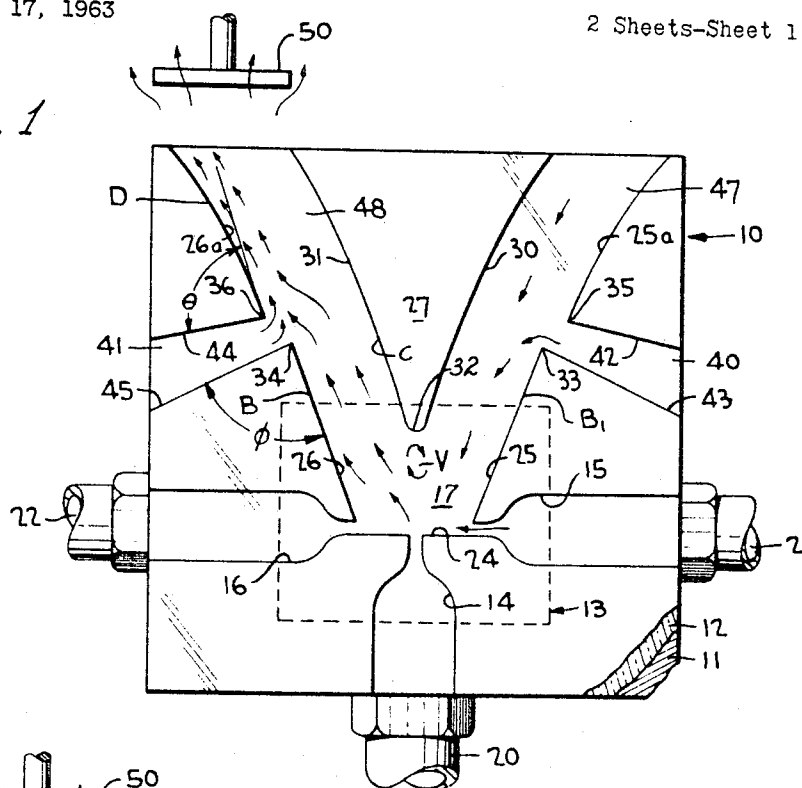


FIG. 2

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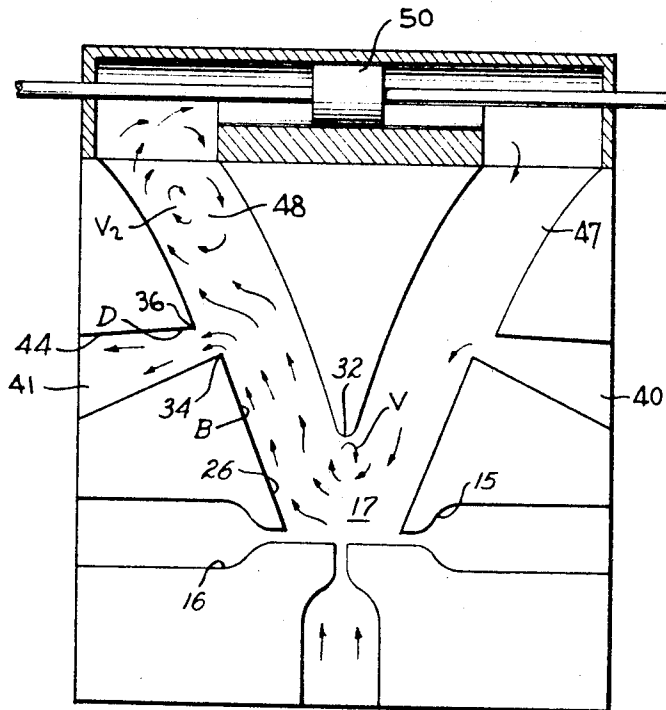
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2 Sheets-Sheet 2

FIG. 3



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3,267,947

PRESSURE RECOVERY FROM BISTABLE
ELEMENT

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22 Claims. (Cl. 137-81.5)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates generally to pure fluid systems and more specifically to a self-adaptive pure fluid system which incorporates a pure fluid amplifier therein.

