

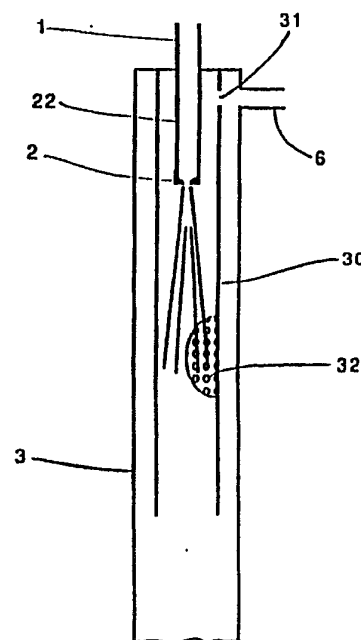


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : B01F 3/04, B03D 1/14, 1/24 C02F 3/14, 3/16, 3/20 C02F 7/00	A1	(11) International Publication Number: WO 92/03220 (43) International Publication Date: 5 March 1992 (05.03.92)
(21) International Application Number: PCT/AU91/00399 (22) International Filing Date: 27 August 1991 (27.08.91) (30) Priority data: PK 1974 27 August 1990 (27.08.90) AU (71) Applicant (for all designated States except US): THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED [AU/AU]; The University of Newcastle, Rankin Drive, Newcastle, NSW 2308 (AU). (72) Inventor; and (75) Inventor/Applicant (for US only) : JAMESON, Graeme, John [AU/AU]; 34 Curzon Road, New Lambton, NSW 2305 (AU).		(74) Agent: GRIFFITH HACK & CO.; 71 York Street, G.P.O. Box 4164, Sydney, NSW 2000 (AU). (81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i>

(54) Title: AERATION APPARATUS WITH DRAFT TUBE**(57) Abstract**

In an aeration apparatus in which a dense dispersion of bubbles is formed within a substantially vertical pipe (3) by the emission of liquid under pressure through a downwardly facing nozzle (2) into the upper end of the pipe (3) and the entrainment of air or other gas through inlet (6), the performance of the apparatus is improved or modified by the incorporation of a draft tube (30) within the pipe. The draft tube (30) serves to provide an ideal cross-section to control the jet issuing from the nozzle (2) and inhibit the formation of large bubbles in the pipe (3). The draft tube may be provided with holes (32) and may adapt various tapering configurations as disclosed in different embodiments of the invention. The use of multiple nozzles (2) and corresponding draft tubes within the pipe (3) is also described.



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⁺ Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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"AERATION APPARATUS WITH DRAFT TUBE"

TECHNICAL FIELD

This invention relates to an aeration apparatus which may be used in many diverse fields including in the
5 aeration of water or other liquids in waste water treatment and pollution control, the separation of oil from water, or the separation of minerals in suspension by the so-called flotation method.

BACKGROUND ART

10 Various types of aeration apparatus are known where a dense dispersion of bubbles in a liquid is emitted from the lower end of a downwardly extending pipe or column and allowed to rise, either in a large body of liquid or within a cell or column. The aim of such apparatus is to
15 provide a dense dispersion of very small bubbles, having a large surface area to issue as a mass from the bottom of the pipe or column. Problems can arise with different types of liquid, often containing different amounts of impurities or other particles and with different flow
20 rates through nozzles in the pipe or column, which can cause bubbles to coalesce within the pipe or column, growing to an unacceptably large size and possibly ultimately causing the collapse of the foam bed of small bubbles being formed within the pipe or column.

25 It is the purpose of this invention to provide modifications to the interior configuration of the pipe or column and/or the nozzles within that column which will inhibit the formation of large bubbles within the pipe or column leading to collapse of the foam bed.

