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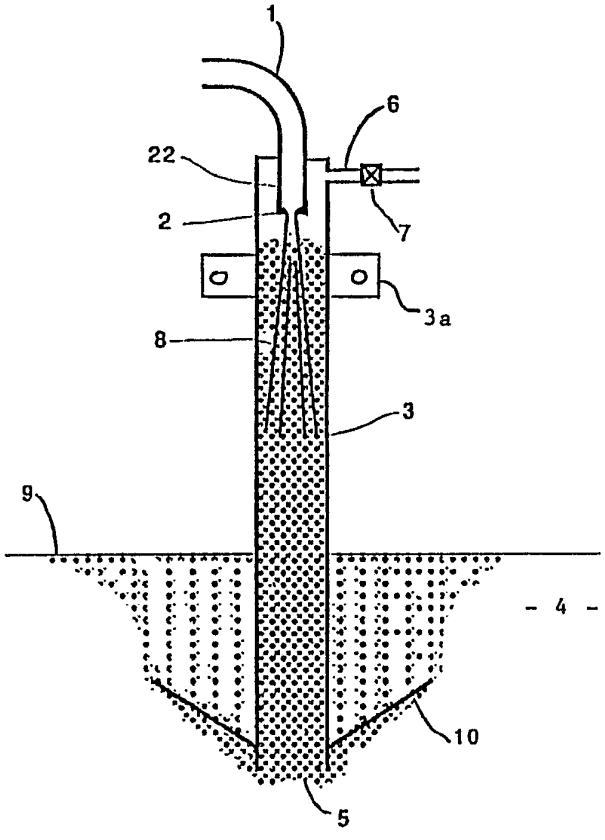
(54) Title: AERATION APPARATUS WITH DIFFUSER

(57) Abstract

Aeration apparatus in which a dense dispersion of bubbles is generated within a conduit or tube (3) having its lower end (5) immersed in a body of liquid (4) is provided with a diffuser plate (10) extending outwardly and upwardly from the outer periphery of the conduit (3), and immersed in the liquid (4). The diffuser plate (10) is typically conical or dish shaped and has a number of holes therethrough permitting bubbles to be released from the underside of the diffuser plate in an even dispersion through the holes into the body of liquid (4). Embodiments are also described wherein a gap is provided between the diffuser plate and the outer periphery of the conduit (3), allowing solids accumulating on the top surface of the plate to be dispersed through the gap.



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"AERATION APPARATUS WITH DIFFUSER"

TECHNICAL FIELD

This invention relates to an aeration apparatus which may be used in many diverse fields including the 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

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 gas-liquid mixture which forms in the pipe can have a voidage of up to 60 percent by volume approximately, and behaves as a homogeneous fluid whose density is much less than the liquid in which the pipe is immersed. Accordingly, in the absence of any special precautions, it tends to rise as a buoyant plume, hugging the outer wall of the pipe and rising rapidly to the surface of the liquid in which the pipe is immersed. Consequently, the bubbles in the plume do not mix well with the liquid and the possibility of optimising contact with this liquid is lost. The present invention aims to prevent the formation of the plume, by mounting a shield or diffuser outside the vertical pipe, which has the effect of breaking up the dense foam which issues from the pipe exit, and allowing the gas bubbles to rise individually in the liquid in the reservoir rather than as a plume.

DISCLOSURE OF INVENTION

Accordingly the present invention provides apparatus for aerating liquids wherein a dense dispersion of bubbles is emitted from the lower end of a substantially vertical conduit adapted to be immersed in use in a body of liquid, characterised by the provision of a diffuser extending outwardly from the exterior of the conduit and positioned

to be immersed in the body of liquid, the diffuser being arranged to disperse bubbles issuing from the lower end of the conduit outwardly away from the conduit as the bubbles rise in the body of liquid.

Preferably the diffuser comprises a plate surrounding the conduit and extending outwardly and upwardly from a predetermined position on the exterior of the conduit.

Preferably the plate is provided with a plurality of holes therethrough sized to allow a predetermined flow rate of bubbles through each hole.

Preferably a gap is provided between the inner periphery of the plate and the exterior of the conduit and a diverting ring is positioned on the exterior of the conduit below the gap, arranged to divert upwardly moving bubbles outwardly away from the conduit and away from the gap between the conduit and the plate.

