

(51) Int Cl.: **B01F 5/06** ^(2006.01) **B01F 5/04** ^(2006.01)

(22) Date of filing: 10.08.2006

(74) Representative: **Moir, Michael Christopher et al**
Mathys & Squire
120 Holborn
London EC1N 2SQ (GB)

(54) **Variable static mixer**

second mixer (102) mounted in the pipeline at a downstream location wherein the second mixer (102) has a plate (18) with a mixing orifice (22) which plate is adapted to move between non-mixing and mixing positions.



Description

Background of the Invention

[0001] This invention relates to mixing devices commonly referred to as static mixers. Generally such mixers are disc-like in shape and include a plate having a central opening or orifice of various fixed geometric configurations and mounted in a pipe through which fluid passes so as to create a turbulent mixing action to the fluid such that other materials introduced into the stream generally via injection nozzles located downstream and generally adjacent the plate are uniformly mixed with the fluid.

[0002] As indicated, standard static mixers have a fixed geometry, which means that the headloss is a direct function of the velocity of the fluid in the pipeline. Generally speaking, a mixer designed for low (1-3 FPS) velocity will generate excessive headloss at high pipeline velocity (8-12 FPS). Conversely, a mixer designed for reasonable mixing and headloss at high velocity generally will not provide good mixing at low velocity.

[0003] To date, this problem has been addressed by making separate mixers with mixing characteristics suited for particular pipeline velocities. For instance, the present applicant commercially supplies three separate mixers with different orifice diameters or beta ratios (beta ratio = orifice diameter/pipe inside diameter) of .7, .8 and .9. See Fig. 9 for further beta information. This enables a user to choose a mixer that gives good mixing performance at high, medium or low pipeline fluid velocities respectively, but no one mixer achieves good performance at all of these different velocities.

[0004] It is therefore an object of at least the preferred embodiments of the present invention to provide a mixer and mixing system that can be adjusted to achieve good mixing performance at differing pipeline velocities without the need of removing one mixer and substituting another mixer in the pipeline.

[0005] According to the invention there is provided a mixer having a plate adapted for mounting within a pipe section and defining a mixing orifice, the plate being adjustably movable to a plurality of operable positions within the pipe section for effecting different degrees of mixing.

[0006] Also according to the invention there is provided a mixing system comprising a first mixer comprising a plate mounted in a pipe section and defining a mixing orifice, and a second mixer as set forth above, the first and second mixers being spaced apart from each other along the flow axis of the pipe section.

[0007] Other preferred but optional features are set out in the subordinate claims. In a preferred form the static mixer has a generally centrally disposed orifice disposed within a generally flat plate adapted for mounting within a pipe such that the plate is adjustably moveable to various alternate operable positions between a first essentially non-mixing position wherein the plate edge is disposed in line with the fluid flow within the pipe to a fully mixing position wherein the plate face is disposed normal

to the fluid flow within the pipe.

[0008] Other objects, features and advantages of the invention shall become apparent as the description thereof proceeds when considered in connection with the accompanying illustrative drawings.

Description of the Drawings

[0009] In the drawings :

Fig. 1 is a top view of a pipe section including the static mixer system of the present invention installed therein;

Fig. 2 is an exploded perspective view of Fig. 1;

Fig. 3 is a side elevational view of Fig. 1;

Fig. 4 is a stylized sectional view along line 4-4 of Fig. 3;

Fig. 5 is a stylized sectional view along line 5-5 of Fig. 3 showing the variable mixer in a full mixing position;

Fig. 6 is an elevational view of the variable position mixer of the present invention positioned within a pipeline in its first essentially non-mixing position;

Fig. 6A is an alternate embodiment of the variable position mixer installed in a swing gate check valve;

Fig. 6B is another alternate embodiment of the variable position mixer when installed in a gate valve;

Fig. 7 is a perspective view of a fixed mixer device disposed within a pipe and viewed from the upstream direction;

Fig. 8 is a view similar to Fig. 7 but viewed from the downstream position; and

Fig. 9 is an illustrative explanation of the term "beta" as applied herein.

Description of the Invention:

[0010] Turning now to the drawings and particularly Figs. 7 and 8 thereof, a typical static mixer is depicted.

The device 10 is of an overall circular outside configuration, that is, a disc-like body 12 including an outside flange portion 14 extending inwardly from the outer periphery 16 of the disc 12 approximately one third of the radius of the entire disc 12 and a pair of radially opposed flaps 18 inwardly extending from the inner periphery 20 of such flange towards each other but not touching so as to form, in essence, a central open area 22 of a dumbbell-type configuration. The flange 14 includes flat opposed upstream and downstream surfaces 14a and 14b which project into the fluid stream, that is, portions of the fluid stream (generally the portions closer to the pipe wall) contact and, in effect, are diverted by surface 14a prior to passing through the central open area formed by the inner peripheral surface 20. In addition, the flaps 18 are bent downwardly inwardly towards the flow direction of the fluid through the pipe 24 in which the device 10 is mounted. Such mounting of the device 10 in the pipe 24 is accommodated by an outer plate 26 of cylindrical con-

figuration and including a radially outwardly extending step 28 on the upstream side thereof such that the periphery 16 of the disc body may contact such step 28 and be held within the confines of the pipe 24 thereby. Pipe collars 30 may be provided at opposed ends of the pipe 24 to accommodate the insertion of the plate 26 therebetween and affixation thereto by bolts or other conventional means (not shown) passing through the plate and collars 26, 30 respectively.