A typical pure fluid amplifier that is preferably incorporated in the self adaptive fluid system of this invention includes an interaction chamber defined for example by an end wall and two outwardly diverging sidewalls, hereinafter referred to as the left and right sidewalls. A nozzle having an orifice in the end wall is provided to issue a well-defined and relatively large energy stream, hereinafter referred to as a power stream, into the interaction chamber. A substantially V-shaped flow divider has one end thereof disposed a predetermined distance from the end wall, the sides of the divider being generally parallel to the left and right sidewalls of the chamber. The regions between the sides of the divider and the left and right sidewalls define left and right output passages, respectively.

Fluid control signals in the form of control streams are supplied by a control nozzle to the interaction chamber, the control nozzle being positioned generally perpendicularly to the power nozzle. The power stream is deflected in the interaction chamber by interaction with the fluid of the control stream, the smaller energy of the control stream controlling the larger energy of the power stream so that amplification is achieved. Since no moving mechanical parts are required for operation of such amplifiers they are known and referred to by those working in the art as "pure fluid amplifiers."

In accordance with this invention, the following types of pure fluid amplifier units can be constructed and embodied in the fluid pressure recovery system of the instant invention.

Fluid amplifiers wherein the control and power streams interact in such a way that the resulting flow patterns and pressure distribution into the output passages are greatly affected by the details of the design of the sidewalls. The effect of sidewall configuration on the flow patterns and pressure distribution which can be achieved depends upon: the relation between width of the power nozzle supplying the fluid stream to the chamber and the distance between opposite sidewalls of the interaction chamber adjacent the orifice of the power nozzle; the angle that the sidewalls make with respect to the centerline of the power stream; the length of the sidewall (when a flow divider is not used); the spacing between the power nozzle and the flow divider (if used); and the density, viscosity, compressibility and uniformity of the fluid flowing in the chamber. It also depends to some extent on the thickness of the fluid element. In general, fluid devices utilizing boundary layer effects, i.e., effects which depend upon details of sidewall configuration can be subdivided into three categories:

(a) Boundary layer elements in which there is no appreciable "lock on" effect. Such a unit has a power gain which can be increased by boundary layer effects, but these effects are not dominant;

(b) Boundary layer units in which "lock-on" effects are dominant and are sufficient to maintain the power stream in a particular flow pattern through the action

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of the pressure distribution arising from boundary layer effects, and requiring no streams other than the power stream to maintain that flow pattern, once established, but having a flow pattern which can be changed to a new stable flow pattern by control stream flow, or by altering the pressures at one or more of the output passages;

(c) Boundary layer units in which the flow pattern can be maintained through the action of the power stream along without being continuously controlled by control stream flow. The flow pattern in this type of unit can be modified by the application of a control stream but otherwise maintains the power stream flow pattern, including "lock on" to the sidewall, even though the pressure distribution at the output passages is increased.

The lock-on phenomena referred to hereinabove is due to a boundary layer effect existing between the stream and a sidewall. Assume initially that the fluid stream is issuing from the power nozzle and is directed toward the apex of the divider. The fluid issuing from the power nozzle orifice, in passing through the chamber, entrains fluid in the chamber and removes this fluid therefrom. If the power stream is slightly closer to, for instance, the left wall than the right wall, it is more effective in removing the fluid in the region between the stream and the left wall than it is in removing fluid between the stream and the right wall. Therefore, the pressure in the left region between the left wall and stream is lower than the pressure in the right region of the chamber and a differential pressure is set up across the power stream tending to deflect it toward the left wall. As the power stream is deflected further toward the left wall, it becomes even more efficient in entraining air in the left region and the pressure in this region is further reduced. This action is self-reinforcing and results in the power stream becoming deflected toward the left wall and entering the left outlet passage. The stream intersects the left wall at a predetermined distance downstream from the outlet of the main orifice; this point being normally referred to as the point of attachment. This phenomena is referred to as boundary layer lock on. The operation of this type of apparatus may be completely symmetrical in that if the stream had initially been slightly deflected toward the right wall rather than the left wall, boundary layer lock on would have occurred against the right wall.

