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Bjornsen et al.

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[54] **COMMON SUPPLY FOR OPPOSING JET FLUIDIC DEVICE**

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[52] **U.S. Cl.** **137/81.5**

[51] **Int. Cl.** **F15c 1/20**

[58] **Field of Search** 137/81.5

[56] **References Cited**

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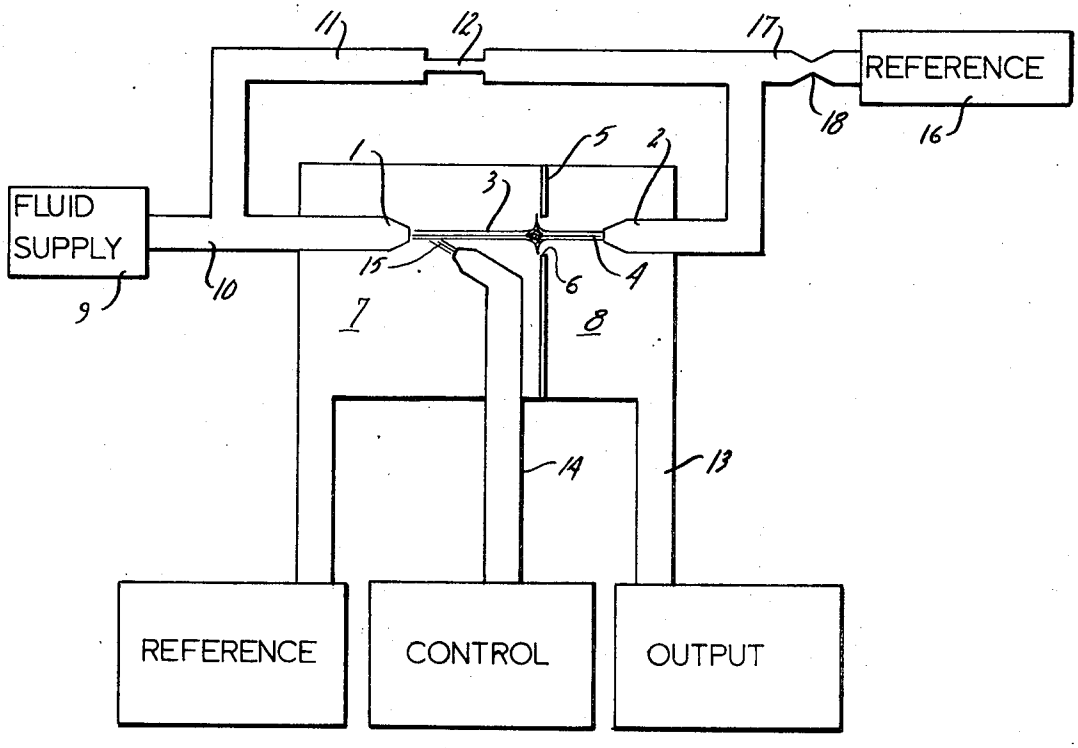
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[57] **ABSTRACT**

An impact modulator includes a pair of opposed nozzles having corresponding orifices establishing opposed impacting streams. An intermediate wall includes a control orifice aligned with the nozzles and located adjacent the impact position. The nozzles are connected to a fluid source with one nozzle connected through a pressure-dropping restrictor. A bleed conduit is connected to the downstream side of the restrictor and includes a bleed restrictor having an orifice which is preferably of a cross section equal to or greater than that of the nozzle orifice.

