



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

(51) International Patent Classification <sup>5</sup> : C02F 1/16, B01D 45/08 // B63J 1/00	A1	(11) International Publication Number: <b>WO 93/02964</b> (43) International Publication Date: 18 February 1993 (18.02.93)
--	----	---

(21) International Application Number: PCT/DK91/00223

(22) International Filing Date: 9 August 1991 (09.08.91)

(71) Applicant (for all designated States except US): ALFA-LAVAL DESALT A/S [DK/DK]; Stamholmen 93, DK-2650 Hvidovre (DK).

(72) Inventors; and

(75) Inventors/Applicants (for US only) : ANDERSEN, Bo, Juul [DK/DK]; Mørdrupvej 82A, DK-3060 Espergærde (DK). WASSINI, Einar [DK/DK]; Carl E. Lentzvej 3, DK-2670 Greve Str. (DK).

(74) Agent: BUDDE, SCHOU &amp; CO. A/S; Sundkrogsgade 10, DK-2100 Copenhagen Ø (DK).

(81) Designated States: AT, AU, BB, BG, BR, CA, CH, CS, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MC, MG, MW, NL, NO, PL, RO, SD, SE, SU, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, NL, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, SN, TD, TG).

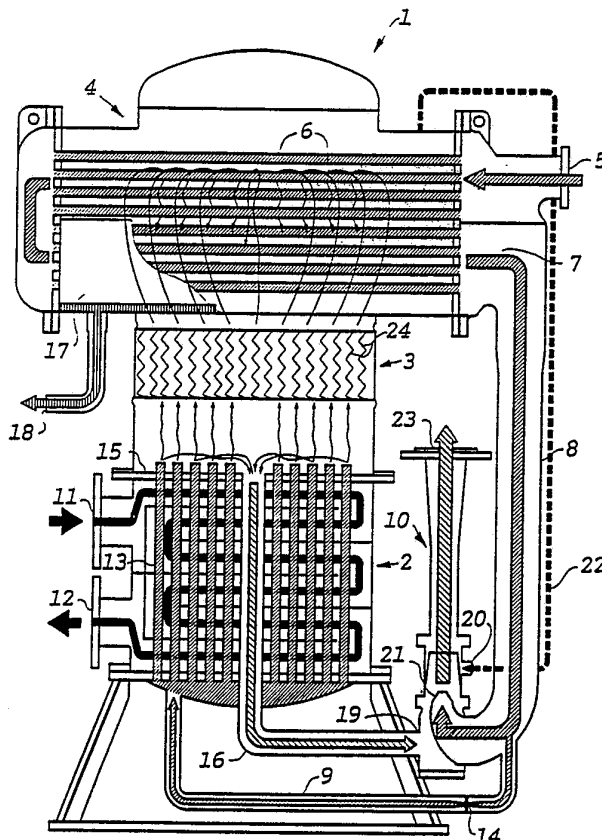
Published

With international search report.

(54) Title: DESALINATION PLANT, ESPECIALLY FOR USE IN MARINE AND OFF-SHORE INSTALLATIONS

## (57) Abstract

In a desalination plant (1) comprising an evaporator (2), a separator (3) for separating droplets of brine from the mixture of steam and such droplets produced by the boiling process in the evaporator (2), and a condenser (4) for condensing the steam into freshwater leaving the plant at an outlet (18), the novel feature is that the separator (3) is of a type with "distributed effect", e.g. consisting of a number of cells bounded by zig-zag baffles (24), each such cell performing a separating function. With this arrangement, the flow cross-sectional area and hence the horizontal space requirement of the separator (3) does not have to exceed that of the evaporator (2), in contrast to Prior-Art plants, in which the separator comprised a large inverted dish requiring much space to operate, as the centrifugal separating effect solely took place at its periphery.



**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	FI	Finland	MN	Mongolia
AU	Australia	FR	France	MR	Mauritania
BB	Barbados	GA	Gabon	MW	Malawi
BE	Belgium	GB	United Kingdom	NL	Netherlands
BF	Burkina Faso	GN	Guinea	NO	Norway
BG	Bulgaria	GR	Greece	NZ	New Zealand
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IE	Ireland	PT	Portugal
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	RU	Russian Federation
CG	Congo	KP	Democratic People's Republic of Korea	SD	Sudan
CH	Switzerland			SE	Sweden
CI	Côte d'Ivoire	KR	Republic of Korea	SK	Slovak Republic
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CS	Czechoslovakia	LK	Sri Lanka	SU	Soviet Union
CZ	Czech Republic	LU	Luxembourg	TD	Chad
DE	Germany	MC	Monaco	TG	Togo
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America

Desalination plant, especially for use in marine and off-shore installations.

