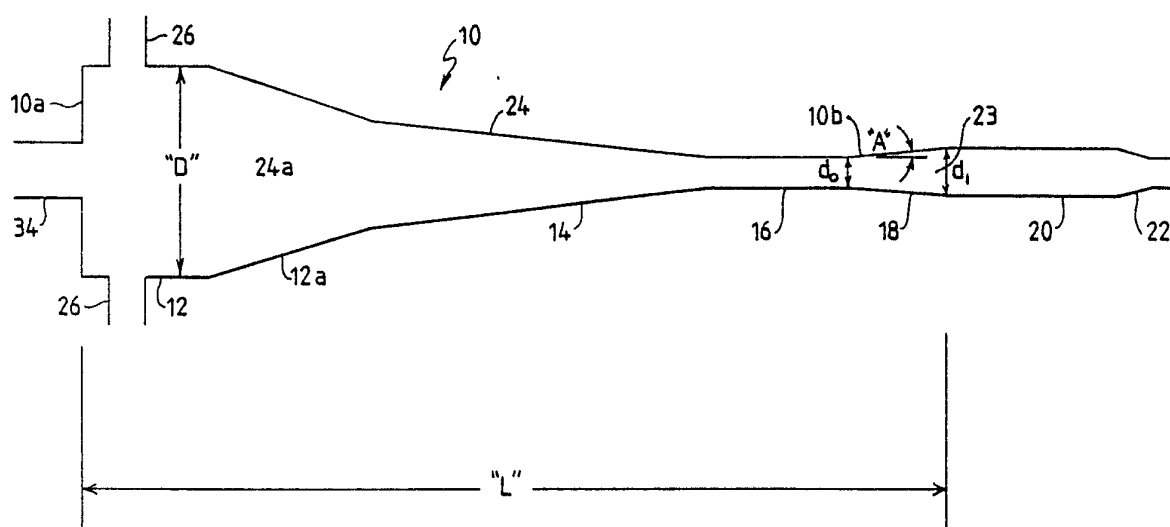




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>4</sup> :</b>  <b>B04C 5/14</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 87/ 06502</b>  <b>(43) International Publication Date:</b> 5 November 1987 (05.11.87)
<b>(21) International Application Number:</b> PCT/AU87/00118 <b>(22) International Filing Date:</b> 22 April 1987 (22.04.87) <b>(31) Priority Application Number:</b> PH 5594 <b>(32) Priority Date:</b> 23 April 1986 (23.04.86) <b>(33) Priority Country:</b> AU  <b>(71)(72) Applicant and Inventor:</b> CARROLL, Noel [AU/AU]; 'Strathalbyn', The Crescent, Sassafra, VIC 3787 (AU).  <b>(74) Agents:</b> LESLIE, Keith et al.; Davies & Collison, 1 Little Collins Street, Melbourne, VIC 3000 (AU).		<b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB, GB (European patent), IT (European patent), JP, LU (European patent), NL, NL (European patent), NO, SE (European patent), US.  <b>Published</b> <i>With international search report.</i>

**(54) Title:** CYCLONE SEPARATOR**(57) Abstract**

A cyclone separator (10) for separating oil from oily water and having a tapered separating chamber (24a) with tangential inlets (26), an axial overflow outlet (34), for separated oil, at the larger diameter end, and an axial underflow outlet (23), for separated water, at the smaller diameter end. An enlarged end portion (18) is provided at the underflow outlet (23) to facilitate separation.

***FOR THE PURPOSES OF INFORMATION ONLY***

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	ML	Mali
AU	Australia	GA	Gabon	MR	Mauritania
BB	Barbados	GB	United Kingdom	MW	Malawi
BE	Belgium	HU	Hungary	NL	Netherlands
BG	Bulgaria	IT	Italy	NO	Norway
BJ	Benin	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	LI	Liechtenstein	SN	Senegal
CH	Switzerland	LK	Sri Lanka	SU	Soviet Union
CM	Cameroon	LU	Luxembourg	TD	Chad
DE	Germany, Federal Republic of	MC	Monaco	TG	Togo
DK	Denmark	MG	Madagascar	US	United States of America
FI	Finland				

## CYCLONE SEPARATOR

This invention relates to cyclone separators.