30 DISCLOSURE OF THE INVENTION

Accordingly the present invention provides apparatus for aerating liquids comprising a substantially vertically
extending conduit having an open lower end, liquid supply means arranged to supply liquid under pressure to at least
35 one downwardly facing nozzle located and arranged within the upper part of the conduit so as to form a downwardly issuing jet of liquid from the or each nozzle within the conduit, support means arranged to support the conduit

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with the lower end immersed in a body of liquid, and one or more draft tubes mounted within the conduit and aligned with the or each nozzle, the or each draft tube having its axis parallel to the axis of the conduit and being
5 configured to direct the flow of gas within the conduit and/or constrain the jet within the conduit.

Preferably the draft tube has one or more holes through the wall of the tube positioned to allow gas rising within the conduit, between the conduit and the
10 draft tube to re-enter the draft tube via the holes.

Preferably the conduit or draft tube is substantially circular in cross-section or is of other cross-section having minor and major lateral axes of the same order and having an effective diameter equal to the diameter of a
15 circle of equivalent area, and wherein the diameter of the conduit is in the range 2 to 20 times the diameter of the nozzle.

More preferably the diameter of the conduit or draft tube is within the range 3 to 12 times the diameter of the
20 nozzle.

The liquid to be aerated may be either the liquid which is passed into the upper end of the conduit through the nozzle in a downwardly moving jet or alternatively may be the liquid comprising the body of liquid into which the
25 lower end of the conduit is immersed. In many applications the liquid issuing into the upper part of the conduit will be the same as the liquid in the body of liquid.

Examples of the use to which the invention may be put
30 include the following:

(a) Aeration of a pond of wastewater or effluent, in which it is desired to create a dispersion of fine bubbles in the wastewater, so as to provide oxygen for the growth of microorganisms used to remove the noxious components
35 and hence reduce the biological oxygen demand prior to discharging into a sewer or river.

(b) Treatment of a water or effluent stream containing finely-dispersed oil droplets, so that the oil

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droplets attach themselves to the bubbles, which rise to the surface of the liquid in a pond or containing vessel, removing the oil droplets out of the main body of the liquid, which is therefore purified.

5 Notwithstanding any other forms that may fall within its scope, one preferred form of the invention and variations thereof will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic cross-sectional elevation
10 through a basic form of aeration device;

Figure 2a is a diagrammatic cross-sectional elevation showing aeration apparatus with multiple nozzles and internal baffles forming draft tubes according to the invention in the conduit;

15 Figure 2b is a sectional plan view of the nozzle and baffle arrangement shown in Figure 2a;

Figure 3 is a diagrammatic cross-sectional elevation of a form of the invention incorporating a draft tube within the conduit;

20 Figure 4 and Figure 5 are views similar to Figure 3 showing alternative configurations of draft tube; and

Figure 6 is a view similar to Figure 3 showing an alternative draft tube configuration.

In the aeration apparatus shown in Figure 1, liquid
25 enters through an entry pipe (1) and a nozzle assembly (22) which terminates in an orifice (2) which faces essentially vertically downwards. The nozzle is mounted in the top of a conduit or pipe (3) which is essentially vertical. In operation, the liquid issues from the
30 orifice (2) in the form of a high-speed jet which can move downwardly through the pipe (3).

The vertical pipe is mounted by way of support means (3a) so that its lower end is submerged in a reservoir of liquid (4). The liquid may or may not be identical in all
35 respects to the liquid entering through the entry pipe (1).

Initially, before commencement of operation, the liquid levels in the reservoir and inside the vertical

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pipe (3) are the same. When the high-speed liquid jet is first established by the orifice (2), it travels downwards through the pipe (3) and plunges into the liquid, entraining gas which is inside the pipe and carrying it
5 out of the lower extremity (5), to rise in the reservoir (4) in the form of fine bubbles. The vertical pipe (3) fills rapidly with a dense foam of bubbles dispersed in the feed liquid, and the pressure in the head space of the pipe drops below the ambient pressure outside the pipe.
10 Accordingly, new gas is drawn into the pipe through the air entry (6).