TECHNICAL FIELD.

5 The present invention relates to a desalination plant of the kind set forth in the preamble of claim 1.

BACKGROUND ART.

10 In previously known desalination plants, the separator comprises a large inverted dish, forcing the flow of the mixture of steam and brine droplets from the evaporator to be diverted towards and around its peripheral edge, where a relatively sudden change of direction produces a centrifugal effect, thus separating the brine droplets from the steam.  
15 Since the centrifugal effect only takes place at the edge of the inverted dish separator, the dish has to be relatively large with a diameter of the order of 1.2 times the diameter of the outlet part of the evaporator. This means, of course, partly that the housing has to be large in order to accommodate the inverted dish separator, partly that the central region of the separator constitutes a "dead space", in which  
20 no effective separation takes place.

DISCLOSURE OF THE INVENTION.

25 It is the object of the present invention to provide a desalination plant of the type referred to initially, in which the above-mentioned "dead space" is eliminated, and in which the space requirement of the separator is considerably reduced, and this object is achieved with a desalination plant, according to the present invention also exhibiting the features set forth in the characterizing clause of  
30 claim 1.

35 With this arrangement, separation takes place over substantially the full flow cross-sectional area of the separator, for which reason the latter need not be larger than the outlet portion of the evaporator.

Advantageous embodiments of the desalination plant according to the invention, the effects of which will be evident from the following detailed portion of the present specification, are set forth in claims 2-5.

5

BRIEF DESCRIPTION OF THE DRAWINGS.

In the following specification, the present invention will be explained in more detail with reference to the drawings, in which

10 Figure 1 is a partly diagrammatic representation of an exemplary embodiment of a desalination plant according to the present invention, seen in vertical cross-section,

Figure 2 is a perspective view of a fragment of the separator used in the plant shown in Figur 1, and

15 Figure 3 shows a practical exemplary embodiment of the plant shown in Figure 1, seen in side view and with certain parts removed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS.

20 The desalination plant 1 shown diagrammatically in Figure 1 comprises three main components known in principle from previously known desalination plants, viz.

- an evaporator 2, adapted to heat seawater and keep it boiling so as to produce a mixture of steam (i.e. water vapour) and droplets containing sea salts in a considerably  
25 higher concentration than in the original seawater,
- a separator 3, adapted to separate droplets and steam coming from the evaporator 2 in such a manner that the droplets fall down and are collected as a small stream of  
30 brine, whereas the steam is allowed to continue upwards in the plant, and
- a condenser 4, adapted to cool the steam coming from the separator 3 so as to make this steam condense and form pure water.

35 Seawater is delivered to the plant at an increased pressure from a pump (not shown) through a seawater inlet

5, from which the relatively cool seawater flows into the tubes 6 of the condenser 4, thus providing the requisite cooling for the condensation of the steam being produced by the evaporator 2. During this process of heat exchange in the condenser 4 the seawater will necessarily be heated somewhat, thus leaving the condenser through a cooling-water outlet 7.

From the cooling-water outlet 7, the seawater, now in a preheated state, flows through a pipe 8, the lower end of which has a comparatively narrow branch in the form of a feed-water inlet tube 9, the main flow through the pipe 8 leading to the drive-nozzle in an ejector 10.

The portion of the seawater flowing through the feed-water inlet tube 9 enters the lower part of the evaporator 2 and flows upwardly through the evaporator tubes 13, the latter being heated by hot water, in the present case constituting cooling water from a diesel engine, such as the ship's propulsion engine, and flowing in through a jacket-water inlet 11 and out through a jacket-water outlet 12.

The supply of seawater through the feed-water inlet tube 9, the supply of hot water through the jacket-water inlet 11, and other operating conditions of the evaporator 2 are adjusted in a manner to provide so-called "rising-film evaporation" in order to provide optimum operating conditions and avoid or minimize the formation of scale.

The means for obtaining this adjustment may comprise a restricted orifice 14 placed within the feed-water inlet tube 9.

As mentioned before, the steam produced in the evaporator 2 continues upwardly to the separator 3, carrying with it a great number of the droplets formed during the process of boiling the water in the evaporator 2. Droplets in this manner reaching the separator 3 will be caught in same and agglomerated into larger drops or small streams, returning under the force of gravity towards the evaporator 2, on top of which they are intercepted by a brine-collecting

pan 15 and made to flow through a brine-outlet tube 16.