11 Claims, 2 Drawing Figures



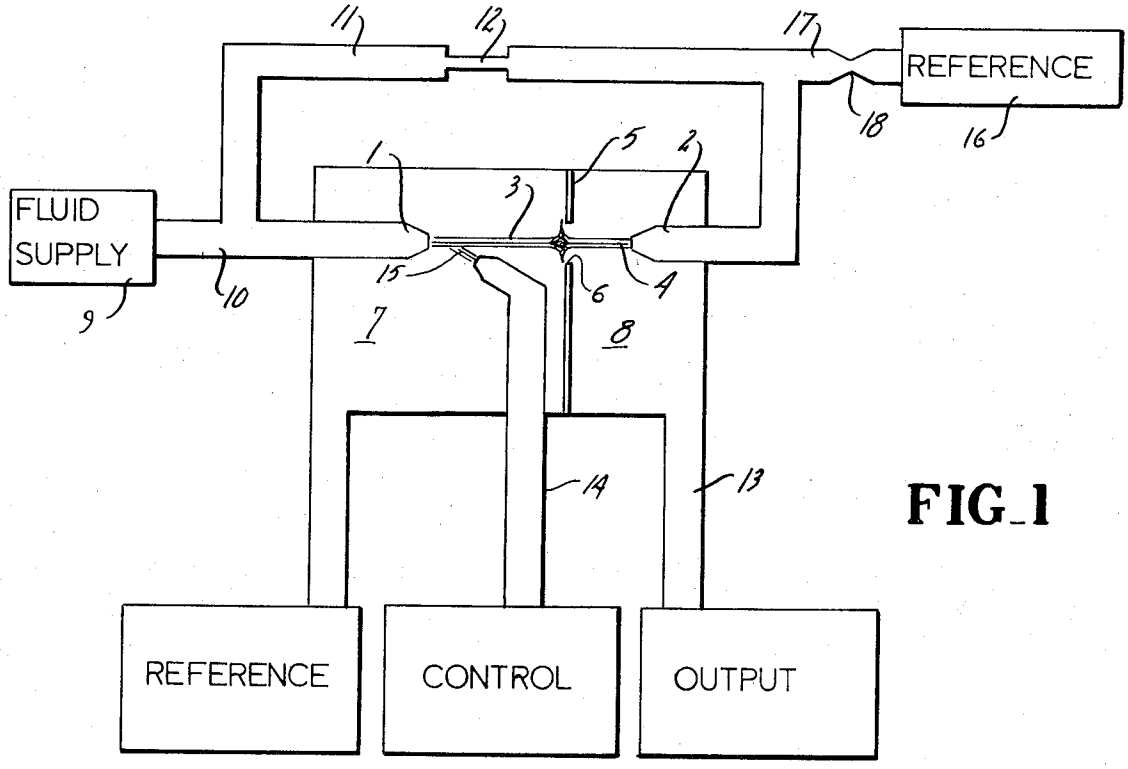


FIG_1

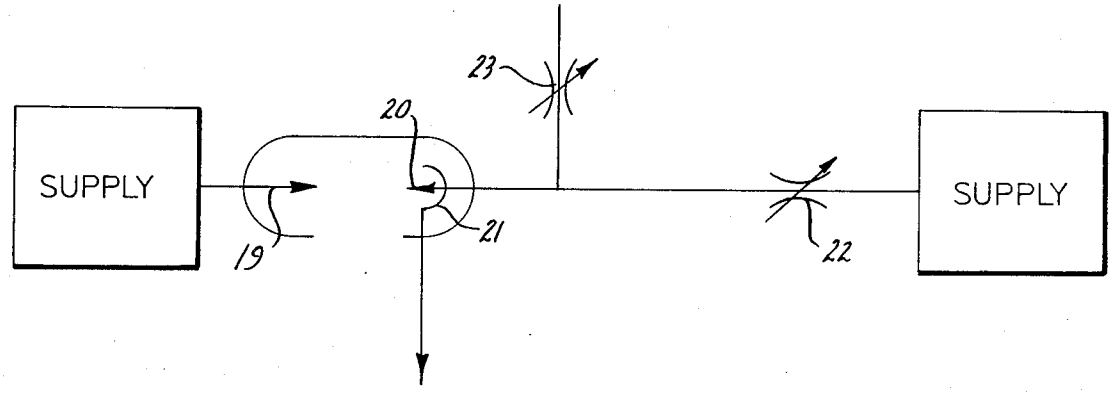


FIG_2

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COMMON SUPPLY FOR OPPOSING JET FLUIDIC DEVICE

BACKGROUND OF THE INVENTION

This invention relates to the main fluid supply for an opposing jet stream fluidic device in which a common supply is provided for establishing a pair of opposed impacting streams.