The gas flow may be regulated by a conveniently placed control valve (7) or other suitable means so that the rate at which air enters through the entry pipe (6) is always
15 less than the maximum amount which can be entrained by the plunging jet (8). In this way, the vertical pipe (3) remains filled with a dense foam which provides a favourable environment for interaction between the gas and liquid phases.

20 The pipe (3) in which the bubbly mixture is produced should preferably be substantially vertical, i.e. within 15° of the vertical. It is possible for the system to perform well in some cases when the axis lies further from the vertical than the limit stated, depending on the
25 degree of coalescence of the bubbles which takes place within the pipe as the dense bubbly foam travels downward toward the pipe exit (5). If the bubbles coalesce, they will rise in the form of large slugs of gas in the uppermost parts of the sloping pipe, to the head space of
30 the pipe (3), as a form of internal gas recycle. On reaching the head space in the pipe (3), they will displace the dense foam, and may cause the collapse of the bubbly mixture in the pipe. Accordingly, the pipe (3) will perform best if it is substantially vertical.

35 Although the invention is described with reference to a circular pipe or draft tube, it is not restricted to this form, and indeed the pipe may be replaced by a vertical duct of any cross-section. Best results will be

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found however with a regular polygon, or a section for which the ratio of the major to minor lateral axes is close to unity.

The action of the liquid jet (8) shown in Figure 1 can be improved by the incorporation of one or more draft tubes according to the invention, to divide the cross-sectional area of the conduit, and in some instances by the use of multiple nozzles. When the system is in operation, the jet plunges into the dense foam which fills the vertical pipe (3), and gas which enters through the inlet (6) is entrained into the dense foam by the shearing action at the edge of the jet. The velocity of the jet should be in the range 3 to 40 metres/sec. If the velocity is too low, the volume of air which can be entrained relative to the volume of liquid supplied will be too little, whereas if the velocity is too high, the energy demand will be excessive. Good practical operational velocities are in the range 12 to 20 metres/sec.

The jet diameter is fixed by practical considerations in that if it is too small, there is the possibility of it becoming blocked by adventitious material in the feed liquid. The minimum diameter should be such that matter suspended will pass through it. The diameter of the vertical pipe (3) should be in the range 2 to 20 times the jet diameter, with satisfactory operation being found in the range 3 to 12 times the jet diameter.

Bubbles produced by the plunging jet are generated by the shearing forces caused by the difference in velocity between the jet and the dense foam into which it plunges. An important determinant of the ultimate size of the bubbles is the power dissipated per unit volume of fluid contained in the generating device. To define this volume, use is made of the observation that the impinging jet tends to spread out as it travels downwards in the dense foam, giving up its forward momentum, and at a certain point, the expanding jet comes into contact with the wall of the vertical pipe (3). The jet has been

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observed to expand as a cone, whose included angle is in the range 10 to 20°. Thus for present purposes the volume in which the energy contained in the jet is essentially dissipated can be defined as the volume of fluid contained in the vertical pipe (3), between the entry point of the jet and the point at which the jet just begins to touch the wall of the vertical pipe (3).

The distance between the entry point of the jet and the point at which the jet just begins to touch the wall of the vertical pipe (3), is referred to as the impingement distance, and it is desirable that the length of the confining vertical pipe (3) should be greater than the impingement distance. In this case, the initial momentum of the jet is spread across the cross-section of the pipe, and a two-phase mixture which is essentially homogeneous has been created.

It will be evident that since the jet expands slowly with distance from the orifice (2), the impingement distance and hence the height of the vertical pipe (3) could become excessive. One solution to this problem is to use a multiplicity of nozzles in a single vertical pipe, and dividing the flow between them, as shown in Figure 2a, in which the liquid is fed through an entry pipe (1) to a chamber (17), before issuing through a multiplicity of nozzles or orifices. The number of jets is determined by practical considerations, because the greater the number of jets, the smaller will be the jet diameter for a given flow rate, and the minimum jet size should be such that it will not become blocked by solids suspended in the liquid. The jet velocity is determined by the pressure in the chamber (17), and is therefore the same for each jet.