The pure water formed in the condenser 4 by the condensation of the steam formed in the evaporator 2 is collected by a condensate-collecting pan 17, from which it leaves the plant through a freshwater outlet 18. For reasons to become evident, this outlet has to deliver the freshwater through some means, such as a pump, preventing entry of air into the space inside the condenser 4.

During normal operation, the pressure in the intercommunicating spaces in the evaporator 2, the separator 3 and the condenser 4 is kept at a level considerably below normal atmospheric pressure. The purpose of this is to lower the boiling point of the sea water in the evaporator 2 to a point, where it can be made to boil easily by supplying so-called low-grade heat, in the present example heat from the cooling jacket of a diesel engine. It is the purpose of the ejector 10 to establish and maintain this lowered pressure. To this end, the ejector 10 comprises two suction inlets, viz. a liquid-suction inlet 19 and a gas-suction inlet 20. The drive nozzle 21 of the ejector 10 is driven by the main stream of preheated sea water flowing through the pipe 8 from the cooling-water outlet 7 in the condenser 4.

In operation then, the seawater being pumped in through the sea water inlet 5 and flowing through the condenser 4, in which it is preheated while providing the requisite cooling effect for the condensation, will - except for the small proportion branched off into the feed-water inlet tube 9 - drive the ejector 10, the latter aspirating brine from the brine-outlet tube 16 through the liquid-suction inlet 19, at the same aspirating air and other uncondensable gases liberated in the evaporator 2 from the condenser 4 through a gas-suction tube 22 indicated in broken lines.

In this manner, the ejector 10 provides three functions at the same time, viz.

- the removal of brine resulting from the operation of the

evaporator 2,

- maintaining the desired low pressure to keep the boiling point down, and
- the removal of uncondensable gases that would otherwise collect in the condenser 4 and prevent it from operating.

As will be evident from Figure 1, there is only one seawater inlet, viz. the inlet 5, and one seawater outlet, viz. the seawater outlet 23 from the ejector 10 (also carrying with it brine and uncondensable gases). This feature makes the plant shown in Figure 1 considerably easier to install than plants having a greater number of seawater inlets and/or outlets.

From what has been stated above with regard to the pressure in the interconnected spaces in the evaporator 2, the separator 3 and the condenser 4, it will now be understood why the freshwater outlet 18 requires some form of means to prevent outside air from entering this space. Such means may as mentioned before be constituted by a suitable pump (not shown).

As already indicated in Figure 1, the separator 3 is effective over substantially the whole of its flow cross-sectional area in separating the droplets of brine from the steam in the mixture produced by the boiling process in the evaporator 2. This means, of course, that the flow cross-sectional area of the separator 3 can be of the same order of magnitude as, preferably equal to the flow cross-sectional area of at least the adjacent part of the evaporator 2.

Figure 2 shows a fragment of an example of a separator 3 capable of such a "distributed effect". To this end, the separator 3 consists of a number of cells arranged in rows, the major part of the walls of each cell being constituted by zig-zag-baffles 24, each having a number of protruding relief chevrons 25 producing such flow conditions in each cell, that the droplets of brine are deposited on the baffles 24 and trickle downwards to the lowermost, input side of the separator 3, from where they fall down onto the brine-col-

lecting pan 15 on top of the evaporator. The fragment shown in Figure 2 is in fact a fragment of a mist eliminator type T271 from Gesellschaft für Verfahrenstechnik Dinslaken mbH & Co. KG, DW-4220 Dinslaken, Germany, said mist eliminator  
5 having proved suitable for the present purpose. It will, however, be obvious that any type of separator being effective over substantially the full flow cross-sectional area may be used, provided, of course, that its operating parameters are otherwise suitable for this purpose.

10 Figure 3 shows a practical embodiment of a desalination plant of the type shown diagrammatically in Figure 4, but does not show the ejector 10 and the external interconnections between the main components of the plant.

Thus, Figure 3 shows the evaporator 2 with its dished  
15 bottom wall 26 resting, preferably secured to, a base 27 adapted to be mounted on a floor or a deck. On top of the evaporator 2 there is the separator 3 with its zig-zag baffles 24, and on top of this again is the condenser 4, the latter extending crosswise beyond the width of the cylindrical housing constituted by the outer walls of the components 2, 3 and 4, the protruding portions being housed in  
20 protruding housing parts 28. The top of the condenser 4 is closed by a dished top wall 29, so that the whole plant resembles a vertical boiler.