BRIEF DESCRIPTION OF DRAWINGS

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 1a is a diagrammatic cross-sectional elevation through a basic form of aeration apparatus with diffuser according to the invention;

Figure 1b is a view similar to Figure 1a showing the behaviour of a bouyant plume of dense foam in the absence of a diffuser;

Figure 1c is a sectional plan view of the diffuser incorporated in the apparatus of Figure 1a;

Figure 2a is a cross-sectional elevation through the lower part of the conduit forming part of the apparatus of Figure 1a showing an alternative embodiment of the diffuser;

Figure 2b is a plan view of the diffuser shown in Figure 2a; and

Figure 3a and Figure 3b are diagrammatic cross-sectional elevations of alternative forms of diffuser.

MODES FOR CARRYING OUT THE INVENTION

Although the invention relates to any form of aeration apparatus in which a dense dispersion of bubbles is emitted from the lower end (5) of a downwardly extending conduit or pipe (3) immersed in a body of water (4), in the form of the invention shown in Figure 1a, liquid 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 orifice (2) in the form of a high-speed jet (8) which can move downwardly through the pipe (3).

The vertical pipe is mounted by way of support means (not shown) so that its lower end is submerged in a reservoir of liquid (4) having a surface (9). The liquid may or may not be identical in all respects to the liquid entering through the entry pipe (1).

Initially, the liquid levels in the reservoir and inside the vertical 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 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. Accordingly, new gas is drawn into the pipe through the air entry (6) and may be regulated by valve (7).

The gas-liquid mixture which forms in the vertical pipe (3) has a voidage of up to 60 percent by volume approximately, and behaves as a homogeneous fluid whose density is much less than the liquid in the reservoir (4). Accordingly, in the absence of any special precautions, it tends to rise as a buoyant plume, hugging the outer wall of the pipe (3) and rising rapidly to the

surface (9), as shown in Figure 1b. Consequently, the bubbles in the plume do not mix with the liquid in the reservoir, and the possibility of contact with this liquid is lost. To prevent the formation of the plume, it has been found advantageous to mount a shield or diffuser (10) outside the vertical pipe (3), which has the effect of breaking up the dense foam which issues from the pipe exit (5), and allowing the gas bubbles to rise individually in the liquid in the reservoir (4) rather than as a plume.

The bubble diffuser can conveniently be made from a plate in the form of a frustum of a cone, inverted so that the open end is uppermost. The cone is perforated with a multiplicity of holes (11) as shown in the alternative view, Figure 1c. In operation, the buoyant plume issuing from the exit (5) of the vertical pipe (3),rises and spreads over the underside of the diffuser (10), to pass through the individual holes (11) in the diffuser (10). After passing through the individual holes (11), the bubbles of gas rise individually through the liquid in the reservoir (4).

The diameter of the conical diffuser (10) shown in Figure 1c should be in the range 1.5 to 10 times the outer diameter of the pipe (3), with good practical results being found when the cone diameter is 2 to 3 times the pipe diameter. The half-angle of the cone from which the frustum is formed is conveniently in the range 30^{o} to 60^{o}. The diameter of the holes (11) can be in the range 1 to 30 mm, and the holes should be distributed evenly over the conical surface to give an open area in the range 1 to 15% of the area of the surface.

It is not necessary for the diffuser to be in the shape of a cone. Other shapes will perform as well, providing the elevation of the underside of the diffuser above the exit (5) of the vertical pipe (3), always increases as the radial distance from the axis of the pipe increases. If the underside of the diffuser surface is at any stage horizontal or tending to dip downwards as radial distance from the vertical pipe increases, there will be a

tendency for the bubbles to collect in this area and coalesce, and thereby form less surface area per unit of gas volume, which will reduce the efficiency of any contacting operation between the gas and the liquid.

An alternative form of the diffuser is shown in Figures 2a and 2b, where the diffuser (12) takes the shape of part of a circular dish, with holes (13) perforating the dish. The radius of curvature of the dish can conveniently be in the range 2 to 20 times the diameter of the vertical pipe (3), and the diameter of the diffuser (12) shown in Figure 2b should be in the range 1.5 to 20 times the outer diameter of the pipe (3), with good practical results being found when the diffuser diameter is 2 to 3 times the pipe diameter. The diameter of the holes (13) can be in the range 1 to 30 mm, and the holes can conveniently be distributed evenly over the surface to give a total area of the perforations in the range 1 to 20% of the area of the diffuser surface.

A difficulty which can arise with the diffuser arrangements as shown in Figures 1a and 2a is that solid matter which may have been suspended in the liquid in the reservoir, may tend to settle on the upper face of the diffuser (10) or (12) and build up into a thick layer which may block the holes (11) or (13). This possibility can be avoided by mounting the diffuser (10) or (12) so that an annular gap (15) exists between the diffuser and the pipe wall (3). The conical diffuser is advantageous in this application because it will provide a surface of constant angle to the horizontal, down which any solids which may have deposited on the upper surface may slide toward the axis of the cone. The half-angle of the cone, of which the diffuser is a frustum, should be such that the solids will slide toward the axis and hence fall through the annular gap (15).