A further improvement can be made by the installation of vertical baffles in a multi-jet system, so as to confine each jet within its own interior vertical duct or draft tube, as shown in Figure 2a and 2b. Without such baffles, the individual jets are bounded mainly by the turbulent fluid in neighbouring jets, and in part by the

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wall of the confining pipe (3). The vertical baffles (20) provide a solid physical boundary which fixes the region of energy dissipation around each jet, and assists it to perform its task of dividing up the entrained gas into fine bubbles. The area of each section (21) of the cross-sectional area of the pipe confined by the vertical baffles (20), should be approximately the same.

Note that in Figure 2a, the nozzles (2) are shown mounted on the lower extremity of short pipes (22), being similar in construction to the single orifice case depicted in Figure 1. The purpose of the pipe piece (22) is to allow the jets to commence at a level within the pipe (3), which is below the air entry line (6). In operation, the containing pipe (3) may fill with dense foam up to the level of the entry point of the jet, and hence liquid may flow back up the air line (6), in which solids may be deposited. Accordingly, it is desirable for the individual liquid injection nozzles (2) to be below the air inlet pipe (6).

The performance of the bubble dispersion system can be enhanced in various ways depending on the interfacial properties of the gas-liquid system. In order for a stable two-phase mixture to fill the vertical pipe (3), it is necessary that there should be little coalescence of the bubbles as they are forced to flow downwards toward the exit (5). Where coalescence occurs, very small bubbles aggregate with others and grow into bubbles so large that they may bridge the pipe (3), and cause collapse of the two-phase mixture within the pipe.

Coalescence is prevented or inhibited by the presence of salts, dissolved matter and especially surface-active agents dissolved in the liquid, as well as the presence of particles of solid or insoluble liquids such as oils and greases. Since the properties of each gas-liquid system will be different, it is unlikely that any single bubble dispersion device will be optimum for all cases, and it may be necessary to modify the design to cope with individual circumstances. A number of modifications

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incorporating the invention are now described which may be usefully employed.

Figure 3 shows an arrangement in which the jet is enclosed by a draft tube (30) in the form of an open-ended cylinder, which extends down the axis of the vertical pipe at least as far as the impingement point described above, where the jet has expanded to occupy the full cross-sectional area of the draft tube. The purpose of the draft tube (30) is to restrict the volume of gas-liquid mixture in the immediate vicinity of the jet, so as to intensify the rate at which energy is dissipated per unit volume of fluid, leading to smaller bubbles in the vertical pipe (3). The diameter of the draft tube can conveniently be in the range 2 to 10 times the nozzle diameter, with satisfactory operation being found in the range 3 to 8 times the nozzle diameter.

The upper end of the draft tube may conveniently be left open, or for ease of construction, it can be made in the form of a cylindrical pipe attached to the head of the pipe (3) as shown in Figure 3, with a communicating opening (31) being provided above the level of entry of the liquid jet, in order to enable gas to recirculate around the draft tube.

In a variation on this improvement, the draft tube may be pierced with holes (32) which may occupy up to 20% of the outer area of the tube over any operable area of the tube wall. The purpose of these holes is to permit circulation of gas which may return to the head space of the vertical pipe (3) due to coalescence of the bubbles, while at the same time providing sufficient integrity to the draft tube to have a substantial confining action on the fluid within it.

Another variation which has been found useful is depicted in Figure 4, which shows a draft tube which is mounted within the vertical pipe (3). The top of the draft tube is placed near the exit orifice (2) and the sides of the upper part of the tube (41) are sloping so that its area increases to a point with increasing

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distance down the vertical pipe (3). At a convenient mid-point (42), the area of the draft tube begins to contract with distance down the pipe, and the lower part (43) of the tube terminates at a convenient point so that the area of the tube exit is larger than the cross-sectional area of the liquid jet at the same level. The purpose of this form of draft tube, which first expands and then contracts in area, is to permit any large bubbles or slugs of gas which may have formed lower down in the vertical pipe (3), to rise and bypass the jet, and then be re-entrained through the entrance (45). Another form of this type of draft tube is shown in Figure 5, in which the draft tube at its widest point essentially forms a seal against the inner wall of the vertical pipe (3). Thus any large bubbles which have risen up the walls of the pipe (3) are trapped in the annular space (44) between the draft tube and the pipe, and are re-entrained through the ring of openings (45) located immediately beneath the widest part of the draft tube (44).