The interaction of pure fluid streams may provide functions heretofore generally obtained by electronic-type amplifying devices. Such devices have been developed and applied both in control and processing systems in recent years and are generally generically designated as "fluidic" devices. A particularly satisfactory fluidic device which permits fluidic circuit designs similar to those employed in electronic circuits is shown in U. S. Pat. No. 3,272,215 to Bjorn G. Bjornsen et al. That patent broadly discloses the basic concept of employing the impact position of a pair of opposing impacting free jets to establish and control a fluid output signal. As more fully disclosed therein, the position of impact of a pair of opposed jets is highly dependent on the relative strength of the two streams. The position is detected by providing a collector orifice adjacent to the impact position with the orifice forming a part of an output chamber to the one side of the impact position and a reference chamber to the opposite side. The pressure within the output chamber is dependent upon the position of impact relative to the orifice. Generally, the main stream through the reference chamber may be defined as the independent jet and the opposed impacting stream which passes through the output chamber may be defined as a dependent jet. As the strength of the independent jet increases, the impact position moves towards the collector orifice to increase the output pressure to the maximum. Conversely, as the independent jet stream strength is decreased, the impact position moves oppositely, reducing the output pressure. The dependent nozzle is generally maintained at a slightly lesser pressure than the independent nozzle such that the impact position of the two jets is essentially within the output chamber in the absence of an input pressure signal. The strength of the streams may be controlled directly or through an alternate control stream means. For example, one or more transverse jets may be provided engaging the independent stream to vary its position or alignment with the opposed dependent stream. Thus, as the strength of the input or control signal stream increases, the independent jet is weakened with respect to the opposing stream, thereby decreasing its relative strength and establishing a reduced output. An increasing input signal pressure results in a decreasing output pressure and provides a typical negative gain type amplification.

The impacting stream devices have been found to provide unusually satisfactory fluidic means as a proportional amplifier as shown in the above-identified U. S. Pat. No. 3,272,215 or, for example, as a summing unit as disclosed in U. S. Pat. No. 3,417,769 to Bjornsen et al. as well as many other practical applications.

Generally, the opposing supply nozzles are of a similar or equal size and are interconnected to a common supply. In order to provide a slight differential, the dependent nozzle is interconnected to the common supply through a fluidic resistance element. The resistance may be achieved by connecting of the dependent nozzle and the independent nozzle to a supply with a junction which establishes a greater pressure drop to the dependent nozzle than to the independent nozzle. Alternately, a restrictor, such as an orifice or a capillary tube, may be connected in the manifold passageway from the supply line to the dependent nozzle. Either results in a satisfactory reduction in the relative pressures.

However, applicant has realized that the insertion of a resistance in the manifold configuration creates an inherent negative feedback within the amplifier which, in turn, reduces its gain in accordance with the usual negative feedback phenomena. Thus, a maximum input signal effectively weakens the independent jet sufficiently with respect to the dependent jet, causing the impact position to move away from the collector orifice. The output pressure will then be minimal and even slightly below the reference pressure. As a result, maximum flow through the dependent nozzle is established as a result of the relatively low downstream pressure. As the independent stream's strength is gradually increased, for example, by removal of the transverse input signal, the output pressure increases with a corresponding increase in the downstream pressure presented to the dependent nozzle. This results in a decreasing flow through the dependent nozzle. Generally, the pressure drop in the restrictor varies directly with the changes in the flow. The decreased flow through the manifold therefore results in a smaller pressure drop across the restrictor and/or the interconnection of the manifold to the main supply. This yields a relative increased pressure to the dependent supply nozzle and a reduction in the amplifier gain.