[0011] It will also be apparent from this and other drawings that the flaps preferably 18 as well as the flange 14 extend inwardly into the fluid flow and that additionally the flaps extend at an angular relationship to such internal pipe or wall surface of approximately 15 degrees in the downstream direction but could even extend at angles of 25 or to 40 degrees. Preferably, the configuration of the flaps 18 is semi-elliptical or semi-circular such that defined open area 22 is entirely made up of rounded boundaries, that is, the areas where the flaps 18 meet the internal periphery 20 of the flange 14 are rounded.

[0012] It should be stated that the particular static mixer configuration above described is that of applicant's issued U. S. Patent No. 5,839,828 that is hereby incorporated into the present Specification by specific reference thereto. It should also be stated that other static mixers of the same general type could also be utilized in the present invention, e.g., those mixers shown in Figs. 12 and 13 of U. S. Patent No. 6,595,682.

[0013] The present invention utilizes the above-described static mixers by installing a first mixer in a fixed position in an upstream location. Such first mixer is adapted to provide good mixing at high fluid velocities. In addition or in lieu thereof as will be discussed hereinafter, a second but variable position static mixer is installed downstream therefrom. The second mixer is dimensioned to provide efficient mixing for low fluid velocities and when coupled with the first mixer in the subject system can provide efficient mixing over a wide range of fluid velocities unachievable with systems incorporating only one of the static mixers in a fixed position.

[0014] Specifically with respect to the particular static mixers that applicant produces, applicant installed a conventional .9 beta mixer with standard chemical injection nozzles downstream of one or both trailing tabs. A second movable .7 beta ratio mixer is installed two pipe diameters downstream from the first fixed mixer. The second mixer is designed to pivot 90 degrees on its vertical axis (same as a disc in a butterfly valve). The rotary position of this second mixer is controlled either by an externally mounted operating lever or by a standard electric butterfly valve operator (gear motor) hereinafter referred to as means for pivoting mixer plate (see Fig. 6).

[0015] In operation at high velocities, the first .9 beta mixer provides good mixing and low headloss. The second .7 beta mixer is rotated so that the disc is parallel to the direction of flow thus providing very little additional headloss and mixing. This fully open (pivoted 90 degrees) position of the second mixer plate is shown in Fig.

6. As the pipeline velocity decreases, the second mixer (the .7 beta mixer) is progressively rotated closed (right angles to the direction of flow). Thus at very low pipeline velocity (3 - 8 FPS), the second .7 beta mixer would be completely closed thus providing a .9 beta mixer followed by the .7 beta mixer.

[0016] The variable static mixer system above described provides excellent mixing and minimal headloss for all pipe velocities.

10 [0017] The position of the movable second mixer could be automatically controlled to provide constant headloss over a range of velocities.

[0018] The shape of each of the mixer plates may be that of the plates described in U.S. Patent No. 5,839,828 issued to the present applicant, Robert W. Glanville, November 24, 1998 and which is hereby incorporated into the present application by specific reference thereto. It should be noted that by the phrase "designed to pivot 90 degrees" means that the second mixer plate is adapted to rotate on its vertical axis from a fully mixing position or closed position as shown in Figs. 2 and 5 to an essentially non-mixing or fully open position as shown in Fig. 6 and that the second mixer plate could, of course, encompass slightly less or much greater rotational angles so long as the above described mixing modes as well as intermediate mixing modes are accomplished.

[0019] With reference to Figs. 1 - 5, additive material is introduced into the system 100 shown therein in conjunction with the first mixer 10. As is known in the art, additive materials are injected through pipes or quills 38 that lead to injection ports 40 in the plates 26 on the downstream side of the mixer. The turbulence created by fluid passing through the orifice or central open area 22, in effect, draws in the additive material to accomplish at least partial mixing thereof within the fluid stream. The particular system shown in the drawings utilizes a fixed static mixer 10 having a beta of .9 that provides good mixing at high velocities. However in order to obtain better improved and more flexible operation and mixing efficiencies at medium and lower fluid velocities, a second and movable static mixer 102 with a lower beta, e.g., .7, is positioned in the pipe downstream from the first mixer 10. A separation distance of two pipe diameters was utilized with the effective results as indicated above. It is believed that such separation distance of at least two pipe diameters should be maintained for mixing efficiency and physical placement

[0020] Preferably, the movable mixer 102 is of the same general configuration and type as the first mixer 10 but is mounted so as to move, i.e., pivot, from a first non-mixing position as shown in Fig. 6 wherein the plate-like body 112 thereof is positioned so that the fluid stream impinges on the narrow vertically disposed edge 113 thereof and thus, in effect, causes little or no headloss or mixing action to a second fully engaged mixing position as shown in Fig. 5 wherein the body 112 is positioned with the face 115 thereof across the pipe opening such that the peripheral flange 117 thereof and the orifice or

central open area 122 are in full contact with the fluid flow. In this second full mixing position, the static mixer exhibits the characteristics of its beta number, that is, if the second mixer is a .7 beta, it will exhibit those mixing characteristics. In this way, the system can thus be efficiently utilized for high flow as well as lower flow by regulating the movable mixer to either its non-mixing or mixing positions.

