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[56] **References Cited**

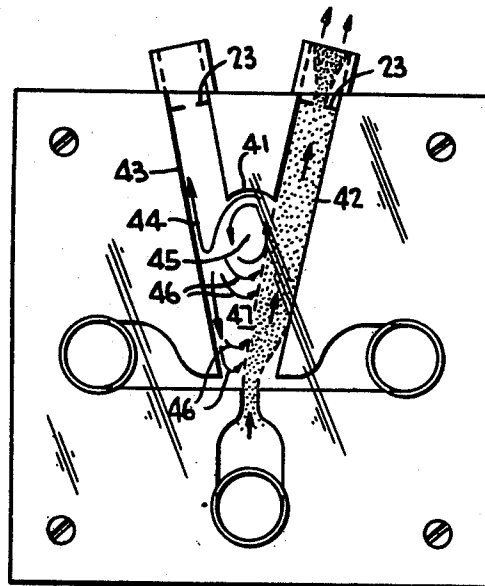
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[54] **FEEDBACK DIVIDER FOR FLUID AMPLIFIER**
4 Claims, 1 Drawing Fig.

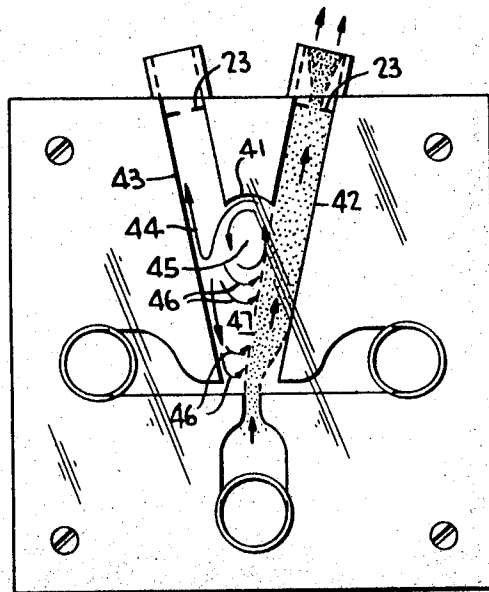
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ABSTRACT: This invention relates to pure fluid amplifiers having dynamic feedback dividers for providing a feedback which contributes assistance to the boundary layer lock-on phenomena.



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FEEDBACK DIVIDER FOR FLUID AMPLIFIER

This application is a divisional application of copending application Ser. No. 222,748, filed Sept. 10, 1962, and now U.S. No. 3,397,713, issued Aug. 20, 1968, entitled Feedback Divider for Fluid Amplifiers.

The invention described herein may be manufactured and used by or for the Government of the United States of America for Governmental purposes without the payment to me of any royalties thereon.

This invention relates to fluid amplifiers and more particularly, to dynamic feedback dividers in fluid amplifiers.

In previous fluid amplifiers, the dividers which separate the output channels were substantially wedge shaped with the pointed edge of the wedge aligned with the power nozzle in such a manner that the divider would separate the interaction region into two output channels. If all of the flow from the power stream could not be contained in one output channel, the divider would separate the power stream into a majority flow and a minority flow into the output channels. The favored channel was the channel which had the majority of the power stream flow. Favoring of one output channel over the other was a function of the symmetry of the amplifier elements, the smoothness of the surfaces exposed to the power stream flow, the divergence of the output channels, the amount of control provided directly on the stream, boundary layer effects, loading of the outputs, and the like. Once favored, the power stream would remain in the favored output channel until a control signal was provided to switch it to the other channel. This control signal could originate externally of the amplifier, could be a portion of the power stream feedback to the interaction chamber from a location downstream from the divider, or the like.

In some fluid amplifiers, such as bistable devices, it is desired that the stream remain in one output channel a prescribed length of time. There are various causes for instability that would prevent the stream from remaining in a favored channel until switching to the other channel is desired. One of these causes is encountered when the amplifier is connected to a load. The resistance in the system could be such that the output channel would no longer carry all of the power stream as it would in an unloaded condition. Under these circumstances, the return of the excess power stream down the favored channel against the flow of the power stream can cause perturbations and turbulences that would promote instability. Since all the fluid does not get out into the load, some of the fluid leaks around the divider and out through the other channel. Oscillations as well as other instabilities may result. Further, the direction of all of the power stream into a favored output channel and maintaining it there could require an excessive amount of control signal, and could require that the control signal be applied for an excessive amount of time.