SUMMARY OF THE INVENTION

The present invention is particularly directed to a means to eliminate the dependent supply pressure variations and the diminishing in the gain of the amplifier with flow such as results from the manifold-type connection to a common supply source. Generally, in accordance with the present invention, a pair of stream-forming means such as suitable supply nozzles are coupled to a fluid supply means with a pressure dropping restriction means in one connection to define a dependent stream source. An alternative flow source is connected to the manifold or supply connection between the restriction means and the nozzle to establish and provide a relatively large portion of the flow to the corresponding stream-forming means and thereby maintain an essentially more constant flow and related pressure drop through the pressure-dropping restriction means. This will, therefore, substantially minimize the variation in the supply pressure to the dependent stream-forming means as the result of the load changes. This, in turn, will minimize the negative feedback characteristic and the undesirable diminution in the gain of the amplifier.

In accordance with a particularly novel aspect of the present invention, the manifold conduit is connected to a main supply conduit through a pressure control or setting means such as the usual pressure-dropping junction and/or a separate manifold restrictor means. A bleed passageway which includes a bleed restrictor means is connected between the pressure-dropping

restrictor means and the dependent supply nozzle. The bleed passageway is connected to atmosphere, other suitable reference pressure or the like. By proper selection of the bleed restrictor means, a very substantial portion of the flow through the pressure-dropping means is divided between the dependent nozzle and the bleed restrictor means. Generally, to provide significant, practical decreased negative feedback characteristics, applicant has found that the bleed restrictor should preferably be selected to be at least equal in size to the orifice of the dependent supply nozzle. However, some improvement in gain characteristics is obtained with smaller bleed restrictors.

The concept can advantageously be applied to the various forms of the impact modulating devices. For example, it can be readily applied directly to the transverse impact modulator, or to the summing impact modulator concept as described in U. S. Pat. No. 3,417,769 where a variable restrictor is interconnected to the one input to control the set point. Set point adjustment can further be provided in the set point modulator design by employing a variable bleed restrictor and a fixed supply restrictor. In the various constructions, however, the bleed orifice means should preferably be relatively large compared to the dependent nozzle orifice to establish optimum results and generally should at least be equal in size to the latter orifice.

BRIEF DESCRIPTION OF DRAWING

The drawing furnished herewith illustrates a preferred construction of the present invention presently contemplated by the inventor in which the above advantages and features are clearly disclosed, as well as others which will be readily understood from the following description of the drawing.

In the drawing:

FIG. 1 is a diagrammatic illustration of a transverse impact modulator constructed in accordance with the present invention;

FIG. 2 is a schematic illustration of a set point impact modulator employing the teaching of the present invention.

DESCRIPTION OF ILLUSTRATED EMBODIMENT

Referring to the drawing and particularly to FIG. 1, a pair of opposed aligned nozzles 1 and 2 are mounted in a suitable opposed and aligned relationship to establish a pair of opposing impacting free streams 3 and 4. An intermediately-located wall 5 is provided with a concentric collector orifice 6 defining a reference chamber 7 to one side of the wall 5 and an output chamber 8 to the opposite side of the wall 5.

The opposed nozzles 1 and 2 are connected to a common fluid source 9 which may be air, liquid, mixtures thereof and the like. The independent nozzle 1 is connected directly to the source 9 through a suitable conduit line 10. The dependent nozzle 2 is connected to the line 10 and thereby to the source 9 through a manifold conduit 11. In the illustrated embodiment of the invention, the interconnecting manifold conduit 11 is provided with a restrictor 12. The supply pressure of source 9 and the restrictor 12 are selected such that the impacting streams 3 and 4 have an impact location within reference chamber 7 very close to the collector orifices in the absence of any specific modification of the strength of the two impacting streams. This substantially blocks flow from nozzle 2 to chamber 7 establishing a maximum output pressure in the output chamber 8 and at the interrelated connecting point or outlet terminal 13.