[0021] It is also desirable to be able to fix the flange 117 position to partially open positions between the extremes of fully open or fully closed indicated above and through such intermediate flows between high and low can be efficiently accommodated. It is also desirable to sense the flow rate in the pipe upstream of the system and utilize such results to automatically control the opening and closing and partially open positions of the flange 117. Such sensing and control means are well known for other devices in the art.

[0022] With respect to the means 130 for pivoting the flange 117, such may comprise of known components such as butterfly valves and include such simple mechanisms as a hand movable handle or knob 132 connected to a rod 134 passing thru the outer plate 136 and, in turn, attached to the flange for rotational movement thereof.

[0023] Also, the vertical axis of rotation of the butterfly-type valve action of the movable flange 90 degrees in either direction as shown in Fig. 6 could be shifted to the horizontal where the flange edge would be positioned horizontally across the pipe in the non-mixing first position. Additionally, a similarly horizontally positioned flange of the second mixer could be incorporated within a conventional swing gate check valve structure such as shown by Fig. 6A such that the non-mixing position is equivalent to the fully open position of the mixer plate adjacent to the valve body and in such case attached to the operating hinge and the mixing position equivalent to the closed position of the valve across the flow path. The operating hinge mechanism as well as the mixer plate in its non-mixing position can be housed in the upper chamber of the valve. Similarly, a standard gate valve structure as shown in Fig. 6B could support the mixer plate of the movable mixer by attaching such to the operating spindle such that moving the spindle up or down positions the mixer flange either into, out of or partially into the fluid stream.

[0024] As above indicated, the preferred form of the invention positions a movable static mixer preferably of a low beta valve downstream from a fixed static mixer usually of a higher beta value; however, it has been found that efficient mixing results can be achieved when a single movable static mixer is placed in the fluid stream, i.e., use of the second movable mixer, without the first fixed static mixer.

[0025] It should also be indicated that in those types of static mixers wherein the structure supporting the mixing orifice (or orifices or orifice pattern) is not entirely within the plane defined by the plate surface, e.g., the supporting structure extends outwardly thereof, that the

non-mixing position in those situations wherein the plate edge is disposed in line with the fluid flow that portions of the supporting structure may project into the fluid stream and cause some turbulence but with only minimal mixing consequences. Also especially with larger diameter plates, the fixed mixer can be directly mounted such as by welding to the pipeline.

[0026] It should be noted that additives can be introduced at other points other than through the pipes or quills and that the material comprising the fluid flow in the pipe could itself compose unmixed feed.

[0027] While there is shown and described herein certain specific structure embodying this invention, it will be manifest to those skilled in the art that various modifications and rearrangements of the parts may be made without departing from the spirit and scope of the underlying inventive concept and that the same is not limited to the particular forms herein shown and described except insofar as indicated by the scope of the appended claims.

[0028] Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

[0029] Statements in this specification of the "objects of the invention" relate to preferred embodiments of the invention, but not necessarily to all embodiments of the invention falling within the claims.

[0030] The description of the invention with reference to the drawings is by way of example only.

[0031] The text of the abstract filed herewith is repeated here as part of the specification.

[0032] A variable static mixer and system for accommodating variable and different flows in a pipeline so as to produce maximum mixing efficiency including a first mixer mounted in the pipeline and a second mixer mounted in the pipeline at a downstream location wherein the second mixer has a plate with a mixing orifice which plate is adapted to move between non-mixing and mixing positions.

Claims

1. A static mixer having a plate adapted for mounting within a pipe section and defining a mixing orifice, the plate being adjustably movable to a plurality of operable positions within the pipe section for effecting different degrees of mixing.
2. The mixer of claim 1, wherein a said position is such that the plate edge is generally aligned with the flow and preferably disposed parallel to a flow axis of the pipe section.
3. The mixer of claim 1 or claim 2, wherein a said position is such that the plate is disposed across and preferably normal to the flow axis of the pipe section.

4. The mixer of claims 2 and 3, wherein said plate is arranged to pivot about a radial axis of said pipe section through at least 90 degrees between said positions and wherein the diameter of said plate is less than the internal diameter of said section. 5
5. The mixer of claim 1, wherein said plate is arranged to pivot about an axis positioned adjacent the internal wall of said pipe section between said positions and wherein said plate edge is disposed adjacent said internal wall when in a non-mixing position. 10
6. The mixer of claim 1, wherein the plate is disposed laterally offset from an internal wall of the pipe section in a non-mixing position and is arranged to move into and across said pipe section to a mixing position. 15
7. The mixer of claim 1, wherein mixer plate is fixedly positionable at any intermediate position between said first and second positions. 20
8. The mixer of any preceding claim, wherein the plate is fixedly positionable in any of said plurality of positions. 25
9. A mixing system comprising a first mixer comprising a plate mounted in a pipe section and defining a mixing orifice, and a second mixer as claimed in any preceding claim, the first and second mixers being spaced apart from each other along the flow axis of the pipe section. 30
10. The mixing system of claim 9, wherein the first mixer is a fixed static mixer. 35
11. The mixing system of claim 9 or claim 10, wherein the first mixer is upstream of the second mixer.
12. The mixing system of any of claims 9 to 11, wherein the first and second mixers are separated by at least two pipeline diameters. 40
13. The mixing system of any of claims 9 to 12, wherein said first mixer has a higher beta than said second mixer. 45