Continuing the discussion of the three categories of the second class of beam type fluid amplifying units, the boundary layer unit type (a) above utilizes a combination of boundary layer effects and momentum interaction between streams in order to achieve a power gain which is enhanced by the boundary layer effects, but since boundary layer effects in type (a) are not dominant, the power stream does not of itself remain locked to the sidewall. The power stream remains diverted from its initial direction only if there is a continuing control flow that interacts to maintain the deflection of the power stream. In a boundary layer unit type (b) the lock-on effect is sufficient to maintain the power stream flowing entirely out one passage in the absence of any fluid control signal. A boundary layer unit type (b) can be made as a bistable unit, but it can be dislodged from one of its stable states by control fluid flow or by the blocking of the output passage connected to the aperture receiving the major portion of the power stream. Boundary layer units type (c) have a very strong tendency to maintain the direction of flow of the power stream through the interaction chamber, this tendency being so strong that complete blockage of the passage connected to one of the output apertures toward which the power stream is directed does not dislodge the power stream from its "locked on" condition. Boundary layer units type (c) are therefore memory units which while sensitive to interacting control fluid flow, are

relatively insensitive to positive loading conditions at their output passages.

To give a specific example: boundary layer effects have been found to influence the performance of a fluid amplifier element if it is made as follows: the width of the interacting chamber at the point where the power nozzle issues its stream is two to three times the width, W , of the power nozzle, i.e., the chamber width at this point is $3W$; and the sidewalls of the chamber diverge so that each sidewall makes a 12° angle with the center line of the power stream. In a unit made in this way, a spacing between the power nozzle and the center divider equal to two power nozzle widths $2W$ will exhibit increased gain because of boundary layer effects, but the stream will not remain locked on either side. This unit with a divider spacing of $2W$ is a boundary layer unit type (a) which if the spacing is less than $2W$ an amplifier of the first class, i.e., a proportional amplifier results. If the divider is spaced more than three power nozzle widths $3W$, but less than eight power nozzle widths $8W$, from the power nozzle, then the power stream remains locked onto one of the chamber walls and is a boundary layer type (b). A substantial blockage of the output passage of such a unit generally causes the power stream to take a new flow pattern into the adjacent output passage if that passage is not blocked.

A boundary layer unit having a divider which is spaced more than twelve power nozzle widths $12W$, from the power nozzle remains "locked on" to a chamber wall even though there is almost a complete blockage of the output passage into which the power stream is directed, and thus it is a boundary layer unit type (c). Another factor effecting the type of operation achieved by these units is the pressure of the fluid applied to the power nozzle relative to the width of the chamber. In the above examples, the types of operation described are achieved if the pressure of the fluid is less than 60 p.s.i. If, however, the pressure exceeds 80 p.s.i. the expansion of the fluid stream upon issuing from the power nozzle is sufficiently great to cause the stream to contact both sidewalls of the chamber and lock on is prevented. Lock-on can be achieved at the higher pressures by increasing the widths of the interaction chamber.

In general, the output passages of the aforescribed pure fluid amplifier are connected to drive loads such as pistons or to various types of pure fluid systems, known to those working in the art. Since many types of load utilization devices require pressure for the operation or control thereof, the fluid flow from the pure fluid amplifier must be converted to a fluid pressure head which preferably increases as the load increases.

As the load into which the output flow from the aforescribed pure fluid amplifiers increases, lock-on will exist in the class (c) type of amplifier, and may continue to exist in the class (b) type of amplifier depending upon the amount of output passage backloading. However, the pressure will not rapidly build up as desired since the fluid from the power stream under increased backloading will flow back and around the apex of the flow divider and into an adjacent output passage. Therefore, the greater the backloading of, for example, the left output passage, the greater the flow from the right output passage and generally the pressure applied to the load will not increase at a high enough rate to provide a constant output pressure to the load.