In the embodiment of FIG. 1, a transverse control signal nozzle 14 is located to provide a control stream 15 engaging independent stream 3 weakening it. This reduces the strength of independent stream 3 relative to dependent stream 4, causing the impact position to move proportionately away from collector orifice 6. This results in a corresponding reduction in the output pressure in chamber 8 to a minimal value and even slightly below the reference pressure as a result of aspiration and the like.

The description, as above, will be recognized as that corresponding to the conventional description now applied to an impact modulator. Applicant, however, realized that the variation in the pressure relationship inserted into the manifold passageway 11 as a result of the restriction established an effective negative feedback characteristic which was directly related to and resulted from the variation in the flow through the manifold which, in turn, was related to the change in the downstream pressure presented to the dependent nozzle 2. In accordance with the present invention, an auxiliary flow path 16 is provided and coupled to the manifold conduit 11 to the downstream side of the restrictor 12. In the illustrated embodiment of the invention of FIG. 1, a conduit 17 is connected to the manifold conduit 11. The conduit 17 is connected to reference pressure and includes a bleed restrictor 18. The bleed restrictor 18 is shown as a small orifice having a diameter essentially corresponding to the diameter of the orifice of the dependent nozzle 2. If the main source 10 is air, the conduit 17 may be terminated to the atmosphere.

The device will function essentially as previously described for the impacting stream devices of the prior art. However, with the teaching of the present invention, a substantial and significant portion of the total flow to the dependent nozzle 2 is directed to atmosphere or the reference pressure through path 16 and the bleed restrictor 18. When the control signal stream 15 weakens the stream 3 in proportion to the control stream strength and correspondingly decreases the downstream pressure presented to the dependent nozzle 2 at the output chamber 8, the flow through nozzle 2, therefore, increases. The increased flow is, however, a relatively small part of the total flow drawn from the main pressurized source 9 as a result of the continued flow through the path 16 and the percentage increase in flow through the pressure-dropping restrictor 12 is, therefore, minimized with a resulting minimized change in the pressure drop across restrictor 12. Similarly, a decrease in the strength of the control stream 15 causes an increase in the strength of stream 3 and decrease in flow through nozzle 2 and restrictor 12. The decreased flow appears in restrictor 12 but is again only a relatively insignificant change because of the substantial total flow to the two paths, and a corresponding minimal decreased pressure drop in restrictor 12 results. As a result, the variation in the pressure drop across restrictor 12 with changes in stream 15 is

minimized and a more nearly constant dependent nozzle supply pressure is established with a resulting constant amplifier gain characteristic.

As previously noted, applicant has found that to obtain a significant and practical decrease in negative feedback, the bleed restrictor **18** should be a suitable orifice or the like having a passageway cross section preferably at least equal to or larger than the orifice of the dependent supply nozzle **2**.

The invention can be applied to other opposing stream controls. For example, a set point modulator based on the impacting concept as disclosed in U. S. Pat. No. 3,417,769 is shown in FIG. **2**. The impacting modulator is schematically shown in FIG. **2** with a pair of opposed nozzles **19** and **20** connected to a suitable supply which may be a common or separate supply of a constant pressure. A collector **21** is provided adjacent the dependent nozzle **20**. A variable set point restrictor **22** such as an adjustable orifice connects the dependent nozzle **20** to the related supply to reduce the pressure to a desired set pressure to the dependent input nozzle of the summing impact modulator. The supply restrictor **22**, as previously described, would, to a large extent, reduce the gain of the summing impact modulator because of the substantial change in flow through the dependent nozzle **20** over the normal operating range. In accordance with the present invention, the flow through the nozzle **20** is only a portion of the flow which is drawn through supply restrictor **22** with a significant part directed through a bleed restrictor or orifice **23** connected to a reference pressure and to the dependent nozzle **20** downstream of the set point control restrictor **22**. As in the previous embodiment, significant results are particularly obtained when the bleed passageway is large compared to the dependent nozzle orifice.

In the second illustrated embodiment, the set point adjustment can, within limited ranges, be achieved by employing a fixed dropping restrictor connected to the main supply and a variable bleed restrictor **22** connected to the reference pressure. However, it is important to maintain a relatively large bleed passageway relative to the main supply orifice at all times.