The invention has particular, but not exclusive, application in liquid-separators, particularly separators for separating oil and water from an oil-water mixture such as of the kind described in International Application PCT/AU83/00028, United States patent specification 4,464,264, United States patent specification 4,576,724 or United States patent specification 4,237,006.

According to the invention there is provided a cyclone separator having an elongate separating chamber extending from a larger diameter end to a smaller diameter end, and having an overflow outlet at the larger diameter end, an underflow outlet at the smaller diameter end and inlet means, for inlet of fluid to be separated to the separating chamber,

at a lengthwise location at least adjacent the larger diameter end; wherein the underflow outlet leads to an axially extending end portion of the separator, through which, in use of the separator, outflow from the underflow outlet passes, said end portion extending from a smaller diameter end to a larger diameter end, the smaller diameter end of the end portion being closest to the larger diameter end of the separating chamber. Preferably, said end portion is of frustoconical form with conicity (half-angle) in the range  $6^{\circ}$  to  $20^{\circ}$ , preferably  $8^{\circ}$ .

The invention is further described by way of example only with reference to the accompanying drawing, the single figure of which is a cross sectional diagram of a cyclone separator constructed in accordance with the invention.

The exemplary cyclone separator shown comprises an outer casing 24 which defines an elongate separating chamber 24a therewithin. The separating chamber is axially symmetrical and of circular transverse cross section. Chamber 24a extends from a larger diameter end 10a of the separator to a smaller diameter end 10b of the separator. In this instance, the separating chamber defines a first portion 12 of cylindrical form, a second tapered portion 14, which tapered portion 14 in turn leads to a third portion 16 of cylindrical form. A tapered portion 12a extends between portions 12, 14. Portion 16 presents, at its end remote from portion 12, an underflow outlet 23. The portion 16 thence leads to an end portion 18 of the separator. The separating chamber 24a has an underflow outlet 23, for the denser fluid, this being located at the end of portion 16 remote from the larger diameter end

10a of the separator. The separating chamber 24a also has one or more tangential fluid inlets 26 positioned adjacent the larger diameter end of the separator and an axial overflow outlet 34 arranged at the larger diameter end (for outflow of the less dense of the components of the fluid to be separated).

The separator 10 is designed specifically, in this particular instance, for separation of oil from an oil-water mixture, the mixture being admitted via inlets 26, the separated water being taken off via outlet 23 and the separated oil being taken off via outlet 34. Separators of this or other type suitable for separating liquid components one from the other are generally designed to ensure relatively low shear stress within the liquid as it is moving within the separating chamber 24a. International Application PCT/AU83/00028, United States patent specification 4,464,264, Australian patent specification 84713/82 and United States patent specification 4,237,006 describe cyclone separators effective for separating oil from an oily water mixture where water predominates. These disclose particular configurations and dimensional constraints applicable to this type of separator. Generally, these separators are characterized by having relatively long length to diameter ratio, for example the diameter  $d_1$  at the larger diameter end of the separator may be related to the overall length of the separator so that the overall length "L" is at least five times the diameter  $d_1$ . More particularly, the separator may be characterised by the following:

$$10 \leq l_2/d_2 \leq 25$$
$$.04 \leq 4A_1/\pi d_1^2 \leq 0.10$$

$$d_0/d_2 < 0.25$$

$$d_1 > d_2$$

$$d_2 > d_3, \quad \text{where } d_1, d_2, d_3 \text{ and}$$

5  $l_1, l_2, l_3$  are the diameters and lengths of the first portion 12, second portion 14 and third portion 16, respectively,  $A_i$  is the total cross sectional area of the or of all of the inlets 26 measured at the points of entry normal to the inlet flow, and  $d_0$  is the diameter of the outlet 34.