It is advantageous to use a diverting ring (14) or (16) in conjunction with the annular space (15). The purpose of the diverting ring is to prevent the dense foam rising from the open end (5) of the pipe (3), from

entering the annular gap (15) and thereby evading the diffuser (10) or (12). The ring is mounted on the outer wall of the vertical pipe (3), and can conveniently be of triangular section (14) as shown in Figure 3a or of semi-circular section as in Figure 3b at (16).

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 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 which they may be removed as a froth.

CLAIMS:-

1. Apparatus for aerating liquids wherein a dense dispersion of bubbles is emitted from the lower end of a substantially vertical conduit adapted to be immersed in use in a body of liquid, characterised by the provision of a diffuser extending outwardly from the exterior of the conduit and positioned to be immersed in the body of liquid, the diffuser being arranged to disperse bubbles issuing from the lower end of the conduit outwardly away from the conduit as the bubbles rise in the body of liquid.

2. Apparatus as claimed in claim 1 wherein the diffuser comprises a plate surrounding the conduit and extending outwardly and upwardly from a predetermined position on the exterior of the conduit.

3. Apparatus as claimed in claim 2 wherein the plate is substantially circular in plan view having a diameter between 1.5 and 10 times the outer diameter of the conduit.

4. Apparatus as claimed in claim 3 wherein the diameter of the plate is between 2 and 3 times the outer diameter of the conduit.

5. Apparatus as claimed in any one of claims 2 to 4 wherein the plate is shaped to the frustrum of a cone having a half angle between 30^{o} and 60^{o}.

6. Apparatus as claimed in any one of claims 2 to 4 wherein the plate is dish shaped, having a radius of curvature between 2 and 20 times the outer diameter of the conduit.

7. Apparatus as claimed in any one of claims 2 to 6 wherein the plate is provided with a plurality of holes therethrough sized to allow a predetermined flow rate of bubbles through each hole.

8. Apparatus as claimed in claim 7 wherein the holes have a diameter between 1mm and 30mm.

9. Apparatus as claimed in either claim 7 or claim 8 wherein the total area of the holes is between 1% and 20% of the surface area of the plate.

10. Apparatus as claimed in any one of claims 2 to

9 wherein a gap is provided between the inner periphery of the plate and the exterior of the conduit.

11. Apparatus as claimed in claim 10 wherein a diverting ring is positioned on the exterior of the conduit below the gap, arranged to divert upwardly moving bubbles outwardly away from the conduit and away from the gap between the conduit and the plate.

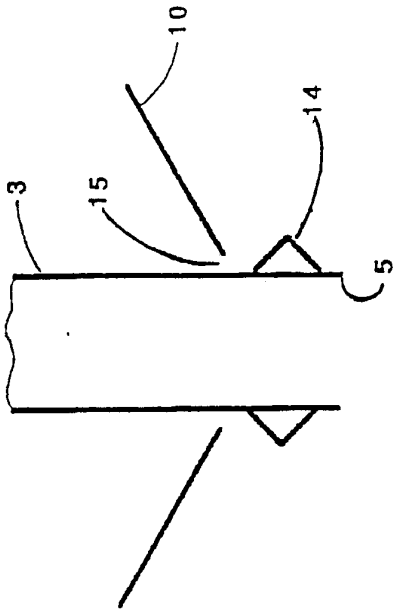

Figure 3(a)

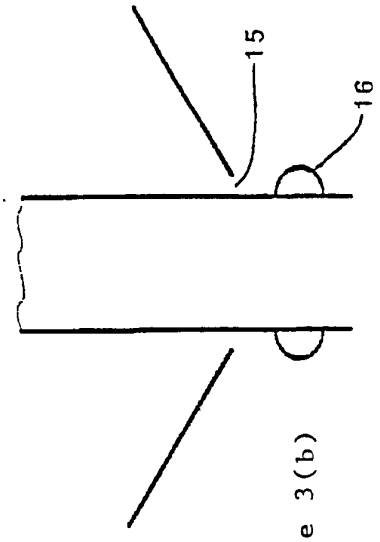

Figure 3(b)