Although shown in a three-dimensional construction, two-dimensional fluidic devices may be similarly constructed.

The present invention thus provides a simple, reliable and inexpensive means for further improving the gain characteristic of a summing impact modulating device or the like.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

We claim:

1. A fluidic apparatus having a pair of opposing and impacting streams, comprising a pair of main stream-forming means for establishing the impacting streams, first and second fluid supply passageway means for connecting said stream-forming means to a corresponding fluid supply means, said first supply passageway means including a flow restriction means to reduce the pressure to the corresponding first stream-forming means with respect to the pressure to the second stream-forming means and thereby establish a selected impact position, said flow-restriction means having a variable pressure drop with flow, means to vary the relative strength of said impacting streams, and an auxiliary fluid flow path coupled to said first passageway means between said restriction means and the corresponding stream-forming means connected to said first passageway means and whereby a change in the flow to the corresponding stream-forming means connected to said first passageway means establishes a relatively small percentage change in the flow through said flow restriction means and maintains the supply pressure of the stream from said first stream-forming means essentially constant.

2. The fluidic apparatus of claim **1** wherein said supply passageway means are connected to a common constant pressure air source, said auxiliary fluid flow path including a bleed passageway means coupled to the atmosphere and a bleed restriction means in said bleed passageway means, said bleed passageway restriction means having a cross sectional flow area at least as great as the cross sectional flow area of the stream-forming means.

3. The fluidic apparatus of claim **1** wherein said supply passageway means are connected to a common constant pressure fluid supply.

4. The fluidic apparatus of claim **1** having a collector orifice located adjacent the impact position of the impacting streams, said pair of stream-forming means including opposed nozzles having corresponding orifices, said fluid supply passageway means connecting said nozzles to a common fluid supply means, a collector orifice located adjacent the impact position of the impacting streams and defining an output chamber adjacent said first one of said pair of first stream-forming means and a reference chamber adjacent the other of said stream-forming means, and said auxiliary fluid flow path including a bleed passageway means coupled to a reference pressure fluid supply and including a restriction in the bleed passageway means having a cross section at least equal to the nozzle orifices.

5. The fluidic apparatus of claim **1** wherein said means to vary the strength of the impacting streams includes a transverse stream-forming means establishing a control stream engaging one of said impacting streams, said supply passageway means being connected to a common constant pressure air source, said auxiliary fluid flow path including a bleed passageway means coupled to the atmosphere and a bleed restriction means in said bleed passageway means.

6. The fluidic apparatus of claim **1** wherein said auxiliary fluid flow path includes a bleed passageway means coupled to a reference fluid supply and a bleed restriction means in said bleed passageway means.

7. The fluidic apparatus of claim **6** wherein said bleed passageway restriction means has a cross sectional flow area at least as great as the cross sectional flow area of the corresponding stream-forming means.

8. The fluidic apparatus of claim **1** wherein said stream-forming means are similar nozzles having corresponding orifices and said supply passageway means are conduits connected to a common constant pressure air source, said auxiliary fluid flow path including a bleed conduit coupled to the atmosphere.

9. The fluidic apparatus of claim **8** having a collector orifice means located in alignment with and adjacent

the impact position of the impacting streams and defining an output chamber adjacent a first one of said pair of stream-forming means and a reference chamber adjacent the other of said stream-forming means.

10. The fluidic apparatus of claim 1 wherein said second stream-forming means is connected to a second fluid supply defining a variable signal source and said first stream-forming means is connected to a first fluid supply, said first fluid supply connection including said passageway means having said flow restriction means to control the set point pressure.

11. The fluidic apparatus of claim 10 said auxiliary fluid flow path includes a bleed passageway means connected to said first fluid supply passageway means between said restriction means and the corresponding stream-forming means, and said bleed passageway means includes a second restriction means, at least one of said restriction means being variable to adjust the set point pressure.

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