According to this invention, a self adaptive fluid system is provided that incorporates a pure fluid amplifier preferably of the type described hereinabove. The system effects a maximum pressure recovery of fluid supplied to an output passage by the power stream when the load applied to the output passage into which the power stream has been displaced by a control stream becomes maximum. By the term "pressure recovery" is meant that proportion of the total head of the power stream available at the load; i.e. converted to static pressure acting on the

load. The present invention maximizes the pressure recovery available in a memory type unit. The system, in addition to providing maximum pressure or flow when maximum pressure or flow are respectively required, is designed to effect an impedance match between the load device and the pure fluid amplifier incorporated in the system. Impedance matching is provided since the output passage to which the power stream is directed continues to accept all of the fluid of the stream regardless of variations in load, from no load to full load, on the output passage.

Broadly, therefore, it is an object of this invention to provide a self adaptive pure fluid system.

More specifically, it is an object of this invention to provide a pure fluid system which incorporates a pure fluid amplifier and adapts itself to produce maximum pressure or flow to a load when maximum pressure or flow are desired without flow out of the opposite output passage.

Still another object of this invention is to provide a pure fluid pressure recovery system that effects an automatic impedance match between the recovery system and its operating environment.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 illustrates the self adaptive pure fluid system in accordance with this invention and the flow pattern of the fluid in the system when an output passage is slightly backloaded;

FIGURE 2 illustrates the flow pattern in the self adaptive system of this invention when an output passage is partially backloaded;

FIGURE 3 illustrates the flow pattern in the self-adaptive fluid system of this invention when the output passage is almost completely blocked by backloading.

Referring now to FIGURE 1 for a more complete understanding of this invention, there is shown a self adaptive pure fluid system which is formed between two flat plates 11 and 12 sealed one to the other by adhesives, machine screws, or other suitable means. The plates 11 and 12 may be composed of any material compatible with the fluid employed in the pressure recovery system 10 and for purposes of illustration are shown to be composed of a clear plastic material. The configuration required to provide the system 10 is formed in the lower plate 11 by molding, etching, or other suitable techniques and the plate 11 is thereafter covered with the plate 12 so that the various passages, ducts and nozzles are enclosed and sealed in a fluid-tight relationship between the two plates.

The system 10 incorporates a pure fluid amplifier shown enclosed by the dotted block 13 in FIGURE 1, the pure fluid amplifier 13 including a power nozzle 14, control nozzles 15 and 16 and interaction chamber 17. Tubes 20, 21 and 22 are respectively threadably connected to the nozzles 14, 15 and 16, respectively, the tubes being connected to sources of fluid for supplying a power stream to the power nozzle 14 and control streams to the control nozzles 15 and 16. The flow divider 27 has symmetrically tapering sidewalls 30 and 31 the sidewalls being located symmetrically with respect to a centerline taken through the power nozzle 14 and located equidistant from the diverging sidewalls 25 and 26 of the interaction chamber 17.

The flow divider 27 terminates at a wedge-shaped tip or apex 32 which is positioned to directly receive the power stream issuing from the power nozzle 14. The sidewalls which are positioned in opposed relationship with respect to the sidewalls 30 and 31 of the flow divider 27 are not continuous, the sidewall sections 25 and 26 terminate at apices 33 and 34, respectively. The sidewall sections 25a and 26a, respectively, are formed by apices 35 and 36, respectively, which are spaced a relatively short distance downstream at the apices 33 and 34, as illustrated. As