The alternative configuration shown in Figure 6 is intended where minor coalescence takes place, and the bubbles are not so large as to cause collapse of the two-phase medium within the vertical pipe (3), but which may benefit from further exposure to the high-speed jet. In this alternative, the draft tube first contracts in area as distance increases down the pipe (3), to reach a minimum at the point (52), below which it increases in area. The cross-sectional area of the open tube at the point (52) should be greater than the area of the expanding liquid jet. Annular spaces (53) and (54) may be left between the draft tube and the inner wall of the pipe (3), or the draft tube may be sealed within the pipe (3).

The dimensions of the vertical pipe (3) or of a constant cross-section draft tube (30) relative to the diameter of the jet, have an important bearing on the operation of the bubble dispersing system. For satisfactory operation, it has been found that the diameter of the vertical pipe or draft tube should be in

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the range 2 to 20 times the nozzle diameter, with satisfactory operation being found in the range 3 to 12 times the nozzle diameter.

5 In many cases, the operating gas will be air at atmospheric pressure, and it is advantageous if the device can operate by drawing air from the atmosphere without the need for a blower or compressor. This can be achieved if the pressure in the vicinity of the jet orifice (2) is less than the atmospheric pressure.

10 In other situations, however, air may be supplied into the upper part of the conduit or pipe (3) under pressure via a blower or compressor. This arrangement may be applicable where it is desired to submerge the pipe (3) to a larger degree within the body of liquid (4), so
15 requiring a greater "head" within the top of the pipe (3) to cause the foam to move downwardly within the pipe and issue from the lower end (5) against the pressure head in the body of liquid (4).

20 Although the invention has been described in one preferred form using air as the gas for "aeration" it will be appreciated that other gases may be used in certain situations where it is required to "aerate" a liquid with a gas other than air.

25 Although the invention has been described with reference to the aeration of wastewaters, it is also suitable for the flotation of mineral particles so as to remove the valuable minerals from unwanted waste matter, by contacting them with fine bubbles in a suspension of the mineral in water, so that the particles which it is
30 desired to remove have been rendered non-wetting by the liquid while the particles which are to remain in the liquid are rendered wettable by the liquid. The valuable particles then adhere to the surface of the fine bubbles and rise with them to the surface of the liquid, from
35 which they may be removed as a froth.

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CLAIMS:-

1. Apparatus for aerating liquids comprising a substantially vertically extending conduit having an open lower end, liquid supply means arranged to supply liquid under pressure to at least one downwardly facing nozzle located and arranged within the upper part of the conduit so as to form a downwardly issuing jet of liquid from the or each nozzle within the conduit, support means arranged to support the conduit with the lower end immersed in a body of liquid, and one or more draft tubes mounted within the conduit and aligned with the or each nozzle, the or each draft tube having its axis parallel to the axis of the conduit and being configured to direct the flow of gas within the conduit and/or constrain the jet within the conduit.

2. Apparatus as claimed in claim 1 wherein the draft tube has one or more holes through the wall of the tube positioned to allow gas rising within the conduit, between the conduit and the draft tube to reenter the draft tube via the holes.

3. Apparatus as claimed in claim 2 wherein the holes occupy up to 20% of the area of the wall of the draft tube in any operable area of the draft tube.