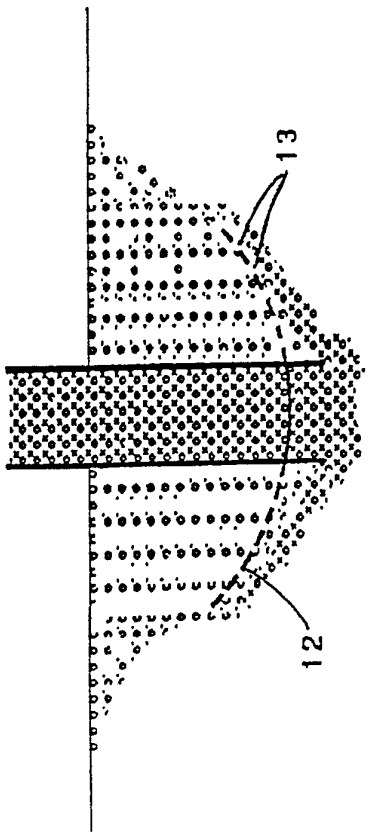

Figure 2(a)

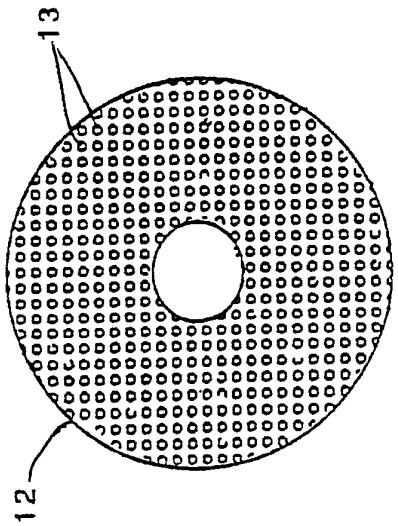

Figure 2(b)

1/2

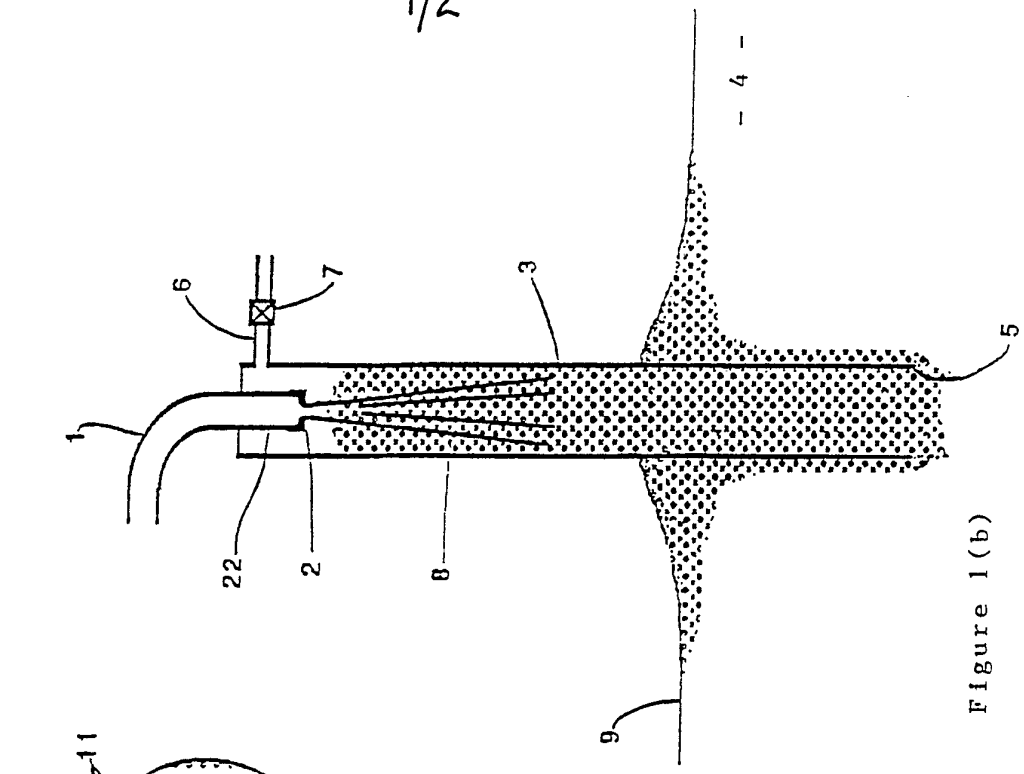

Figure 1(b)

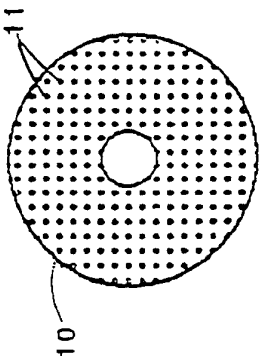

Figure 1(c)