10 Where provided, the tapered portion 12a may have a taper whose conicity (half-angle) is  $10^\circ$ . The portion 14 may have a taper whose conicity (half-angle) is  $20'$  to  $1^\circ$ . Where a portion such as portion 14 is tapered, the respective diameter such as diameter  $d_2$  thereof in the above formulae is to be taken as the diameter thereof at the largest diameter end. These ratios are described in United States patents 4,576,724 and 4,237,006. In a particular form, disclosed in United States patent 20 4,576,724, the following relationship applies:

$$d_0/d_2 < 0.1.$$

25 The portion 18 is of frustoconical form increasing, away from the outlet 23 from a diameter  $d_3$  at the end closest the outlet 23 to a diameter  $d_4$  at the end remote therefrom. The conicity (half-angle) "A" of the portion 18 may be  $8^\circ$  and portion 18 may be of length  $l_4$  rather more than the smallest diameter  $d_3$  thereof such as  $l_4 < 30 \quad l_4/d_3 < 5$ . In accordance with conventional practice, the outlet 23 may be coupled such as via a pipe 20 through a suitable flow restricting means, or choke 22, which may be constructed in accordance with

the teachings of United States patent specification 4,464,264, or International Application PCT/AU83/00028 for outflow therefrom of the denser liquid (water in this instance) from the separator. Particularly, the flow restricting means may present a passageway 22a which is of generally frustoconical form decreasing in diameter away from the end portion 18 to a diameter at the end remote from the end portion 18 which is in the range  $1/3$  to  $2/3$  the diameter of the passageway 22a at the end adjacent end portion 18.

The provision of the portion 18 has been found to be particularly useful in that it permits a relative shortening of the length of the separator as compared with its diameter, as compared with what would be the case otherwise. As mentioned, separators for separating liquid components, particularly the aforementioned oily water mixtures, are generally characterized by being of relatively great length and the reduction in length achievable by use of the portion 18 is therefore of practical significance in enabling fitment of separators into confined spaces and, furthermore, in reducing manufacturing costs. The provision of the portion 18 is thought to facilitate operation by permitting recovery of a dynamic pressure head loss which normally occurs in the operation of separators of the kind in question. In particular, there will normally be a substantial static pressure loss from the inlets 26 to the outlet 23 of the separator, and the frustoconical configuration of the portion 18 aids in minimising this loss.

As described in International Application PCT/AU85/00010, the multiple tangential inlets 26

shown may be replaced by a single inlet of involute form.



## CLAIMS:

1. A cyclone separator having an elongate separating chamber extending from a larger diameter end to a smaller diameter end, and having an overflow outlet at the larger diameter end, an underflow outlet at the smaller diameter end and inlet means, for inlet of fluid to be separated to the separating chamber, at a lengthwise location at least adjacent the larger diameter end; wherein the underflow outlet leads to an axially extending end portion of the separator, through which in use of the separator, outflow from the underflow outlet passes, said end portion extending from a smaller diameter end to a larger diameter end, the smaller diameter end of the end portion being closest to the larger diameter end of the separating chamber.

2. A cyclone separator as claimed in claim 1 wherein said end portion is of frustoconical form, with a conicity (half-angle) in the range of  $6^{\circ}$  to  $20^{\circ}$ .

3. A cyclone separator as claimed in claim 2 wherein the conicity (half-angle) of the end portion is substantially  $8^{\circ}$ .

4. A cyclone separator as claimed in claim 2 or claim 3 wherein the end portion is longer than the diameter thereof at the smallest diameter end of the end portion.

5. A cyclone separator as claimed in claim 4 wherein

$$1 < l_4/d_3 < 5,$$

where  $l_4$  is the length of the end portion and  $d_3$  is the diameter of the end portion at its smallest diameter end.