Accordingly, this invention is directed to improvements in fluid amplifier dividers which provide: increased stability in a fluid amplifier; reliability of memory functions; an assist to the boundary layer lock-on phenomena; the reduction or elimination of counter flow through the unfavored output channel as well as the need therefor; momentum in a feedback flow which serves as a locking control signal; feedback signals which have vector properties, and feedback signals which operate in the manner of a servo feedback signal.

It is, therefore, an object of this invention to provide an improved divider in a fluid-operated device.

A further object of this invention is to provide a divider which contributes to the stability of a fluid amplifier.

A still further object of this invention is to provide a divider which enables reliability of memory functions in a fluid amplifier.

Another object of this invention is to provide a divider which contributes assistance to the boundary layer lock-on phenomena by means of feedback.

Still another object of this invention is to provide a divider in a bistable fluid-operated device which reduces the counterflow in the output channel not favored by the power stream.

A further object of this invention is to provide a divider which eliminates the need of counterflow in the output channel not favored by the power stream in a fluid amplifier so as to enable the use of the fluid amplifier in outer space or other low-pressure environments.

A still further object of this invention is to provide a divider in a fluid amplifier which provides a momentum in a feedback flow which serves as a control signal.

The FIG. shows one embodiment of this invention.

Briefly, the purposes of this invention are accomplished by the provision of a divider in a fluid amplifier which feeds back a part of the power stream in one receiver to reinforce the forces diverting the power stream into said one receiver. Feedback is against a blunt or curved end of the divider to provide a pressure seal over the entrance to the not favored output channel and also to reinforce the diverting forces on the power stream which direct it into the favored channel. A vortex is generated which further enhances the reinforcement and provides a dynamic characteristic.

The sole FIG. shows a bistable fluid amplifier. One common method of making the amplifier is a laminar construction. That is, the fluid channels are etched or machined in one block such as brass, then sealed with a flat plate, such as a plexiglass plate, as shown.

The bistable amplifier shown in FIG. 1 has power jet nozzle, opposed control nozzles, and a pair of output receiver channels 42 and 43. Separating the receivers 42 and 43 is a divider with a concave curved surface 41. All of the downstream material of the divider has been removed to present the surface 42 as the curved leading edge of the divider between output receivers 42 and 43. Between the curved surface 41 and the interaction chamber 47, there is no divider structure. The curved structure 41 is concave when viewed from the power nozzle. The interaction chamber 47 is bounded by the divider surface 41, a pair of divergent sidewalls which are the outer boundaries of output receivers 42 and 43 and the wall that defines the distance that the control nozzles are set back from the power nozzle. The power nozzle and the control nozzles are directed into the interaction chamber 47. As is conventional in the art, the control nozzles control which receiver channel wall the power jet latches on to.

In operation, the divider curved edge 41 forms a vortex and directs the feedback flow down along the unfavored receiver sidewall into the interaction chamber 47. The flow that is adjacent the divider 41 is directed in a path that approaches the receiver sidewall, and in the vicinity of the sidewall, turns to travel near the sidewall in a direction away from the interaction chamber 47 as shown by flow line 44. A majority of the feedback flow is directed into the interaction chamber 47 as shown by flow line 44. A majority of the feedback flow is directed into the interaction chamber where a vortex 45 is formed by curved flow of the feedback fluid to provide momentum to the power stream in receiver 42 to further lock the power stream therein. The remainder of the flow distributes through the remainder of the interaction chamber 47 in the circular paths indicated by the remaining arrows 46.

The flow line 44 indicates a pressure area which is a barrier sufficient to maintain power stream integrity even if the pressure available exterior to the fluid amplifier is very low. This permits the amplifier to operate in outer space. The vortex 45 and the lock-on assist vectors 46 would be maintained in the absence of a counterpressure down the unfavored receiver 43.