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illustrated in FIGURE 1, the sidewall sections 25a and 26a are set back from the apices 33 and 34 of the sidewall sections 25 and 26, respectively, and therefore the lateral distance between the sidewall section 25 and the sidewall 30 is smaller than the lateral distance between the sidewall section 25a and the sidewall 30. Correspondingly the lateral distance between the sidewall section 26 and the sidewall 31 of the flow splitter 27 is less than the lateral distance between the sidewall section 26a and the sidewall 31. The apices 33 and 35 define opposite sides of the entrance to a duct or passage 40 and the apices 34 and 36 define opposite sides of the entrance to a duct or passage 41. The sidewalls 42 and 43 of the duct 40 diverge as do the sidewalls 44 and 45 of the duct 41. The sidewalls 30 and 31 and the sidewall sections 25a and 26a, respectively, form the sidewalls of output passages 47 and 48, respectively, of the pressure recovery system 10.

The sidewalls 25 and 26 are set back from the orifice of the power nozzle 14 a distance such that the power stream has a tendency to lock on to the sidewalls 25 and 26 at points B1 and B, respectively, when control streams from control nozzles 16 and 15, respectively, displace the power stream in the interaction chamber 17. In general, high pressure regions or points of boundary layer attachments are produced by the power stream impinging at relatively high velocity against a surface. Such high pressure regions tend to seal off the downstream flow of the stream from feeding back through the high pressure region. Thus, once a high pressure region is created by deflection of a high velocity stream, the pressure of the fluid downstream of the region will have to exceed the pressure of the region before the point of attachment will be disturbed. As the pressure downstream of the point of attachment increases and exceeds that of the point of attachment the point in effect moves upstream to a new location until the pressure between the point of attachment and the surface exceeds the increased downstream pressure. Thus, it is possible to have the point of attachment move along the sidewalls of either the chamber 17 or the flow splitter 27 as a result of increasing and decreasing pressure downstream of the point of attachment.

In order to understand the operation of the pure fluid system 10, illustrated in FIGURE 1, assume that the power nozzle 14 is issuing a power stream into the interaction chamber 17. If a control stream is directed from the control nozzle 15 into the interaction chamber it will tend to displace the power stream into the output passage 48. The sidewall 26 is positioned sufficiently close to the orifice of the power nozzle 14 so that boundary layer attachment occurs at point B and may occur at point C depending upon the amount or quantity of flow from the power nozzle 14 and the width of the passage between the sidewall section 26 and the opposite section of sidewall 31. If the quantity of flow from the nozzle 14 is insufficient to completely fill the passage between the section 26 and the sidewall 31, the power stream will attach to the wall section closest to the edge of the stream. Thus, the points B and C or alternatively, the point B or the point C may each represent points of attachment of the power stream and the control stream entrained in the power stream.

A portion of the combined power and control stream will also be directed against the wedge-shaped apex 32 formed on the end of the divider 27. A high pressure is formed in a region upstream of the apex 32 since the apex 32 is positioned to receive direct impingement of the power stream. A vortex V represents a high pressure region in the interaction chamber 17 will be created as a result of fluid impinging against the tip of the apex 32. The vortex V rotates clockwise as illustrated in FIGURE 1 and tends to suck fluid from the duct 40 and from the output passage 47 into the entrance of the output passage 48. The fluid stream flowing over the apex 34 of the sidewall section 26 reattaches at the point D to the sidewall section 25a and issues from the output passage 48

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along with fluid sucked from the duct 41 into the stream passing across the apices 34 and 36 at relatively high velocity. Thus, in the absence of any backloading of the output passage 48 maximum flow will issue from that passage because of the entrainment of fluid from the ducts 40 and 41 and from the output passage 47.