6. A cyclone separator as claimed in any preceding claim wherein said separating chamber comprises first, second and third chamber portions axially arranged in that order, the inlet means comprising at least one inlet open to the first portion, the overflow outlet and underflow outlet being arranged to axially outlet from the first portion and the third portion respectively, and wherein the first and third portions are of substantially cylindrical form and the second portion is of tapered form, wherein

$$\begin{aligned} 10 &\leq l_2/d_2 \leq 25 \\ .04 &\leq 4A_i / \pi d_1^2 \leq 0.10 \\ d_0/d_2 &< 0.25 \\ d_1 &> d_2 \\ d_2 &> d_3 \end{aligned}$$

where  $l_1$ ,  $l_2$  and  $l_3$  are the lengths of the first, second and third portions respectively,  $d_1$  and  $d_3$  are the diameters of the first and third portions respectively,  $d_2$  is the diameter of the second portion at its largest diameter end,  $d_0$

is the diameter of the overflow outlet and  $A_i$  is the total cross-sectional area for inflow of material to the separating chamber as presented by the inlet means and measured at the points of entry normal to inlet flow.

7. A cyclone separator as claimed in claim 6 including a tapered portion of the separating chamber, joining said first and second portions thereof.

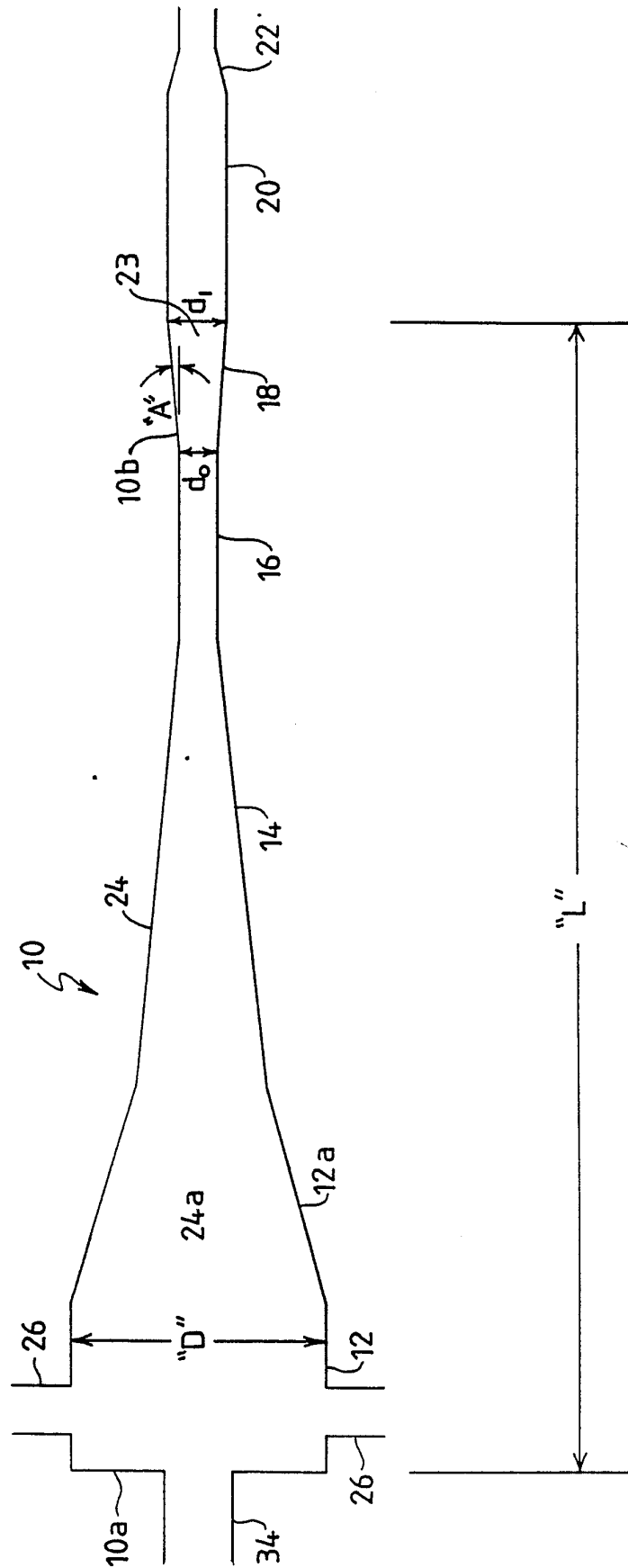
8. A cyclone separator as claimed in claim 6 or claim 7 wherein the conicity (half-angle) of the second portion is in the range  $20'$  to  $1^\circ$ .

