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(54) Title: DIRECTED MULTIPORT EDUCTOR AND METHOD OF USE

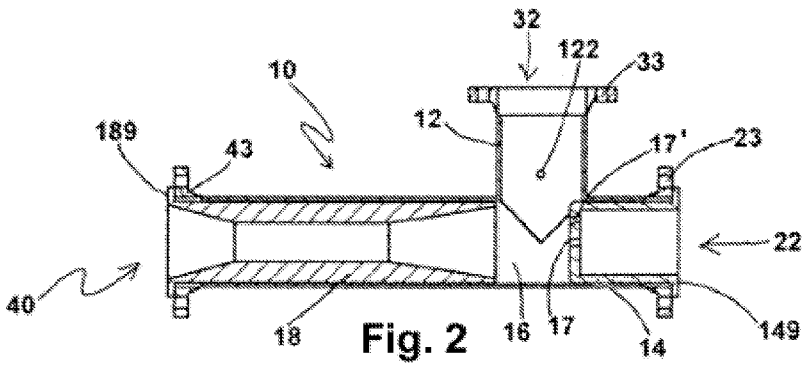


Fig. 2

(57) Abstract: A directed multiport jetting nozzle in an eductor having a focal point of the motive fluid inside the throat of a venturi-diffuser body of the present eductor provides an efficient pump and mixer providing substantial surface contact area between the motive flow and the bulk material for movement through the outlet of the eductor. The result of this design provides a homogeneous mixture of the motive fluid and the bulk material which may be hydrating or wetting, or the creation of a slurry.

# DIRECTED MULTIPORT EDUCTOR AND METHOD OF USE

## BACKGROUND OF INVENTION

The present invention relates to a fluidic jetting device; specifically, to a multiport nozzle directing a motive flow into the throat of a venturi-diffuser permitting homogeneous mixing, shearing or wetting of a bulk fluidic material with the motive flow to an outlet of the diffuser.

Eductor arrangements have long been used to provide pumping, mixing, blending, hydrating and shearing in a wide variety of industries, including chemical, petrochemical, pulp and paper, food, water and waste water treatment facilities. These types of eductors can be used for lifting, pumping, mixing or agitating liquids or other flowable materials such as powders or slurries. Eductors use a venturi design which permits small eductors to move large volumes of fluids or fluidic materials. Because the motive flow provides the kinetic energy necessary to entrain and move another fluid after thoroughly mixing the two, the mixture and discharge of the combined material is accomplished with lowered motive energy usage than if the volume was pumped with a conventional centrifugal pump.

The low pressure section or mixing chamber of the eductor pulls the flowable bulk material into the venturi neck of the eductor and out the diffuser or belled end of the eductor. Most prior art eductor bodies provided a single nozzle extending into the neck of the venturi, thereby

hindering mixing in the vacuum or mixing chamber of the eductor body. The present invention separates the multiple directed nozzle ports from the venturi neck thereby opening the mixing chamber to the rapid and unimpeded bulk material flow which is thereafter carried into the neck of the venturi. Eductor systems have long been recognized to provide lower capital costs because of their simplicity of design and limited size, require less energy to drive the pump providing motive force, provide less heating of the transported material, provide less settling because of the volume of circulation or movement provided, and provide better control when the bulk material and inlet side are properly sealed to outside air. These advantages are improved with this new directed multiport nozzle design when combined with the characteristics of the venturi-diffuser of the present invention.

**SUMMARY OF INVENTION**

A present embodiment of the invention disclosed herein provides an eductor having a cylindrical body having a longitudinal bore therethrough and a perpendicular extension having a bore therethrough forming a low pressure vestibular mixing chamber portion of the eductor; a multiport nozzle inserted in a first end of the cylindrical body terminating on an inlet side of the vestibular portion of the mixing chamber; a venturi-diffuser inserted in a second end of the cylindrical body having an inlet lip adjacent

an output side of the vestibular mixing chamber; and, said multiport nozzle providing a plurality of ports directing a hydraulic flow from an inlet of the cylindrical body toward an inlet lip of the diffuser having a venturi throat narrowing to provide turbulent flow, enlarging at an outlet of the diffuser.

This form of eductor features a multiport nozzle which provides three or more directed ports. Another embodiment of the invention provides a multiport nozzle having at least five directed ports. The multiport nozzle provides an angled ejection converging on a point within the venturi-diffuser. The cylindrical body also features a flange on the inlet side and the outlet side and a flange on the perpendicular section to provide an absolute seal from exterior air pressure on the eductor body when assembled. The shape of the venturi-diffuser permits about 70% recovery of the inlet pressure on the outlet of the eductor body. Both the nozzle body and the venturi-diffuser are fabricated from polyoxymethylene, also known as acetal plastic.