50

55

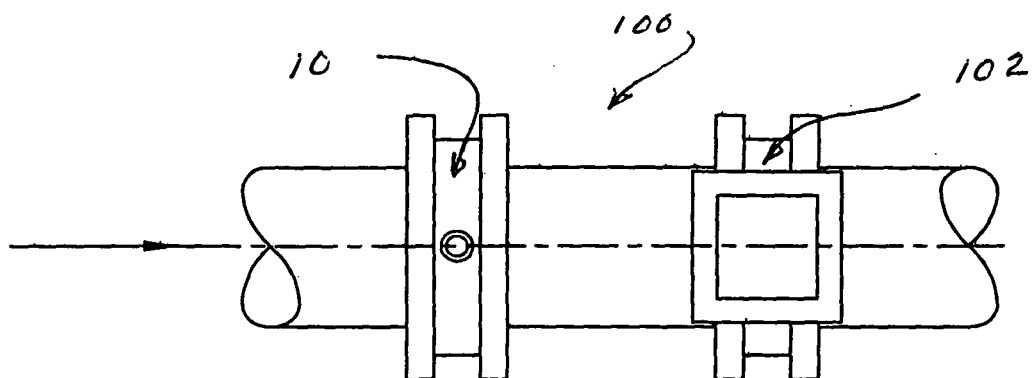


FIG. 1

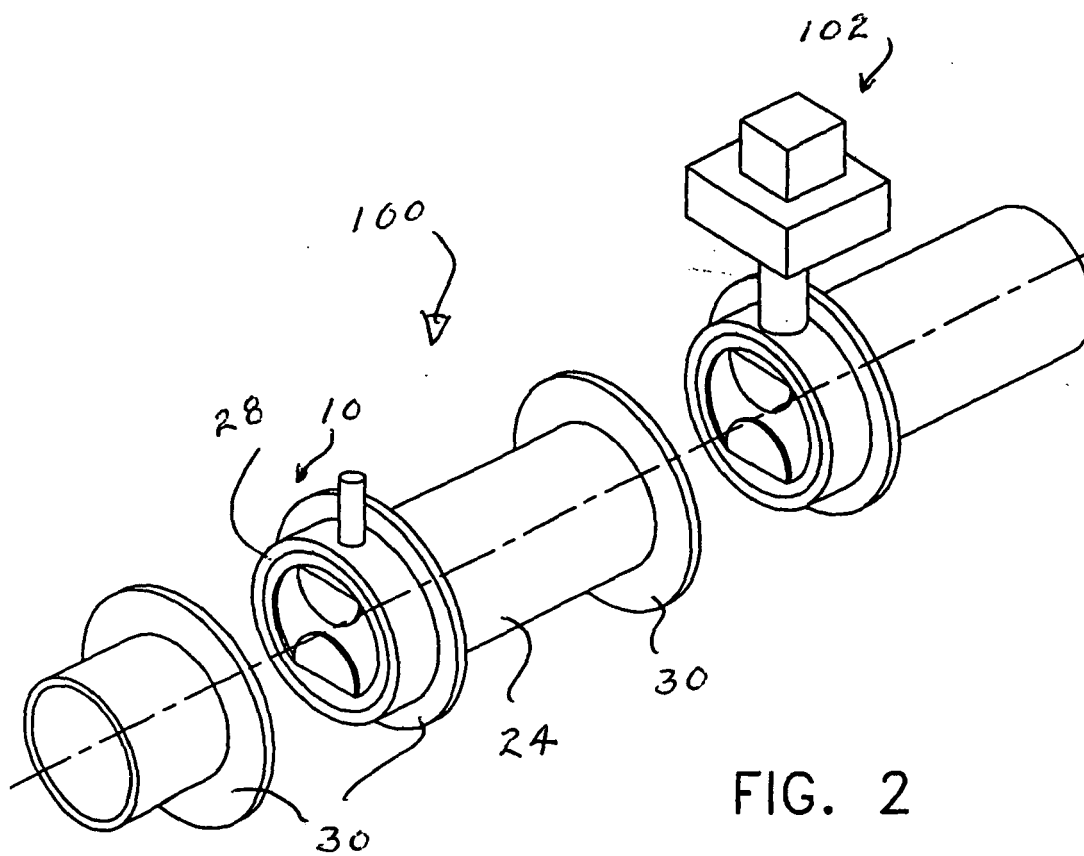


FIG. 2

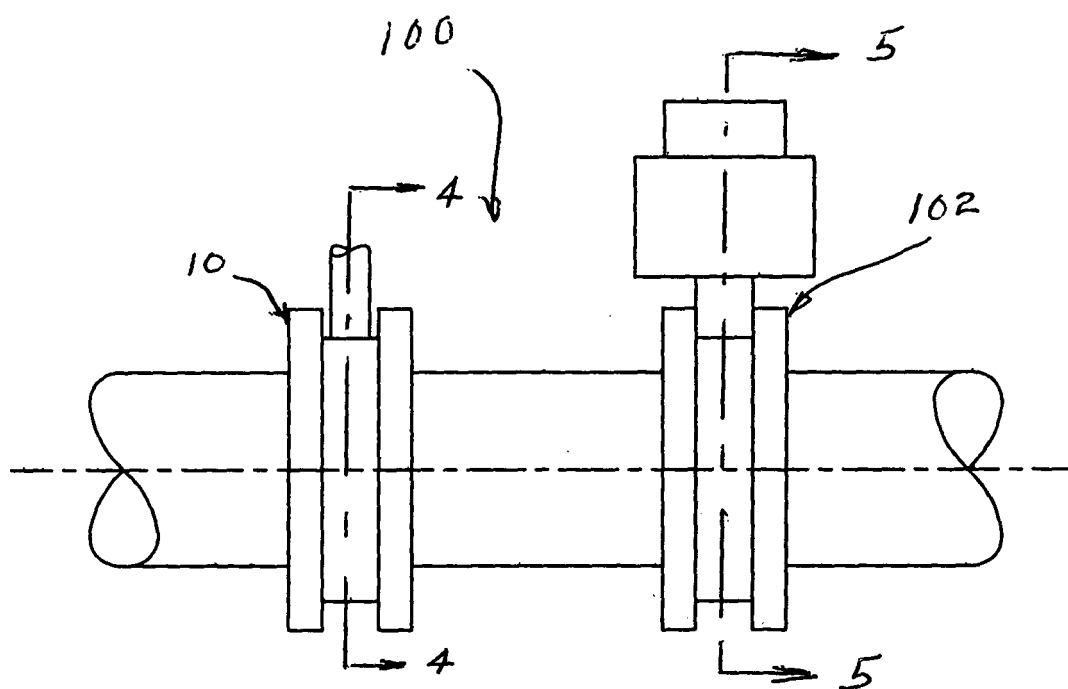


FIG. 3

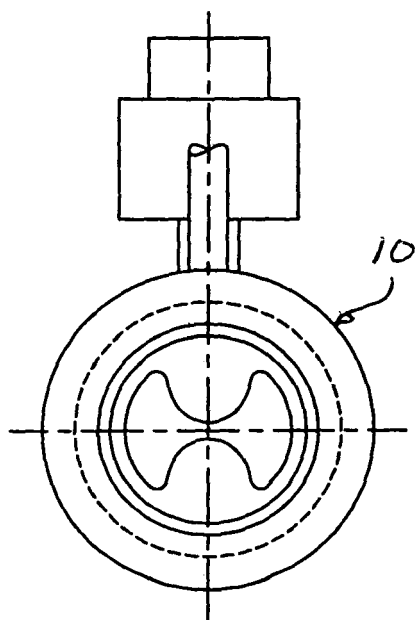


FIG. 4

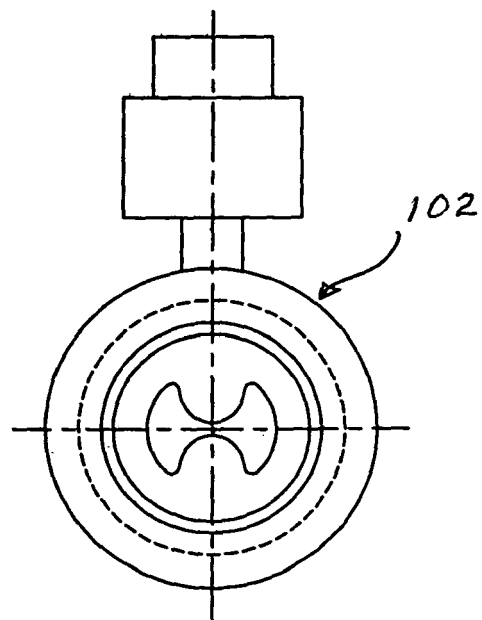


FIG. 5

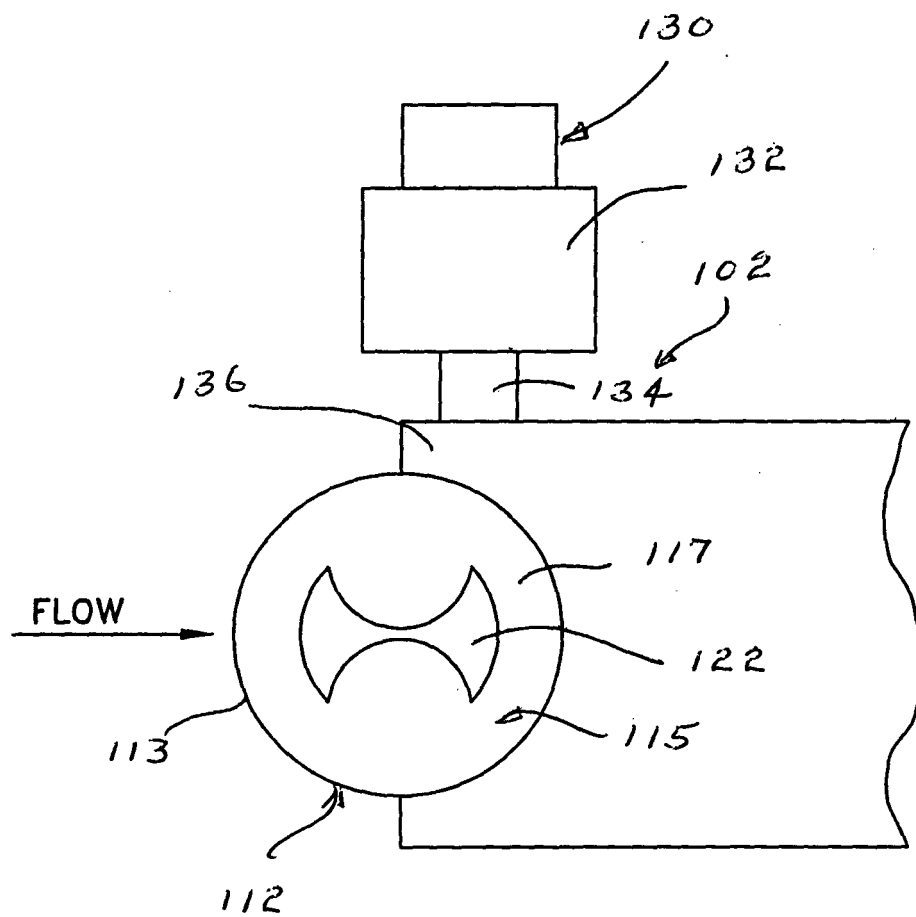


FIG. 6

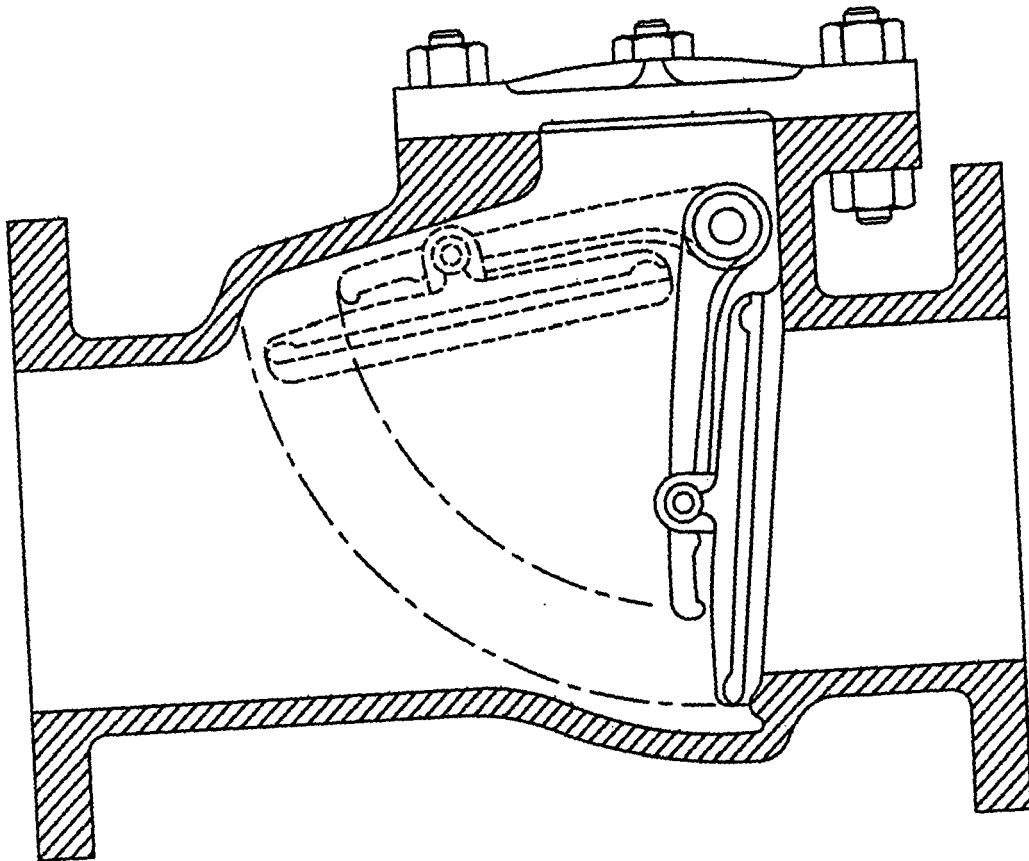


FIG. 6A

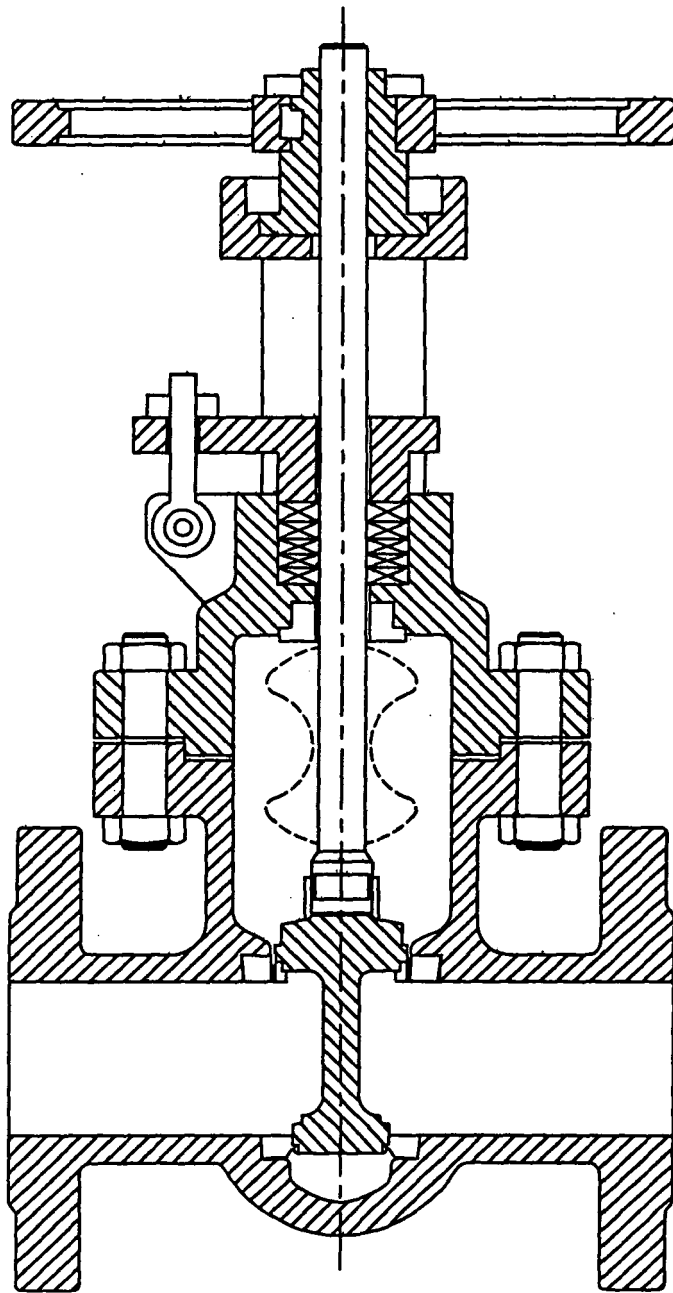


FIG. 6B

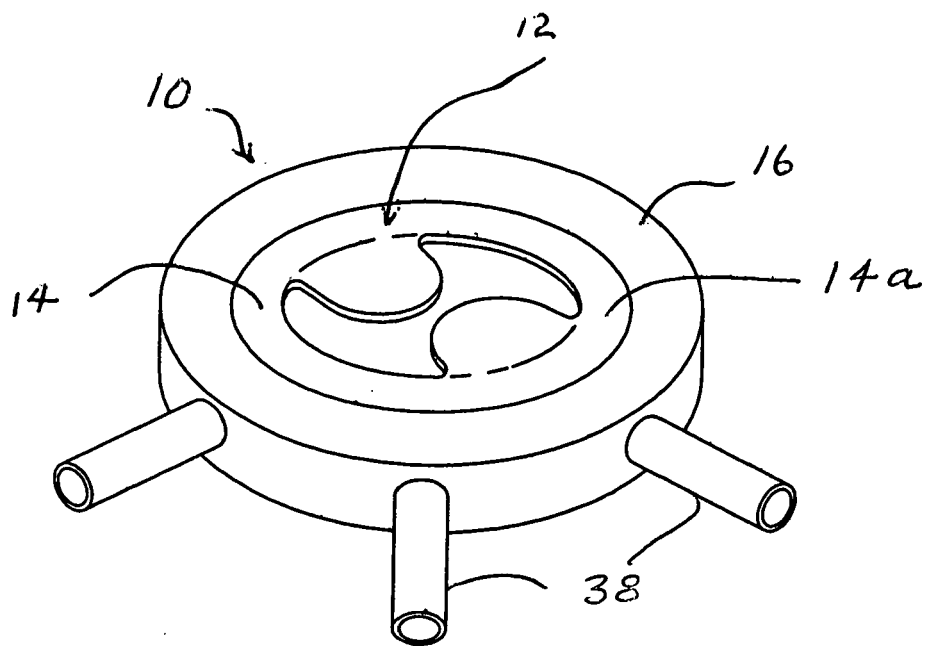


FIG. 7

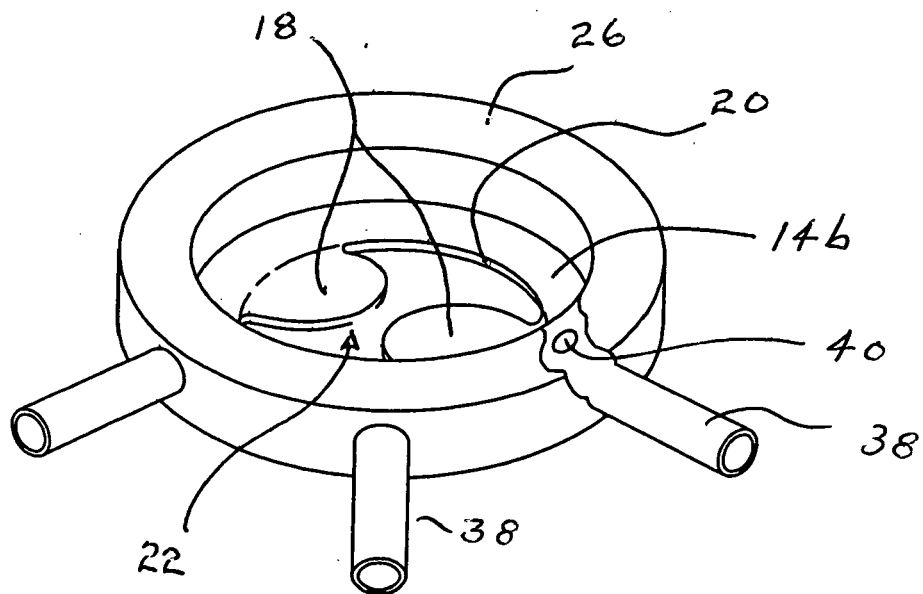