Referring now to FIGURE 2, there is illustrated the flow pattern which results as the backloading in the output passage 48 increases as a result of increasing the load which may for example take the form of a piston 50. As a result of the increasing pressure in the output passage 48 the point of attachment D is effectively moved upstream to a position closer to the apex 36 as illustrated in FIGURE 2, and the points of attachment B and C move downstream, the point B ultimately coinciding with the apex 34 of the sidewall section 26. A recirculating vortex V1 may now be created between the apices 34 and 36 by flow across the entrance of the duct 41 from the point of attachment D to the apex 34 and the pressure of the vortex V1 may be sufficient to prevent any fluid entering the output passage 48 from the duct 41, the vortex V1 increasing in pressure as the point D moves upstream towards the apex 36. The high pressure region created by the vortex V is now sufficient to stop any appreciable flow from the output passage 47 or the duct 40 into the interaction chamber 17.

Referring now to FIGURE 3, there is shown the flow pattern which results when the output passage 48 is almost completely blocked by, for example, backloading the output passage 48 with the piston 50 movable in a closed output system which is connected to receive fluid from either output passage 47 or 48. The greatly increased pressure in the output passage 48 which is correspondingly created by the heavy backloading of that output passage causes the point of attachment D to move to a position at the apex 36. Thus the fluid from the power stream turns with a radius of curvature substantially about the apex 34 and impinges against the sidewall 44 at the apex 36 thereby creating a high pressure region at that point. A portion of the fluid from the power stream will now egress from the duct 41 because of the movement of the point of attachment D into that duct, as illustrated in FIGURE 3. The point D located in the duct 41 defines the downstream point of attachment and in effect prevents fluid from flowing upstream to the point B.

The reduced flow out passage 48 increases the flow out of passage 41 and the power stream tends to move toward the right causing an increase in the flow directed toward the apex 32 reinforcing the vortex V and raising the pressure in the interaction region 17 and the controls 15 and 16. This vortex tends to force the power jet stream toward the wall 26.

In the design of the ducts 40 and 41 the angles ϕ and θ , FIGURE 1, are important. The wall 26a at the apex 36 is generally parallel to the wall 26, as illustrated, and thus, the angle θ is determined primarily by the position of the wall 44. Since, as indicated, it is desirable to produce a relatively high pressure at the point of attachment of the stream to wall 44, and this is effected by having the stream impact against the wall, the angle θ should be at least approximately 90° and preferably greater so that the desired impact angles may be achieved. The angle ϕ formed between the sidewalls 26 and 45 should be small enough so that preferably there is divergence in the direction of flow between the sidewalls 42, 43 and 44, 45, respectively. Duct sidewall divergence, as discussed hereabove, reduces the possibility of oscillation in the duct due to abrupt discontinuities between the input end and output end of the vents with resulting oscillation.

From the foregoing description of operation it will be apparent to those working in the art that a maximum pressure is produced by the system 10 when a maximum load is applied to the output passage and that a maximum flow results when the backloading of the output passage is minimum. As illustrated in the accompanying draw-

ing, the sidewall sections 25a and 26a are set back from the sidewall sections 25 and 26. Such setback is preferable because the possibility of undesired oscillation of the system 10 is minimized and the amount of fluid which would bleed from the ducts 40 and 41 is reduced. In addition, the ducts 40 and 41 are provided with diverging sidewalls 42, 43, 44, 45, respectively, in order to effect an impedance match between the load 50 and the fluid amplifier 13.

With regard to impedance matching in general, it is known to those skilled in the art that if a moving column of fluid meets an abrupt continuity in the system, a reflected wave will be produced which travels the length of the column of fluid as a sinusoidal oscillating wave. An abrupt discontinuity may for example take the form of relatively abrupt change in flow direction as for example by a right angle bend between a passage and a tube or pipe or by an abrupt change of pressure between the fluid in the tube or pipe and a pressure of the region into which the fluid discharges. An abrupt discontinuity in a pure fluid system reflects shock waves which create oscillations in the fluid flowing in the passage or tube in the same manner that a pipe organ produces standing waves in the air columns of each pipe; that is, nodes or antinodes are produced by the abrupt discontinuity which cause fundamental and overtone oscillations in the air columns. As will be appreciated by those working in the art, oscillating shock waves created by abrupt discontinuities are generally undesirable in pure fluid systems because they create high levels of noise and tend to cause unanticipated oscillation of the unit. By providing a diverging duct to fluid output flow from the system 10, a relatively smooth transition is provided between the fluid pressure in the system 10 and the ambient pressure of fluid egress. Thus, the impedance of the ambient pressure conditions and the impedance of the output from the system 10 are somewhat matched by the divergence of the ducts 40 and 41 and the possibility of unanticipated oscillation in the system 10 accordingly reduced.