The fluid amplifier in this disclosure is the wall effect amplifier. The basic bistability comes about because the stream entrains away fluid and produces a low-pressure separation bubble on the wall. This is indicated in the drawing by the exposure of the short bottom end of the sidewall of the favored receiver to which the power stream is shown not attached. The entrainment and the bubble provide a low-pressure region which allows the higher pressure on the opposite side of the power stream to hold the stream against the favored sidewall. The effectiveness of the holding of the stream against the sidewall depends on the pressure differential on the two sides

of the stream. The feedback divider splits off part of the stream and directs it so as to increase the pushing pressure lock-on. In the embodiment shown, should the stream move away from the bistable position, more of the stream is split off and the pushing pressure is increased forcing the stream back into its bistable position. The action of this restoring pressure that is generated is similar to the action of a servoloop.

Fluid amplifiers of the type of which this invention is an improvement are more adequately disclosed in the copending application entitled Fluid Amplifier Employing Boundary Layer Effect, Ser. No. 58,188, filed Oct. 19, 1960 and now U.S. Pat. No. 3,396,619 revised Aug. 13, 1968, by Raymond W. Warren et al. Mr. Warren is one of the inventors of this application.

So, it is seen that we have provided an improved divider in a fluid amplifier. The divider improvements of this disclosure contribute to stability and enable reliability of memory functions in a fluid amplifier. The counterflow in the not-favored output channel is reduced or eliminated and operation in outer space is provided. The lock-on phenomenon is reinforced by the feedback flow and by the momentum of such flow. The feedback flow has vector properties. The counterflow around the pointed edge of the divider has been eliminated and the wandering of the power stream has been used to provide a pressure proportional to such wandering to reinforce the power stream in a stable position in the manner of a servoloop.

It will be apparent that the embodiment shown is only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

The divider 41 can be concave as shown, blunted as said above, squared off, or in any shape that will provide the flow pattern needed to reinforce the lock-on pressure differential and provide stability. An example of such a flow pattern is shown by arrows 46 and vortex 45. Dividers shaped like a flat open box, with the open end directed toward the power stream, will provide a flow pattern that is equivalent to that provided by a concave divider.

We claim:

1. In a fluid amplifier:

- a. a fluid power source for producing a fluid stream;
- b. A pair of divergent receiver means;
- c. means for directing said power stream toward said receiver means;

- d. divider means for separating said pair of receiver means;
- e. said divider means being a solid element having a pair of divergent sides which form the inner sides of said pair of receiver means; and having a third side connecting the closer ends of the divergent sides; and

- f. said third side providing a feedback flow to reinforce the continuance of power stream in one of said receiver means.

2. In a fluid amplifier:

- a. a fluid power source for producing a fluid stream;
- b. a pair of divergent receiver means;
- c. means for directing said power stream toward said receiver means;

- d. divider means for separating said pair of receiver means;
- e. said divider means being a solid element having a pair or receiver means, and having a third side connecting the closer ends of the divergent sides; and
- f. said third side being arcuate in shape.

3. In a fluid amplifier:

- a. a fluid power source for producing a fluid stream;
- b. a pair of divergent receiver means;
- c. means for directing said power stream toward said receiver means;
- d. divider means for separating said pair of receiver means;
- e. said divider means being a solid element having a pair of divergent sides which form the inner sides of said pair of receiver means, and having a third side connecting the closer ends of the divergent sides; and
- f. said third side being concave in shape with respect to said power source.

4. A fluid device comprising an inlet for supplying power fluid, a pair of outlets, a pair of control inlets for directing said power fluid to a selected outlet, and a vortex chamber all leading from a common mixing chamber, said vortex chamber being disposed intermediate said outlets and in alignment with said inlet to receive power fluid therefrom, said vortex chamber being dimensioned to create a vortex movement of fluid therein with a portion of said fluid being directed to said selected outlet to maintain said fluid at said selected outlet after the application of fluid from said control inlets has terminated, said control inlets being disposed at substantially right angles with respect to said inlet and said vortex chamber, said outlets being angularly disposed away from said inlet on opposite sides of said vortex chamber and between said vortex chamber and said control inlets.

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