This application also discloses a method of fluidic mixing providing the steps of supplying a fluidic bulk material to an inlet of an eductor on a perpendicular portion of the eductor body which is typically operates at a vacuum; and, supplying a fluidic motive flow through an inlet of the eductor to a multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and into a centralized portion of a throat

of a venturi-diffuser for movement down the venturi-diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow. This method of fluidic mixing permits a variety of fluidic bulk materials with varying physical characteristics to be mixed by supplying a first fluidic bulk material to an inlet of an eductor; and, supplying a fluidic motive flow through an inlet of the eductor to a multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and into a centralized portion of a throat of a venturi-diffuser for movement down the venturi-diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow until the first fluidic bulk material has been completely mixed; then adding a second fluidic bulk material to an inlet of an eductor; and, varying a rate of passage of the fluidic bulk material to the vestibular section of the eductor for mixing. These methods can also be accomplished by utilizing the additional step of varying the fluidic motive flow to the multiported nozzle to correspond to the physical characteristics of the second fluidic bulk material.

**BRIEF DESCRIPTION OF DRAWINGS**

Fig. 1 is a perspective three-dimensional drawing of the eductor body embodiment of the present invention.

Fig. 2 is a side cross-sectional view of the eductor of the present application showing the spaced relationship between the nozzle body inserted into the

eductor from the venturi-diffuser body inserted the opposing end of the eductor body.

Fig. 3 is an end view of the mulitport directed nozzle of the present application of the cross-sectional body of Fig. 2.

Fig. 2B is a outlet face view of the nozzle of Fig. 2A.

Fig. 4 is a top plan view of the eductor body assembly showing the relative spaced relationship of the multiport directed nozzle body and the venturi-diffuser of the present application.

Fig. 5 is a side plan view of the eductor body assembly showing the relative spaced relationship of the multiport directed nozzle body and the venturi-diffuser of the present application.

Fig. 6 is a cross-sectional view of a smaller nozzle embodiment of the present invention providing three outlet ports.

Fig. 7 is an outlet face view of the smaller nozzle embodiment of the nozzle of Fig. 6.

Fig. 8 is a cross-sectional view of a larger embodiment of the directed nozzle of the present invention providing six outlet ports.

Fig. 9 is an outlet face view of the larger embodiment of the nozzle of Fig. 8.

Fig. 10 is a cross-sectional side view of a larger embodiment of the venturi-diffuser.

Fig. 11 is an inlet face view of the venturi-diffuser of the Fig. 10.

Fig. 12 is a cross-sectional side view of smaller embodiment of the venturi-diffuser.

Fig. 13 is an inlet face view of the venturi-diffuser of Fig. 12.

## DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The present invention relates to a directed multiport jetting eductor device **10** as more specifically shown in Fig. 1A and 1B, for mixing, blending, hydrating or shearing a fluidic or flowable material such as a powder or slurry in a high velocity motive flow **22** which imparts extreme shearing forces on any material being drawn from a source **32** through a perpendicular extension **12** to the eductor **10** into a vestibular portion **16** of the device **10** thereby eliminating fisheyes, microgels and clumps normally found in many mixing devices. Fig. 1A is a top view and Fig. 1B is a cross-sectional side view. The slurry output from this mixing/shearing process is then carried through a venturi-diffuser body **18** to the outlet **40** completing the process. The eductor body **10** of the present embodiment is fabricated from 304 stainless steel and provides a flange **23**, **33**, and **43** on each end of the eductor body **10**. Other compatible materials could be used to fabricate the eductor body without departing from the invention disclosed herein. Stainless steel was chosen as an economical corrosion resistant material, but other nickel alloys for more corrosive environments

could readily be substituted. Both the multiport nozzle **14** and the venturi-diffuser body **18** provide a flange permitting each to be securely fastened between the body flanges **23** and **43** and the piping from the pump for the motive flow and the outlet pipe (both of which are partially shown in this view.) A flange **33** on extension **12** permits the sealed hermetic connection of a flowable bulk material source that can be drawn into the vestibular portion **16** of the eductor body **10** for mixing. The flanges on each opening of the eductor body **10** used in conjunction with the sealing flanges on the nozzle and diffuser bodies which are crimped between the input and outlet lines of the body permit the highly efficient mixing of motive force fluid with the bulk material without adjustment for outside air allowing proper measuring of flow rates and output to maximize the efficiency of the process. Since there is no leakage in the system, the volume of motive flow and the mass of the bulk flowable material being mixed, sheared or wetted, can be carefully controlled in a dynamic manner through either manual or electronic adjustment of pump speed or pressure and by opening and closing the valve (not shown) on the flowable bulk material delivery input extension. These control mechanisms can be automated with standard programmable logic devices (PLDs) or by standardized digitial technology now found in this art field.