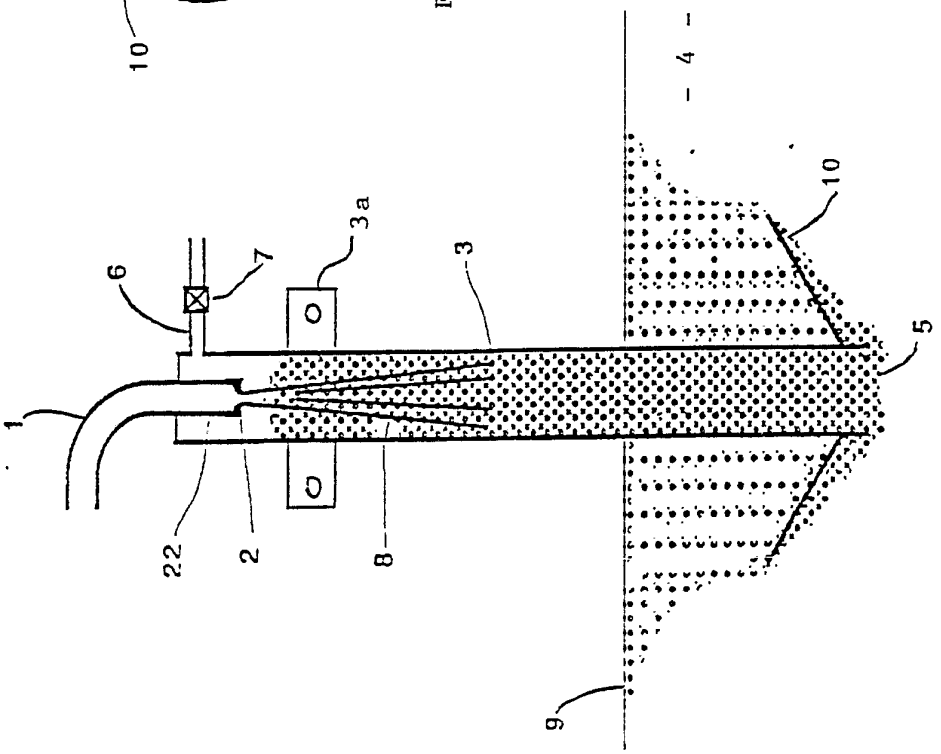

Figure 1(a)

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 Y	US,A, 4477341 (DORFLINGER et al) 16 October 1984 (16.10.84) See Fig 1, column 2 line 48 - column 3 line 33.	(1) (2-5)
X Y	US,A, 4534862 (ZLOKARNIK) 13 August 1985 (13.08.85) See Fig 1.	(1) (2-5)
X Y	US,A, 4564480 (KAMELMACHER) 14 January 1986 (14.01.86) See Figs 1,2, Col 2 line 28 - Col 4 line 11.	(1) (2-5)
Y	EP,A, 261968 (JAMESON) 30 March 1988 (30.03.88) See Fig 1, Abstract.	(1-5)

(continued)

* Special categories of cited documents : [10]

"A" Document defining the general state of the art which is not considered to be of particular relevance

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"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"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

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29 November 1991 (29.01.91)	16 December 91
International Searching Authority	Signature of Authorized Officer
AUSTRALIAN PATENT OFFICE	J.M. SELLARS

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	FR,A, 2437866 (CARBOXYQUE FRANCAISE) 30 April 1980 (30.04.80) See Fig 3.	(1-5)
Y	US,A, 4282172 (McKNIGHT) 4 August 1981 (04.08.81) See Figs 2,3, Col 4 line 28 - Col 6 line 60.	(1)
Y	US,A, 4863644 (HARRINGTON et al) 5 September 1989 (05.09.89) See Figs 1,2, Col 2 line 64 - Col 5 line 30.	(1-5)
Y	US,A, 4938899 (OROS et al) 3 July 1990 (03.07.90) See Figs 1,2, Col 2 line 21-49.	(1-5)
Y	DE,A, 1484829 (ECKERT) 29 May 1969 (29.05.69) See Fig 1, Claims 1-3.	(1-5)

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers ..., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4a

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00398

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	4477341	AT	3367/82	BE	894940	DE	3144386
		FI	823770	FR	2515987	GB	2108858
		IT	1191065	JP	58088062	SE	8206273
US	4534862	DE	3008476	EP	35243	ES	500066
		ES	8201443	JP	56150444	PH	17501
		ZA	8101424	US	4508546	AT	7361
		DE	3008589	EP	35705	ES	500123
		ES	8201433	JP	56136608	ZA	8101473
EP	261968	AU	79006/87	US	4938865	ZA	8707238