9. A cyclone separator as claimed in any one of claims 6 to 8 wherein  $d_0/d_2 < 0.1$ .

10. A cyclone separator as claimed in any preceding claim including flow restriction means coupled to the larger diameter end of said end portion to restrict flow from the end portion.

11. A cyclone separator as claimed in claim 10 wherein said flow restricting means comprises a passageway which decreases in diameter away from said end portion to a diameter at the end of the passageway remote from said end portion which is in the range  $1/3$  to  $2/3$  of the diameter of the passageway adjacent said end portion.

FIG 1



# INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 87/00118

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) According to International Patent Classification (IPC) or to both National Classification and IPC <div style="text-align: center; font-size: 1.2em;">Int. Cl.<sup>4</sup>      B04C 5/14</div>																																									
<b>II. FIELDS SEARCHED</b> <div style="text-align: center; font-size: 0.8em;">Minimum Documentation Searched<sup>7</sup></div> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Classification System</td> <td style="width: 50%; border: none;">Classification Symbols</td> </tr> <tr> <td style="text-align: center; padding: 10px 0;">IPC</td> <td style="text-align: center; padding: 10px 0;">B04C 5/14</td> </tr> </table> <div style="text-align: center; font-size: 0.8em;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched<sup>8</sup></div> <div style="padding: 10px 0;">AU : IPC as above</div>			Classification System	Classification Symbols	IPC	B04C 5/14																																			
Classification System	Classification Symbols																																								
IPC	B04C 5/14																																								
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b> <table style="width: 100%; border: none;"> <tr> <th style="width: 10%; font-size: 0.8em;">Category<sup>10</sup></th> <th style="width: 70%; font-size: 0.8em;">Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup></th> <th style="width: 20%; font-size: 0.8em;">Relevant to Claim No. <sup>13</sup></th> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 27819/63 (291918) (COLLECTRON) 27 August 1964 (27.08.64)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5,10,11</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>US,A, 3501014 (FITCH et al) 17 March 1970 (17.03.70)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5,10,11</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>GB,A, 2011285 (TEXACO) 11 July 1979 (11.07.79)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5,10,11</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>US,A, 3716137 (FRYKHULT) 13 February 1973 (13.02.73)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5 10</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 63071/60. (250915) (CSIRO) 2 May 1963 (02.05.63)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5,10</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 21481/77 (506959) (NRDC) 27 July 1978 (27.07.78)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 10359/52 (159274) (DORR) 31 July 1952 (31.07.52)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 7296/52 (153946) (STAMICARBON) 13 March 1952 (13.03.52)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 5909/51 (157382) (STAMICARBON) 10 January 1952 (10.01.52)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>AU,B, 7079/55 (204955) (FREEMAN et al) 25 August 1955 (25.08.55)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>US,A, 3489286 (ESTABROOK) 13 January 1970 (13.01.70)</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>D. Bradley "The Hydrocyclone", published 1965 by Pergamon Press, see pages 152 &amp; 153</td> <td style="text-align: center; vertical-align: top;">1,2,3,4,5</td> </tr> </table> <div style="text-align: right; padding-top: 10px;">CONTINUED</div>			Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>	