The motive flow **22** is provided by a fluid pump (not shown, but well

known to those having ordinary skill in this art) which may be water or air or other liquid which is pumped into the inlet of the eductor body **10** and through a multiport nozzle **14** made from polyoxymethylene (commonly referred to as POM and also known as polyacetal or polyformaldehyde or acetal plastic). POM is an engineering machinable thermoplastic used in precision parts that require high stiffness, low friction and excellent dimensional stability. It is commonly known under DuPont's trade name Delrin. The venturi-diffuser body is also made of POM which resists wear from the slurry mixtures pushed through the diffuser throat. Again, alternative materials for these elements can be readily substituted without departing from the spirit or scope of this disclosure. As may be readily seen in Fig. 2A the nozzle provides outlet ports directed at an acute angle α to the perpendicular face **17** of the nozzle body **14**. In the cross-sectional view of Fig. 2A port **17'** is formed with the angle α specifically to converge with the other ports output at a point in the throat of the venturi-diffuser **18** as shown in Fig. 1B. As can also be seen, body **14** provides a flange **15** larger than the inner diameter of the eductor body **10** which is compressed between the flange **23** and the connecting flange of the inlet piping **20** to seal the joint. In this embodiment, as shown in Fig. 2B, three ports (**17'**, **17''** and **17'''**) are provided in face **17**, each directed at an angle to converge at a point **18'** inside the throat of the venturi-diffuser **18**. shown in Fig. 1B.

The venturi-diffuser body **18** is shown in cross-section in Fig. 3A. Made from POM, this body **18** provides a lip **18'''**, throat **18''** and widened diffuser end **21** for directing the turbulent motive flow **22** as shown in Fig. 1B to the outlet **40** of Fig. 1B. The outlet from plurality of jetting nozzles (irrespective of the number of ports provided in the nozzle body such as shown in Fig. 2B) converge at a point **18'** central in the throat **18''** of the venturi-diffuser **18**. Fig. 3B is an inlet face view of the venturi-diffuser of Fig. 3A. Body **18** provides a throat **18''** and lip **18'''** into which the motive flow and bulk material mixture is directed.

Similarly, Fig. 4A and 4B disclose two alternative jetting nozzles providing four outlet ports and six outlet ports respectively. Typically, the smaller inner diameter eductor body will be limited by the number of outlet ports so Figs. 4A and 4B can be a four inch ID design and Figs. 5A and 5B can be a six inch ID design. In Fig. 4A, flange **15** is intended to seat against the flange **23** on the eductor body **10** of Fig. 1B. This jetting nozzle is inserted in the inlet ID of the body **10** and is provided with beveled edge **13** around the nozzle face **170**. The peripheral ports **171**, **171'** and **171''** are each angled at an angle α around a central port **172** which is not angled but follows the central axis of the nozzle body. The angle is chosen to permit the outlets to converge at a point inside the throat of the venturi-diffuser.

Similarly, a larger diameter jetting nozzle is shown in Fig. 5A and 5B. This nozzle body provides a flange **105** and leading beveled edge **110** and is ported with six ports **181-186** on face **180**. As might be understood, the angle of the peripheral ports **181-185** are made at an angle β converging on a point inside the throat of the venturi-diffuser body. Like the central port of Fig. 4A, the central port is not angled but is concentric with the central longitudinal axis of the nozzle body.

Finally, the larger bodied venturi-diffuser **200** is used in large ID eductor body providing an enlarged throat **206** inside a leading edge lip **202**. The venturi throat **214** then flares into diffuser portion **210** returning the flow to about 70% of the inlet pressure. Again, this venturi-diffuser body **200** provides a flange **212** that is intended to secure the body **200** inside the eductor body and hermetically seal the venturi-diffuser outlet path to the outlet side of the eductor. The focal point of the jetted nozzle flows is directed to a point **204** just inside the leading edge lip **202** of the nozzle in a manner similar to that found and described in the smaller diameter venturi-diffuser body of Figs. 3A and 3B.

This invention has been shown and described with respect to several preferred embodiments, but will be understood by one having ordinary skill in the art to which this invention pertains that various changes in the form and detail from the specific embodiments shown can be made without

departing from the spirit and scope of the claimed invention.

## CLAIMS

1. An eductor comprising:

a cylindrical body having a longitudinal bore therethrough and a perpendicular extension having a bore therethrough forming a low pressure vestibular mixing chamber portion of the eductor;

a multiport nozzle inserted in a first end of the cylindrical body terminating on an inlet side of the vestibular portion of the mixing chamber;

a venturi-diffuser inserted in a second end of the cylindrical body having an inlet lip adjacent an output side of the vestibular mixing chamber; and,

said multiport nozzle providing a plurality of ports directing a hydraulic flow from an inlet of the cylindrical body toward an inlet lip of the diffuser having a venturi throat narrowing to provide turbulent flow, enlarging at an outlet of the diffuser.

2. The eductor of claim 1 wherein the multiport nozzle provides three or more directed ports.

3. The eductor of claim 1 wherein the multiport nozzle provides at least five directed ports.

4. The eductor of claim 1 wherein the multiport nozzle provides an angled

ejection converging on a point within the venturi-diffuser.