4. Apparatus as claimed in any one of claims 1 to 3 wherein each draft tube is of substantially constant cross-section throughout its length and has either a substantially circular cross-section or is of other cross-section having minor and major lateral axes of the same order and having an effective diameter equal to the diameter of a circle of equivalent area, and wherein the diameter of the draft tube is in the range 2 to 20 times the diameter of the nozzle.

5. Apparatus as claimed in claim 4 wherein the diameter of the draft tube is in the range 3 to 12 times the diameter of the nozzle.

6. Apparatus as claimed in any one of claims 1 to 3 wherein the draft tube has a relatively narrow upper end positioned adjacent the nozzle, flaring downwardly and

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outwardly to a relatively wide mid-section, and then tapering downwardly and inwardly, terminating in an open lower end wider than the upper end but narrower than the mid-section.

5 7. Apparatus as claimed in claim 6 wherein a single draft tube is provided within the conduit and wherein the outer periphery of the mid-section of the draft tube forms a seal against the inner periphery of the conduit.

10 8. Apparatus as claimed in claim 7 wherein holes are provided through the wall of the draft tube below the mid-section.

15 9. Apparatus as claimed in any one of claims 1 to 3 wherein the draft tube has a relatively wide upper end positioned adjacent the nozzle, tapering downwardly and inwardly to a relatively narrow mid-section, and then flaring downwardly and outwardly, terminating in an open lower end.

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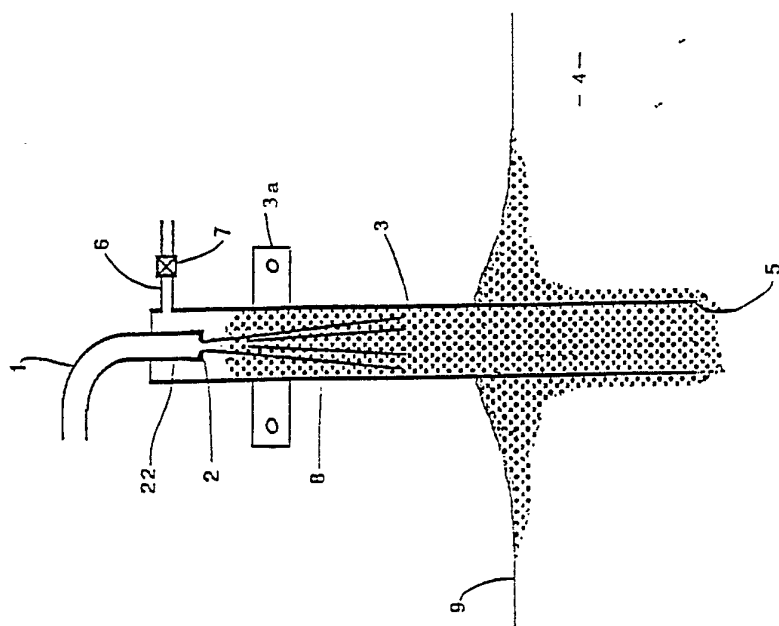


Figure 1

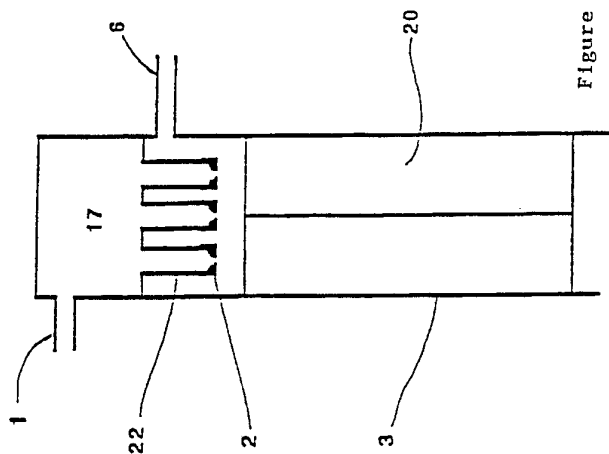


Figure 2(a)