FIG. 8

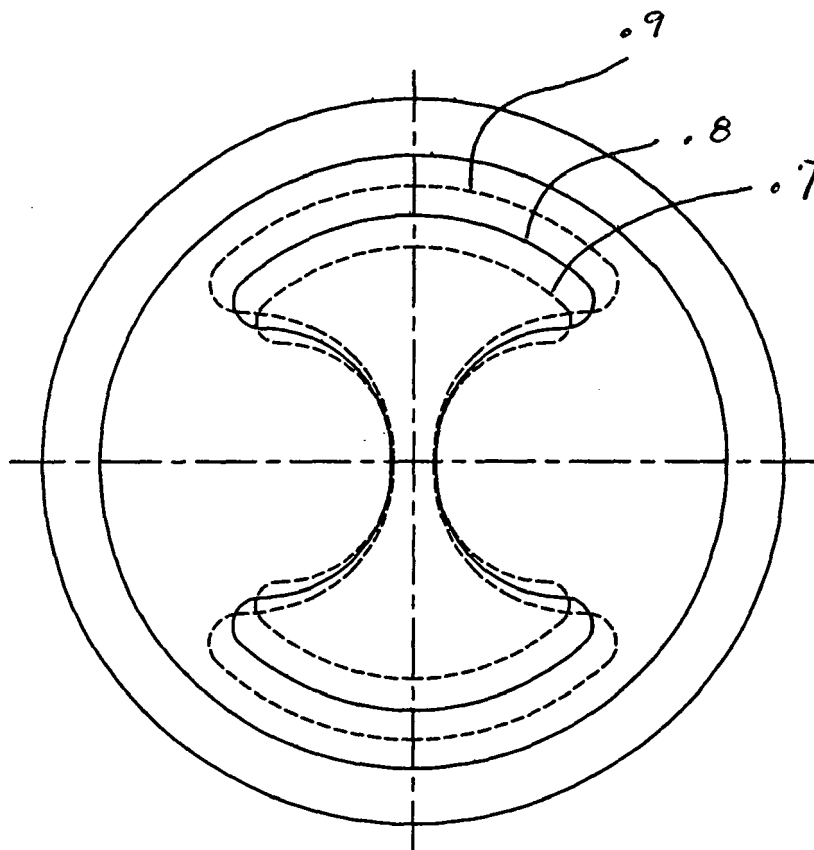


FIG. 9



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 25 4207

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 166 862 A1 (BALCKE DUERR ENERGIETECH GMBH [DE] DUERR BALCKE GMBH [DE]) 2 January 2002 (2002-01-02) * paragraph [0021]; figure 7 *	1-4, 7-11,13	INV. B01F5/06 B01F5/04
X	US 4 846 212 A (SCOBIE WILLIAM B [US] ET AL) 11 July 1989 (1989-07-11) * column 3, line 4 - column 3, line 41; figures 1,2 *	1-4, 7-11,13	