5. The eductor of claim 1 wherein the cylindrical body provides a flange on the inlet side and the outlet side and a flange on the perpendicular section to provide an absolute seal from exterior air pressure on the eductor body when assembled.

6. The eductor of claim 1 wherein the diffuser provides about 70% recovery of the inlet pressure.

7. The eductor of claim 1 wherein the diffuser is fabricated from polyoxymethylene.

8. A method of fluidic mixing comprising:

supplying a fluidic bulk material to an inlet of an eductor; and,

supplying a fluidic motive flow through an inlet of the eductor to a multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and into a centralized portion of a throat of a venturi-diffuser for movement down the venturi diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow.

9. A method of fluidic mixing of a variety of fluidic bulk materials with varying physical characteristics comprising:

supplying a first fluidic bulk material to an inlet of an eductor; and,

supplying a fluidic motive flow through an inlet of the eductor to a

multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and into a centralized portion of a throat of a venturi-diffuser for movement down the venturi-diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow until the first fluidic bulk material has been completely mixed;

adding a second fluidic bulk material to an inlet of an eductor; and,

varying a rate of passage of the fluidic bulk material to the vestibular section of the eductor for mixing.

10. The method of claim 9 comprising the additional step of varying the fluidic motive flow to the multiported nozzle to correspond to the physical characteristics of the second fluidic bulk material.

AMENDED CLAIMS
received by the International Bureau on2 September 2011 (02.09.2011)

1. An eductor comprising:

a cylindrical body having a longitudinal bore therethrough and a perpendicular extension having a bore therethrough forming a low pressure vestibular mixing chamber portion of the eductor;

a multiport nozzle inserted in a first end of the cylindrical body terminating on an inlet side of the vestibular portion of the mixing chamber;

a venturi-diffuser inserted in a second end of the cylindrical body having an inlet lip adjacent an output side of the vestibular mixing chamber; and,

said multiport nozzle providing a plurality of ports directing a hydraulic flow from an inlet of the cylindrical body toward an inlet lip of the diffuser having a venturi throat narrowing to provide turbulent flow, and enlarging at an outlet of the diffuser wherein the hydraulic flow from the multiport nozzle converges in an interior portion of the venturi throat.

2. The eductor of claim 1 wherein the multiport nozzle provides three or more directed ports converging on an interior portion of the inlet to the diffuser.

3. The eductor of claim 1 wherein the multiport nozzle provides at least five directed ports converging on an interior portion of the inlet to the diffuser.

4. The eductor of claim 1 wherein the multiport nozzle provides an angled

ejection converging on a point within the venturi-diffuser.

5. The eductor of claim 1 wherein the cylindrical body provides a flange on the inlet side and the outlet side and a flange on the perpendicular section to provide an absolute seal from exterior air pressure on the eductor body when assembled.

6. The eductor of claim 1 wherein the diffuser provides about 70% recovery of the inlet pressure.

7. The eductor of claim 1 wherein the diffuser is fabricated from polyoxymethylene.

8. A method of fluidic mixing comprising:

supplying a fluidic bulk material to an inlet of an eductor; and,

supplying a fluidic motive flow through an inlet of the eductor to a multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and into a centralized portion of a throat of a venturi-diffuser for movement down the venturi diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow.

9. A method of fluidic mixing of a variety of fluidic bulk materials with varying physical characteristics comprising:

supplying a first fluidic bulk material to an inlet of an eductor; and,

supplying a fluidic motive flow through an inlet of the eductor to a

multiported nozzle directing the hydraulic flow across a vestibular section of the eductor and converging in a centralized portion of a throat of a venturi-diffuser for movement down the venturi-diffuser to homogeneously mix the fluidic bulk material with the hydraulic flow until the first fluidic bulk material has been completely mixed;

adding a second fluidic bulk material to an inlet of an eductor; and,

varying a rate of passage of the fluidic bulk material to the vestibular section of the eductor for mixing.

10. The method of claim 9 comprising the additional step of varying the fluidic motive flow to the multiported nozzle to correspond to the physical characteristics of the second fluidic bulk material.