Although the entrances to the ducts 40 and 41 are illustrated in the figures of the accompanying drawing as positioned downstream of the apex 32, the entrances may alternatively be positioned upstream of the apex 32 as long as they remain downstream of the points of attachment B and B1. If the entrances are positioned upstream of the points of attachment B and B1 then the flow will enter the low pressure separation from the ducts 40 or 41 directly resulting in instability. The positioning of the entrances to the ducts 40 and 41 is determined primarily by the velocity of the power stream anticipated at the point of attachment B. As will be obvious from the foregoing description it is important that the point of attachment D receive fluid with a velocity high enough to seal off the pressure downstream of the point D.

The position of the apex 32 relative to the orifice of the power nozzle 14 is also determined by the velocity of the fluid impinging against the apex 32. Optimum sealing results when the apex 32 is positioned in the high velocity portion of the power stream.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A pure fluid system comprising an interaction chamber for receiving and confining fluid flow, a power nozzle for issuing a power stream into one end of said chamber, a control nozzle for issuing a control stream in interacting relationship with said power stream for effecting amplified directional displacement thereof, plural passages located downstream of said interaction chamber for receiving fluid flow therefrom, a substantially wedge shaped flow splitter located between said passages for splitting flow into said passages, a duct extending laterally from at

least one of said passages downstream of the apex of said flow splitter and communicating with a predetermined fluid environment.

2. A pure fluid system comprising an interaction chamber for receiving and confining fluid flow, a power nozzle for issuing a power stream into one end of said chamber, a control nozzle for issuing a control stream in interacting relationship with said power stream for effecting amplified directional displacement thereof, plural passages located downstream of said interaction chamber for receiving fluid flow therefrom, a substantially wedge shaped flow splitter located between said passages for splitting flow into said passages, a duct extending laterally from at least one of said passages downstream of the apex of said flow splitter and communicating with a predetermined fluid environment, said duct including a pair of opposed sidewalls diverging as said duct extends from said one of said passages.

3. A pure fluid system comprising an interaction chamber for receiving and confining fluid flow therein, a power nozzle for issuing a power stream into one end of said chamber, a control nozzle for issuing a control stream in interacting relationship with said power stream for effecting amplified directional displacement thereof, a pair of passages located downstream of the interaction chamber for receiving fluid therefrom, a duct extending from each of said passages downstream of the region of interaction between the control and power stream, each duct communicating with a predetermined fluid environment and including a pair of opposed sidewalls diverging as each duct extends from each passage.

4. A pure fluid system comprising an interaction chamber for receiving and confining fluid flow therein formed by a pair of diverging sidewalls and an end wall, a power nozzle extending through said end wall for issuing a power stream therefrom, at least one control nozzle extending through one of said sidewalls for issuing a control stream in interacting relationship to said power stream so as to effect displacement thereof in said interaction chamber, a substantially V-shaped divider located downstream of said power nozzle and having diverging walls positioned intermediate said sidewalls, each sidewall extending from said chamber comprising at least two separated sections, a duct located between said separated sections, and communicating with a predetermined fluid environment, the distance between the edges of said divider and a downstream section of each sidewall being greater than the difference between the walls of said divider and an upstream section of said sidewall.

5. A pure fluid system as claimed in claim 4 wherein said duct diverges in proceeding towards the region of fluid environment.

6. The pure fluid system as claimed in claim 4 wherein said divider includes a rounded apex positioned to receive an impinging fluid jet from said power nozzle.