X	US 2 624 541 A (HERBERT ZIEBOLZ) 6 January 1953 (1953-01-06) * abstract; figure 1 *	1,5	
X	GB 730 046 A (PYRENE CO LTD) 18 May 1955 (1955-05-18) * page 1, line 52 - page 2, line 18; figures 1-3 *	1-4	
X	EP 0 095 791 A2 (SHELL INT RESEARCH [NL]) 7 December 1983 (1983-12-07) * abstract; claim 1; figure 1 *	1	
X	NL 78 461 C (TOTAL KOMMANDITGESELLSCHAFT) 16 June 1955 (1955-06-16) * the whole document *	1,6	TECHNICAL FIELDS SEARCHED (IPC)
A	US 5 265 846 A (SHREVE CRAIG D [US]) 30 November 1993 (1993-11-30) * abstract; figures 1-4 *	1-13	B01F F16K
A	DE 20 23 961 A1 (MASHEDER DESIGN STUDIES LTD) 25 November 1971 (1971-11-25) * claim 1; figures 1,2 *	1	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 January 2007	Examiner Muller, Gérard
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

2
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 25 4207

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-01-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1166862	A1	02-01-2002 DE 50005198 D1	11-03-2004
US 4846212	A	11-07-1989 NONE	
US 2624541	A	06-01-1953 NONE	
GB 730046	A	18-05-1955 NONE	
EP 0095791	A2	07-12-1983 CA 1233462 A1	01-03-1988
		DE 3364257 D1	31-07-1986
		ES 8404872 A1	01-09-1984
		JP 1716546 C	14-12-1992
		JP 3080529 B	25-12-1991
		JP 58216721 A	16-12-1983
		NO 831881 A	29-11-1983
		SG 47987 G	28-08-1987
		US 4487510 A	11-12-1984
NL 78461	C	NONE	
US 5265846	A	30-11-1993 NONE	
DE 2023961	A1	25-11-1971 NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5839828 A [0012] [0018]
- US 6595682 B [0012]