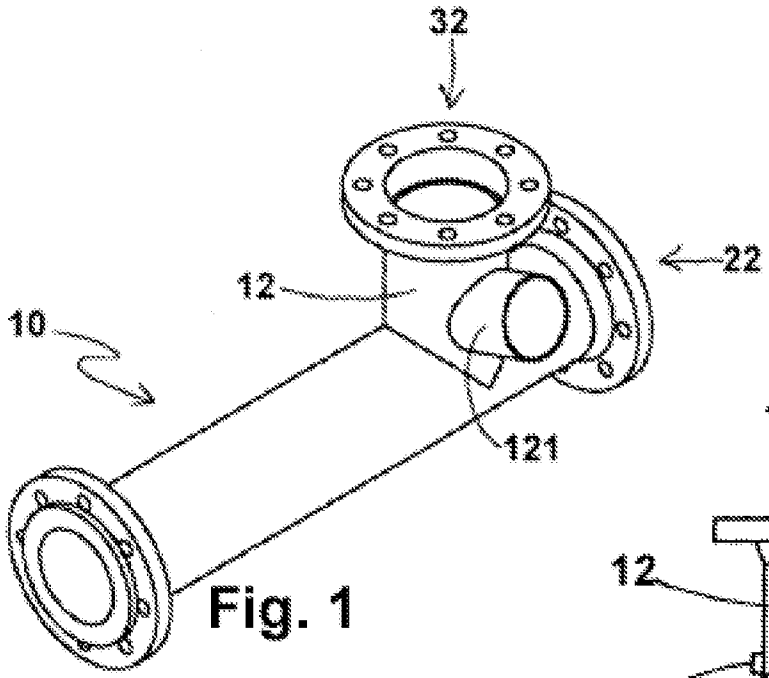


Fig. 1

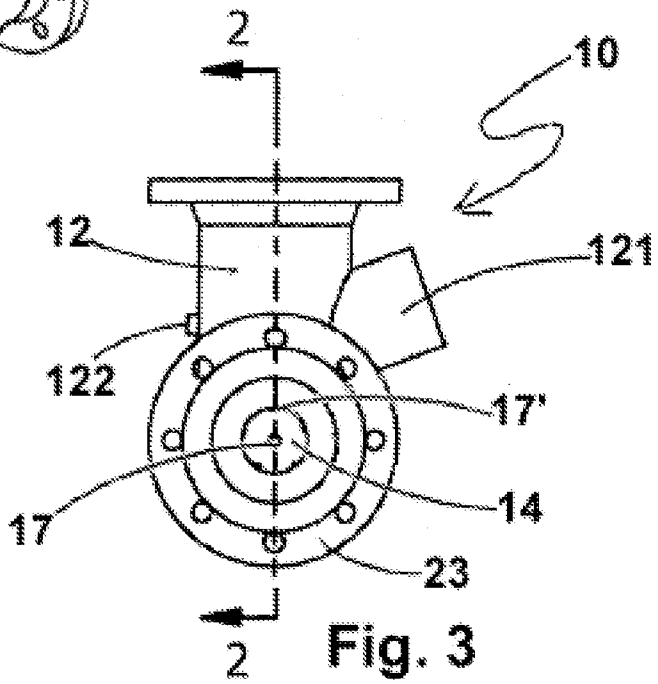


Fig. 3

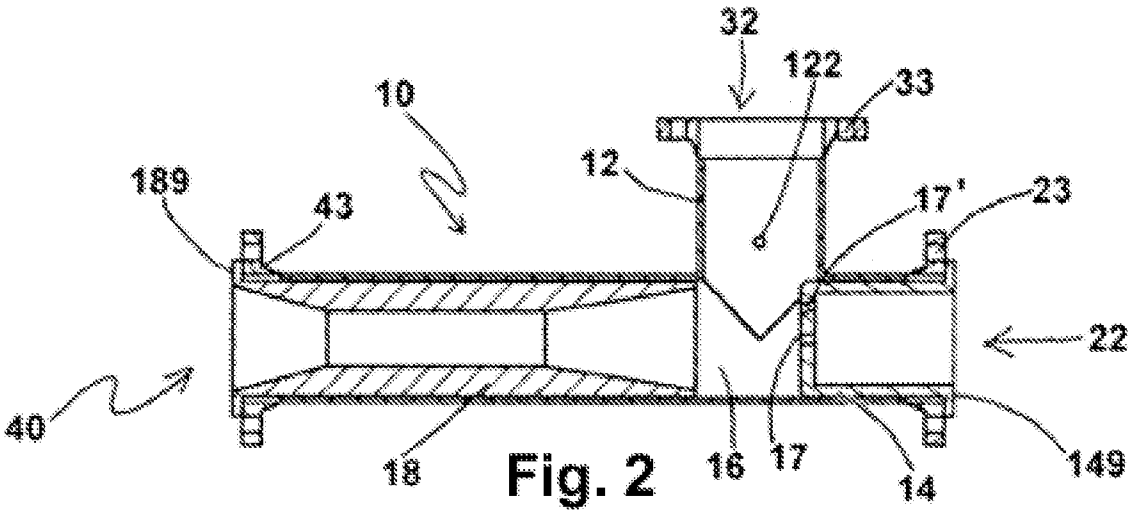


Fig. 2

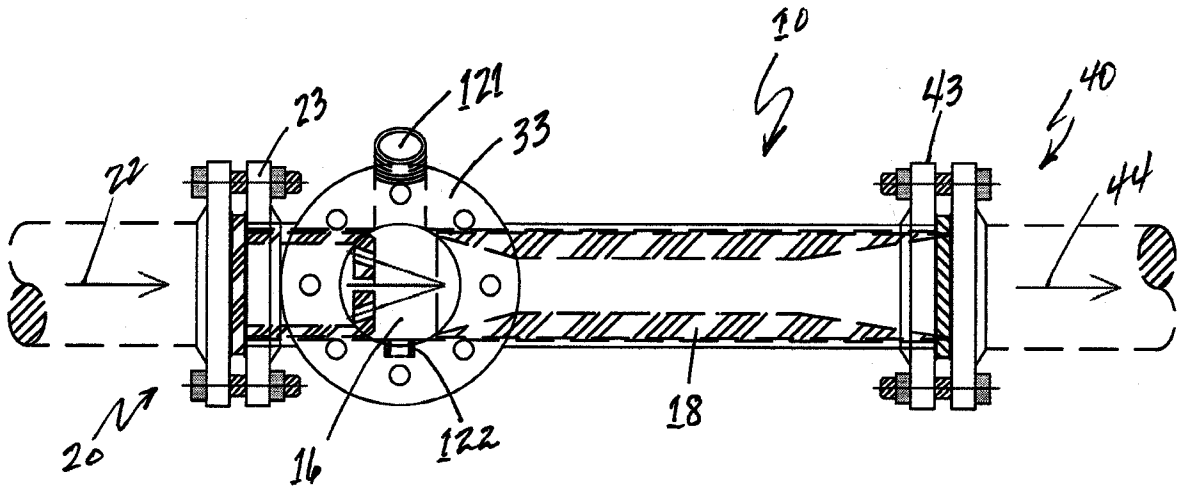