7. A pure fluid system comprising an interaction chamber, a divider having a relatively narrow end and walls diverging outwardly at an angle of not greater than approximately 90° relative to one another, said end of said divider defining one end of said interaction chamber, a power nozzle for issuing a stream of fluid across said interaction chamber towards said end of said divider, a pair of outwardly diverging sidewalls defining opposite sides of said interaction chamber and extending from a location upstream of said end of said divider to a location downstream thereof, said sidewalls being located such as to cause a boundary layer to be established between each sidewall and a stream of fluid issued by said power nozzle, each sidewall defining a different output passage with a wall of said divider, a further passage extending generally transverse of and into communication with one of said output passages generally downstream of said end of said divider, said further passage extending into communication with a region of relatively constant pressure.

8. The combination according to claim 7 wherein said further passage has a pair of outwardly diverging sidewalls.

9. The combination according to claim 8 wherein the downstream sidewall of said further passage is at an angle of at least 90° with respect to the sidewall forming an outlet passage downstream of said further passage.

10. The combination according to claim 9 wherein the upstream sidewall of said further passage is at an angle of less than 90° relative to the sidewall forming an outlet passage upstream of said further passage.

11. The combination according to claim 10 wherein said sidewall defining the outlet passage communicating with said further passage is divided into an upstream and a downstream section by said further passage, said upstream section being located closer to said wall of said divider than said downstream section.

12. The combination according to claim 7 wherein the upstream sidewall of said further passage is at an angle of at least 90° with respect to the sidewall forming an outlet passage downstream of said further passage.

13. The combination according to claim 12 wherein the upstream sidewall of said further passage is at an angle of less than 90° relative to the sidewall forming an outlet passage upstream of said further passage.

14. The combination according to claim 13 wherein said sidewall defining the outlet passage communicating with said further passage is divided into an upstream and a downstream section by said further passage, said upstream section being located closer to said wall of said divider than said downstream section.

15. A pure fluid system comprising an interaction chamber, a divider having a relatively narrow end and walls diverging outwardly at an angle of not greater than approximately 90° relative to one another, said end of said divider defining one end of said interaction chamber, a power nozzle for issuing a stream of fluid across said interaction chamber towards said end of said divider, a pair of outwardly diverging sidewalls defining opposite sides of said interaction chamber and extending from a location upstream of said end of said divider to a location downstream thereof, at least one of said sidewalls being located such as to cause a boundary layer to be established between said sidewall and a stream of fluid issued by said power nozzle, said sidewall defining an outlet passage with an adjacent wall of said divider, a further passage extending generally transverse to and through said one of said sidewalls into communication with said outlet passage, said further passage extending into communication with a region of predeterminable pressure.

16. The combination according to claim 15 wherein said further passage has a pair of outwardly diverging sidewalls.

17. The combination according to claim 16 wherein the downstream sidewall of said further passage is at an angle

of at least 90° with respect to the sidewall forming an outlet passage downstream of said further passage.

18. The combination according to claim 17 wherein the upstream sidewall of said further passage is at an angle of less than 90° relative to the sidewall forming an outlet passage upstream of said further passage.

19. The combination according to claim 18 wherein said sidewall defining the outlet passage communicating with said further passage is divided into an upstream and a downstream section by said further passage, said upstream section being located closer to said wall of said divider than said downstream section.

20. The combination according to claim 15 wherein the downstream sidewall of said further passage is at an angle of at least 90° with respect to the sidewall forming an outlet passage downstream of said further passage.

21. The combination according to claim 20 wherein the upstream sidewall of said further passage is at an angle of less than 90° relative to the sidewall forming an outlet passage upstream of said further passage.

22. The combination according to claim 21 wherein said sidewall defining the outlet passage communicating with said further passage is divided into an upstream and a downstream section by said further passage, said upstream section being located closer to said wall of said divider than said downstream section.

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