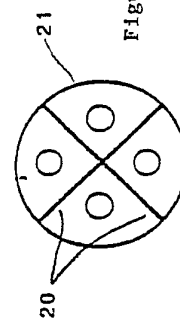


Figure 2(b)

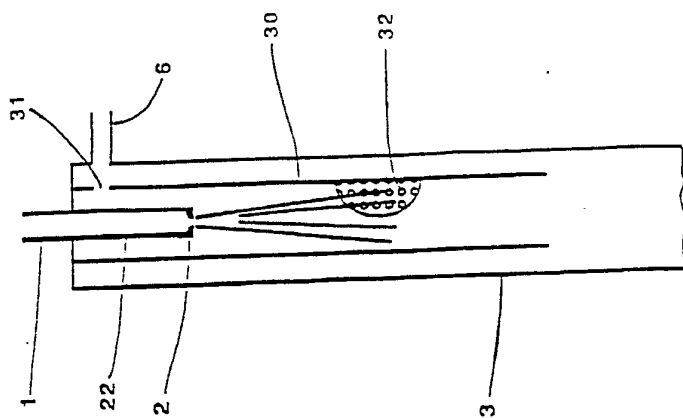


Figure 3

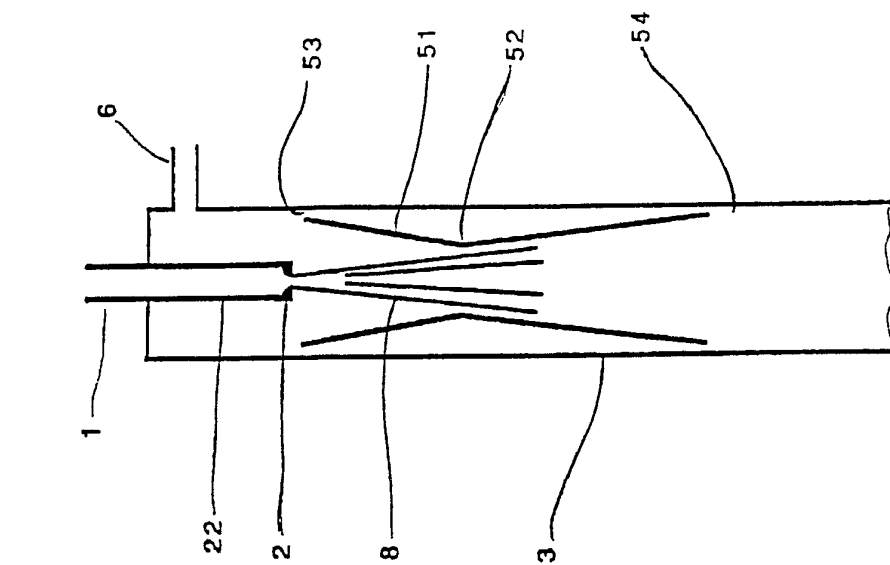


Figure 4

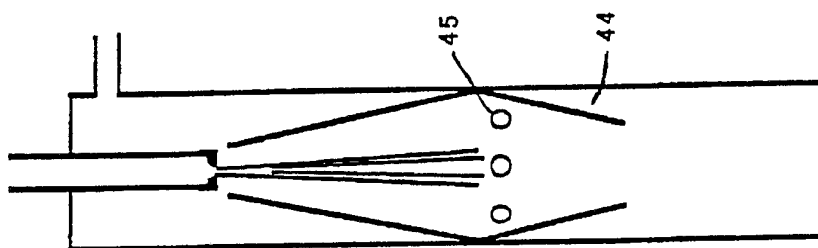


Figure 5

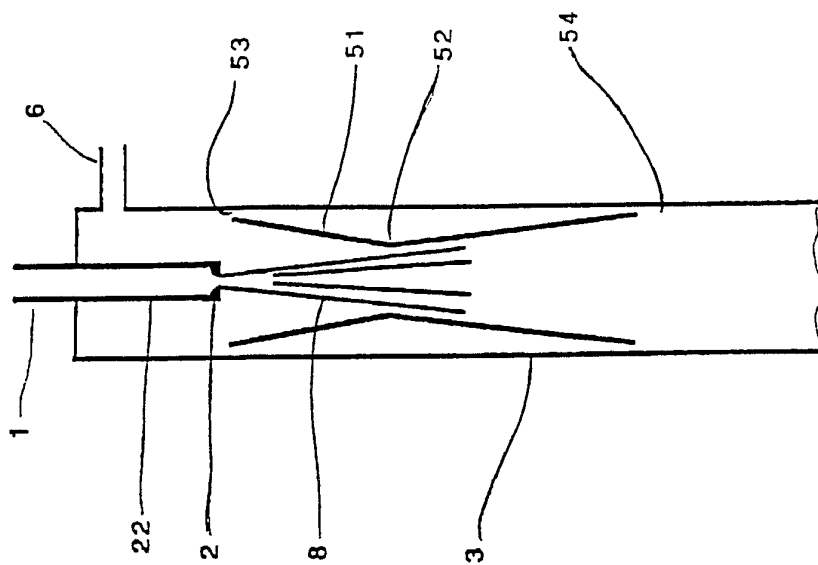
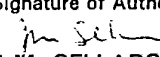


Figure 6

INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶				
According to International Patent classification (IPC) or to both National Classification and IPC Int. Cl. ⁵ B01F 3/04, B03D 1/14, 1/24, C02F 3/14, 3/16, 3/20, 7/00				
II. FIELDS SEARCHED				
Minimum Documentation Searched ⁷				
Classification System	Classification Symbols			
IPC	B01F 3/04, B03D 1/14, 1/24, C02F 3/14, 3/16, 3/20, 7/00			
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸				
AU : IPC as above, B01F 13/02, B01F 15/02, C02F 1/40				
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹				
Category [*]	Citation of Document, ¹¹ with indication, where appropriate of the relevant passages ¹²	Relevant to Claim No ¹³		
X	AU,B, 4645/39 (111958) (SUTHERLAND) 28 November 1940 (28.11.40) See Fig 1, column 1 line 25 - column 4 line 15.	(1,9)		
X	US,A, 4220612 (DEGNER et al) 2 September 1980 (02.09.80) See Figs 3,4, Col 3 line 54 - Col 6 line 30.	(1,4,5)		
A	US,A, 4100071 (BEURER et al) 11 July 1978 (11.07.78) See Fig 1, Col 3 line 18 - Col 4 line 56.	(1)		
A	EP,A, 261968 (JAMESON) 30 March 1988 (30.03.88) See Abstract, Fig 1.	(1)		
<p>[*] Special categories of cited documents : ¹⁰</p> <table border="0"> <tr> <td style="vertical-align: top;"> <p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="vertical-align: top;"> <p>"T" Later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p> </td> </tr> </table>			<p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" Later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
<p>"A" Document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" Later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>			
IV. CERTIFICATION				
Date of the Actual Completion of the International Search 29 November 1991 (29.11.91)		Date of Mailing of this International Search Report 16 December 91		
International Searching Authority AUSTRALIAN PATENT OFFICE		Signature of Authorized Officer  J.M. SELLARS		

**ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 91/00399**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	4220612	AU 25699/77	BR 7703775	CA 1078081	
		DE 2726578	ES 459760	FR 2354820	
		GB 1582193	IT 1080894	JP 52154175	
		NL 7706459	PT 66650	ZA 7703310	
		US 4226706	AU 14537/76	CA 1055622	
		DE 2624543	FR 2313127	GB 1537751	
		IT 1061391	JP 51147472	SE 7606175	
		US 4110210			
US	4100071	AT 9504/75	BE 849220	CH 600938	
		DE 2556522	DK 5435/76	FR 2334409	
		GB 1519390	IT 1124737	NL 7611606	
EP	261968	AU 79006/87	US 4938865	ZA 8707238	