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FIG. 4

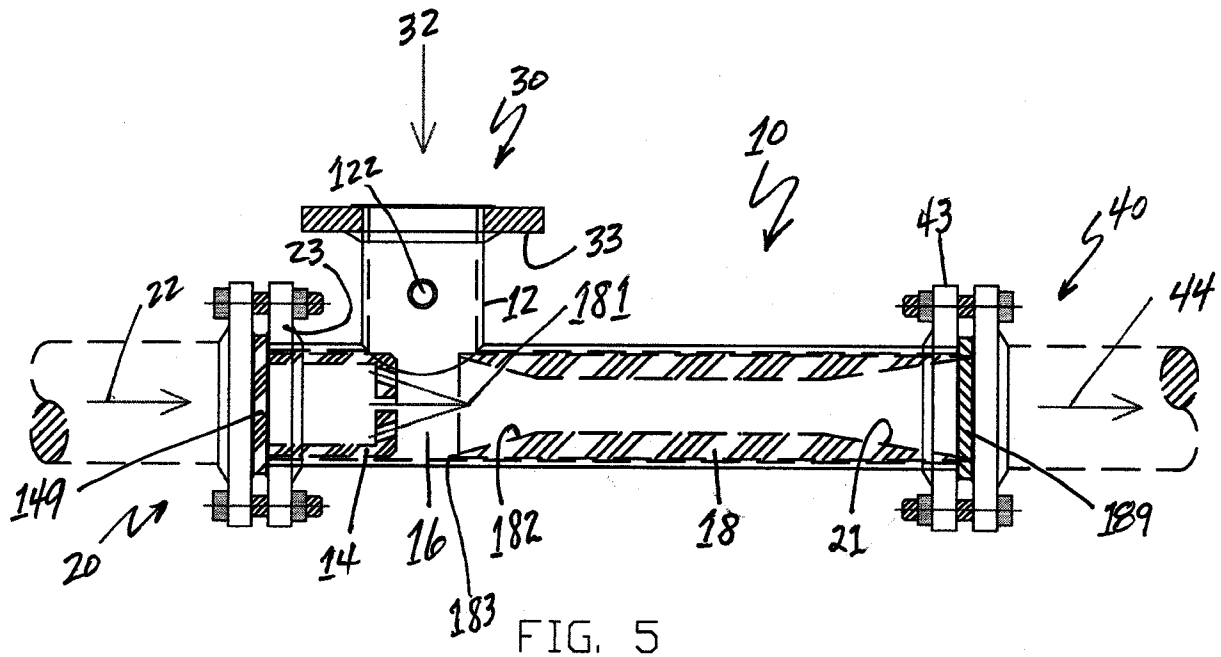
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FIG. 5