X	AU,B, 27819/63 (291918) (COLLECTRON) 27 August 1964 (27.08.64)	1,2,3,4,5,10,11	X	US,A, 3501014 (FITCH et al) 17 March 1970 (17.03.70)	1,2,3,4,5,10,11	X	GB,A, 2011285 (TEXACO) 11 July 1979 (11.07.79)	1,2,3,4,5,10,11	X	US,A, 3716137 (FRYKHULT) 13 February 1973 (13.02.73)	1,2,3,4,5 10	X	AU,B, 63071/60. (250915) (CSIRO) 2 May 1963 (02.05.63)	1,2,3,4,5,10	X	AU,B, 21481/77 (506959) (NRDC) 27 July 1978 (27.07.78)	1,2,3,4,5	X	AU,B, 10359/52 (159274) (DORR) 31 July 1952 (31.07.52)	1,2,3,4,5	X	AU,B, 7296/52 (153946) (STAMICARBON) 13 March 1952 (13.03.52)	1,2,3,4,5	X	AU,B, 5909/51 (157382) (STAMICARBON) 10 January 1952 (10.01.52)	1,2,3,4,5	X	AU,B, 7079/55 (204955) (FREEMAN et al) 25 August 1955 (25.08.55)	1,2,3,4,5	X	US,A, 3489286 (ESTABROOK) 13 January 1970 (13.01.70)	1,2,3,4,5	X	D. Bradley "The Hydrocyclone", published 1965 by Pergamon Press, see pages 152 & 153	1,2,3,4,5
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>																																							
X	AU,B, 27819/63 (291918) (COLLECTRON) 27 August 1964 (27.08.64)	1,2,3,4,5,10,11																																							
X	US,A, 3501014 (FITCH et al) 17 March 1970 (17.03.70)	1,2,3,4,5,10,11																																							
X	GB,A, 2011285 (TEXACO) 11 July 1979 (11.07.79)	1,2,3,4,5,10,11																																							
X	US,A, 3716137 (FRYKHULT) 13 February 1973 (13.02.73)	1,2,3,4,5 10																																							
X	AU,B, 63071/60. (250915) (CSIRO) 2 May 1963 (02.05.63)	1,2,3,4,5,10																																							
X	AU,B, 21481/77 (506959) (NRDC) 27 July 1978 (27.07.78)	1,2,3,4,5																																							
X	AU,B, 10359/52 (159274) (DORR) 31 July 1952 (31.07.52)	1,2,3,4,5																																							
X	AU,B, 7296/52 (153946) (STAMICARBON) 13 March 1952 (13.03.52)	1,2,3,4,5																																							
X	AU,B, 5909/51 (157382) (STAMICARBON) 10 January 1952 (10.01.52)	1,2,3,4,5																																							
X	AU,B, 7079/55 (204955) (FREEMAN et al) 25 August 1955 (25.08.55)	1,2,3,4,5																																							
X	US,A, 3489286 (ESTABROOK) 13 January 1970 (13.01.70)	1,2,3,4,5																																							
X	D. Bradley "The Hydrocyclone", published 1965 by Pergamon Press, see pages 152 & 153	1,2,3,4,5																																							
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top; font-size: 0.8em;"> <sup>10</sup> Special categories of cited documents:  <sup>14</sup> "A" document defining the general state of the art which is not considered to be of particular relevance  <sup>15</sup> "E" earlier document but published on or after the international filing date  <sup>16</sup> "L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  <sup>17</sup> "O" document referring to an oral disclosure, use, exhibition or other means  <sup>18</sup> "P" document published prior to the international filing date but later than the priority date claimed             </td> <td style="width: 50%; vertical-align: top; font-size: 0.8em;"> <sup>19</sup> "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  <sup>20</sup> "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step  <sup>21</sup> "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.  <sup>22</sup> "A" document member of the same patent family             </td> </tr> </table>			<sup>10</sup> Special categories of cited documents: <sup>14</sup> "A" document defining the general state of the art which is not considered to be of particular relevance <sup>15</sup> "E" earlier document but published on or after the international filing date <sup>16</sup> "L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) <sup>17</sup> "O" document referring to an oral disclosure, use, exhibition or other means <sup>18</sup> "P" document published prior to the international filing date but later than the priority date claimed	<sup>19</sup> "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 <sup>20</sup> "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step <sup>21</sup> "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. <sup>22</sup> "A" document member of the same patent family																																					
<sup>10</sup> Special categories of cited documents: <sup>14</sup> "A" document defining the general state of the art which is not considered to be of particular relevance <sup>15</sup> "E" earlier document but published on or after the international filing date <sup>16</sup> "L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) <sup>17</sup> "O" document referring to an oral disclosure, use, exhibition or other means <sup>18</sup> "P" document published prior to the international filing date but later than the priority date claimed	<sup>19</sup> "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 <sup>20</sup> "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step <sup>21</sup> "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. <sup>22</sup> "A" document member of the same patent family																																								
<b>IV. CERTIFICATION</b> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;">                 Date of the Actual Completion of the International Search  <div style="text-align: center; font-size: 1.1em;">2 July 1987 (02.07.87)</div> </td> <td style="width: 50%; border: none; vertical-align: top;">                 Date of Mailing of this International Search Report  <div style="text-align: center; font-size: 1.1em;">(14-07-87) 14 JULY 1987</div> </td> </tr> <tr> <td style="width: 50%; border: none; vertical-align: top;">                 International Searching Authority  <div style="text-align: center; font-size: 1.1em;">Australian Patent Office</div> </td> <td style="width: 50%; border: none; vertical-align: top;">                 Signature of Authorized Officer  <div style="text-align: center;">                       A. HENDRICKSON                 </div> </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="text-align: center; font-size: 1.1em;">2 July 1987 (02.07.87)</div>	Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.1em;">(14-07-87) 14 JULY 1987</div>	International Searching Authority <div style="text-align: center; font-size: 1.1em;">Australian Patent Office</div>	Signature of Authorized Officer <div style="text-align: center;">                       A. HENDRICKSON                 </div>																																			
Date of the Actual Completion of the International Search <div style="text-align: center; font-size: 1.1em;">2 July 1987 (02.07.87)</div>	Date of Mailing of this International Search Report <div style="text-align: center; font-size: 1.1em;">(14-07-87) 14 JULY 1987</div>																																								
International Searching Authority <div style="text-align: center; font-size: 1.1em;">Australian Patent Office</div>	Signature of Authorized Officer <div style="text-align: center;">                       A. HENDRICKSON                 </div>																																								

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	AU,B, 47105/79 (521482) (NRDC) 6 December 1979 (06.12.79)	6,7,8,9
---	--	---------

Y AU,B, 84713/82 (559530) (VORTOIL) 6 January 1983 6,7,8,9  
(06.01.83)

## V. OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE

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 6.4(a).

## 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 AU 87/00118

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 Members			
US	3501014	DE	1929771	GB	1237167
GB	2011285	CA	1117034	DE	2849201
		US	4337068	US	4380105
				US	4316729
				ZA	7806322
US	3716137	CA	951650	DE	2013499
		GB	1280598	FR	2039041
AU	21481/77	CA	1096782	DE	2703610
		FR	2339437	GB	1527794
		JP	52097474	SE	7700856
		ZA	7700226	ES	455427
				IL	51300
				US	4148723
AU	47105/79	CA	1117441	GB	1583742
				US	4237006
AU	84713/82	CA	1191111	EP	68809
		JP	58030356	NO	822136
				GB	2102310
				US	4576724

END OF ANNEX