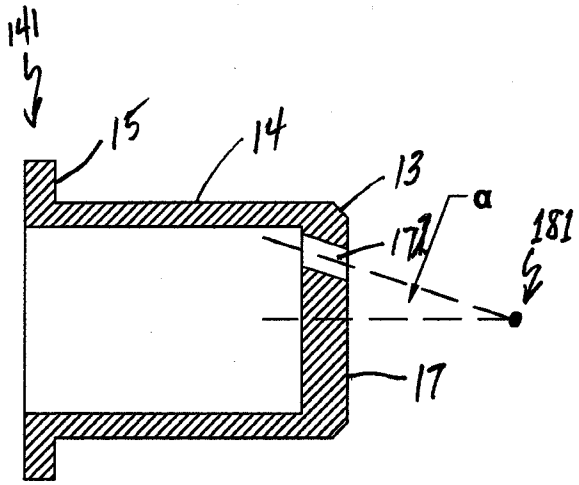


FIG. 6

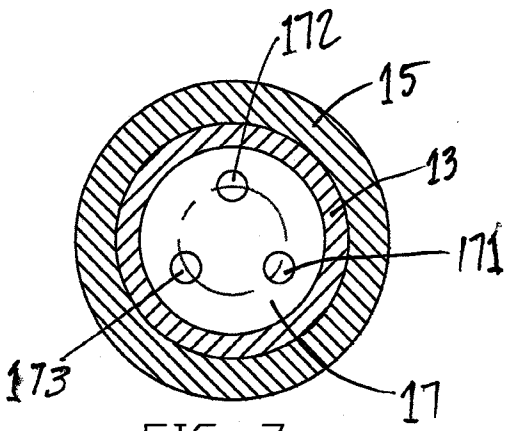


FIG. 7

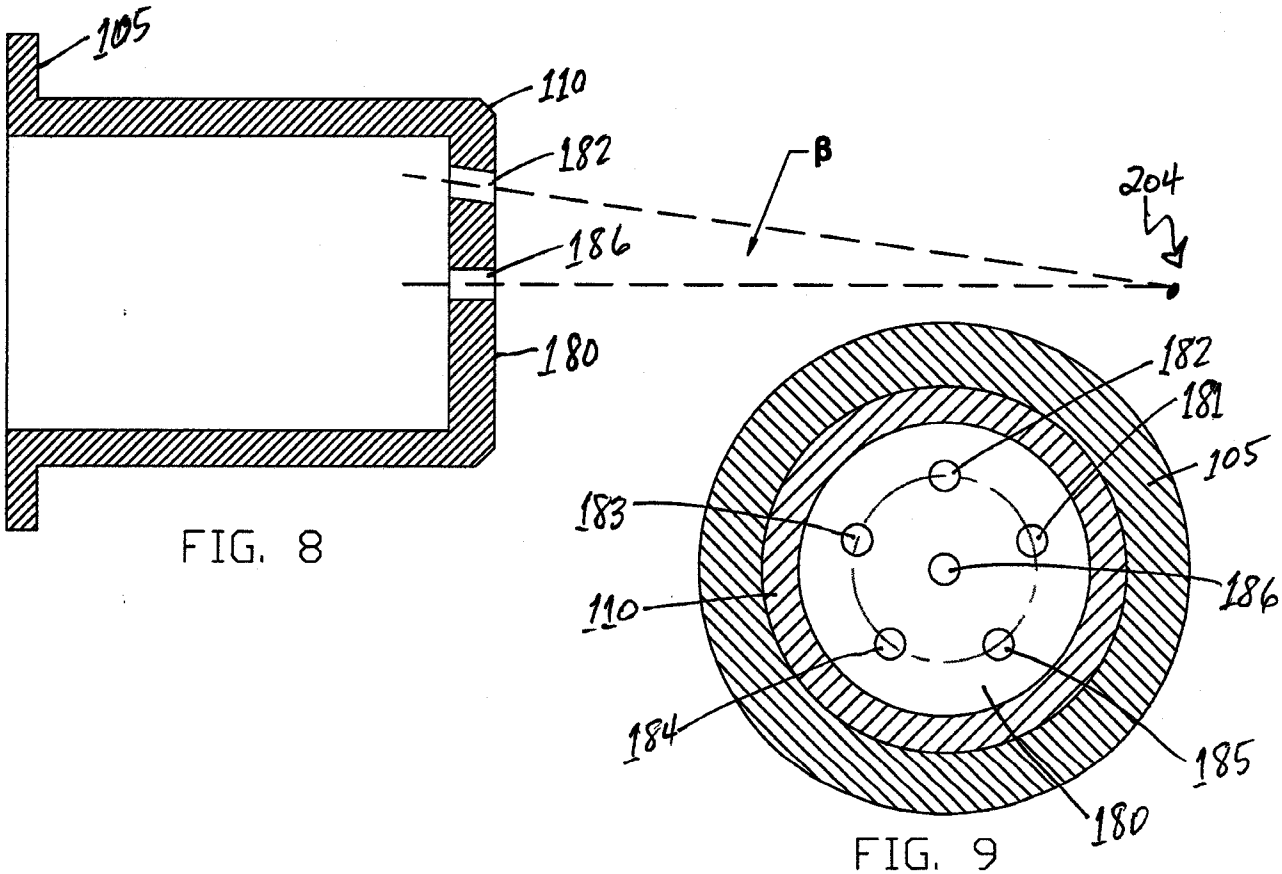


FIG. 8

FIG. 9

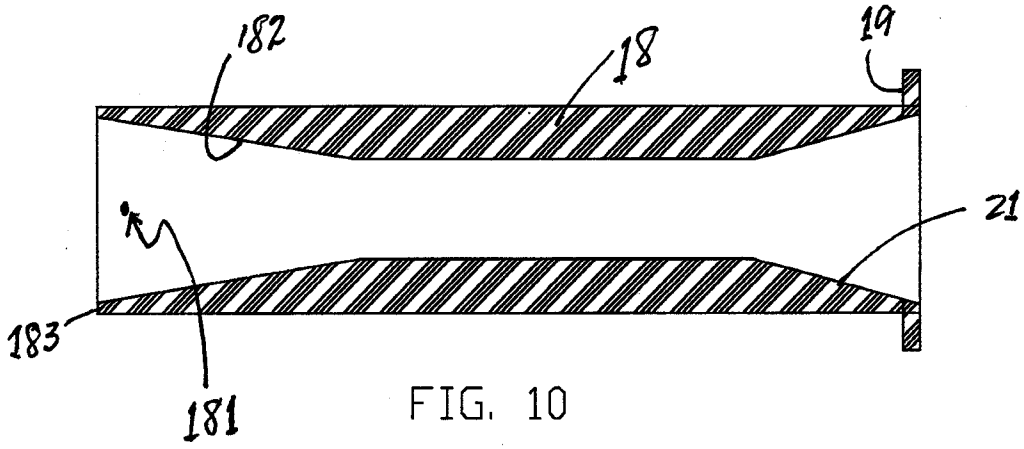


FIG. 10

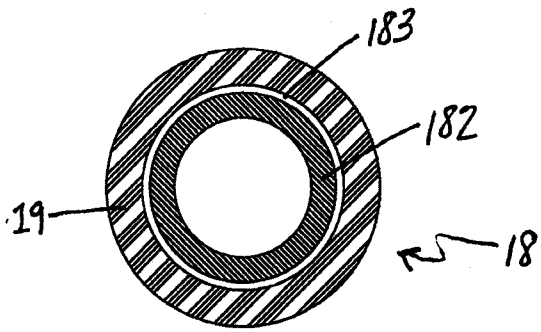


FIG. 11

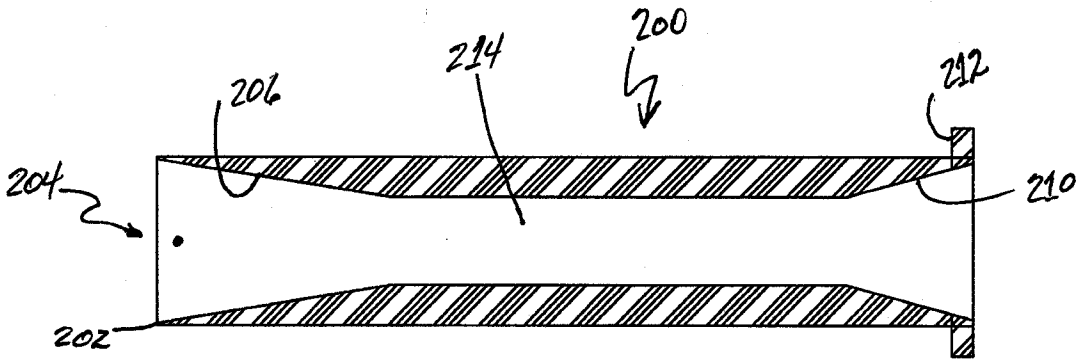


FIG. 12

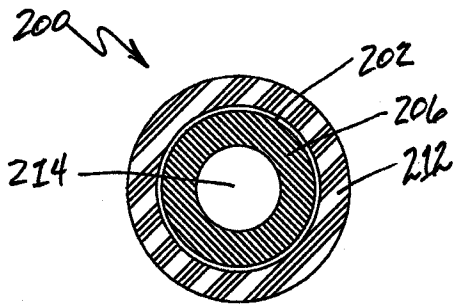


FIG. 13

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/030937

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01F 5/04 (2011.01)
USPC - 239/398
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B01F 5/04 (2011.01)
USPC - 137/602, 888, 892; 239/398

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase and Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 7,635,218 B1 (LOTT) 22 December 2009 (22.12.2009) entire document | 1-10 |
| Y | US 3,678,140 A (ADAMS et al) 18 July 1972 (18.07.1972) entire document | 1-10 |
| Y | US 7,311,270 B2 (KAPILA) 25 December 2007 (25.12.2007) entire document | 5 |
| Y | US 3,470,826 A (FOULDS) 07 October 1969 (07.10.1969) entire document | 7 |
| Y | US 4,781,467 A (WILLIAMS) 01 November 1988 (01.11.1988) entire document | 10 |

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"P" document published prior to the international filing date but later than the priority date claimed
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