25 The active part of the separator 3, i.e. the part comprising the zig-zag baffles 24, is releasably secured inside the outer wall of the separator 3 by means of an inwardly protruding peripheral rim 30 formed in said outer wall and a bezel ring 31 releasably inserted into a peripheral groove 32 also formed in said outer wall.  
30

When for some reason or other it is necessary to  
remove the active part of the separator 3, this may be done by dividing the housing by dismantling a flange joint 33, thus gaining access to the bezel ring 31 and the active  
35 part of the separator 3 constituted by the zig-zag baffles 24.

Parts shown in Figure 3 having reference numbers not mentioned in the above description of Figure 3 have already been described in connection with Figure 1, to which reference is made.

5

10

15

20

25

30

35

List of Parts

1. desalination plant
2. evaporator
3. separator
- 5 4. condenser
5. seawater inlet
6. condenser tube
7. cooling-water outlet
8. pipe
- 10 9. feed-water inlet tube
10. ejector
11. jacket-water inlet
12. jacket-water outlet
13. evaporator tube
- 15 14. restricted orifice
15. brine-collecting pan
16. brine-outlet tube
17. condensate-collecting pan
18. freshwater outlet
- 20 19. liquid-suction inlet
20. gas-suction inlet
21. drive nozzle
22. gas-suction tube
23. seawater outlet
- 25 24. zig-zag-baffle
25. protruding relief chevron
26. dished bottom wall
27. base
28. protruding housing part
- 30 29. dished top wall
30. inwardly protruding peripheral rim
31. bezel ring
32. peripheral groove
33. flange joint

C L A I M S :

1. Desalination plant (1) of the type comprising
- a) an evaporator (2) adapted to convert water to be desalinated to a mixture of water vapour and entrained therein droplets containing dissolved solids in a raised concentration,
- b) a separator (3) placed above said evaporator (2) and adapted to separate said droplets from said water vapour, allowing the droplets to be collected and form a flow of brine leaving the plant through suitable outlet means (16) and the vapour to flow upwards into
- c) a condenser (4) placed above said separator (3) and adapted to condense said water vapour so as to form freshwater and to allow same to leave the plant through suitable outlet means (18), and
- d) means to supply water to be desalinated, heat for the evaporator and cooling effect for the condenser, as well as to remove uncondensable gases and maintain a suitable pressure within the intercommunicating spaces in the evaporator and the condenser,
- characterized in
- e) that said separator (3) is of a type with distributed effect, i.e. that at substantially all points on its full flow cross-sectional area it is capable of receiving said mixture to be separated on its inlet side facing the evaporator (2), of performing said separation between its inlet and outlet sides, of allowing the droplets separated out to fall down below it, and of allowing the water vapour to flow upwards to said condenser (4).
2. Desalination plant according to claim 1, characterized in that said separator (3) is of a type constituted by an assembly of separator cells each being adapted to perform the functions mentioned in claim 1, item e.
3. Desalination plant according to claim 1 or 2, characterized in
- a) that at least that part of its housing containing said

- separator (3) is generally circular-cylindrical,
- b) that said separator (3) has an outside wall extending between its inlet and outlet sides and of generally circular-cylindrical shape so as to fit snugly within said housing part,
- 5 c) that said housing is adapted to be opened by being divided at a location (33) between said evaporator (2) and said condenser (4), and
- d) that said housing part comprises means (30, 31, 32) for  
10 releasably securing the separator (3) in its operating position, said location (33) being so placed as to allow the separator (3) to be removed from the housing when opened.

4. Desalination plant according to claim 3, characterized in that the whole housing, possibly with the exception of protruding parts (28) containing portions of the condenser (4), is generally circular-cylindrical with substantially the same diameter as said housing part and comprises dished bottom (26) and top (29) walls, of which the  
15 bottom wall (26) is secured to or integral with a base (27) for mounting the plant on a floor or a deck.

5. Desalination plant according to claim 3 or 4, characterized in that said means (30, 31, 32) for releasably securing the separator in its operating position comprise

25 a) an inwardly protruding peripheral rim (30) in the wall of said housing part,

b) a peripheral groove (32) in the wall of said housing part at a distance below said rim (30) corresponding at least to the height of the separator (3), and

30 c) a bezel ring (31) adapted to fit into said groove.

1/3

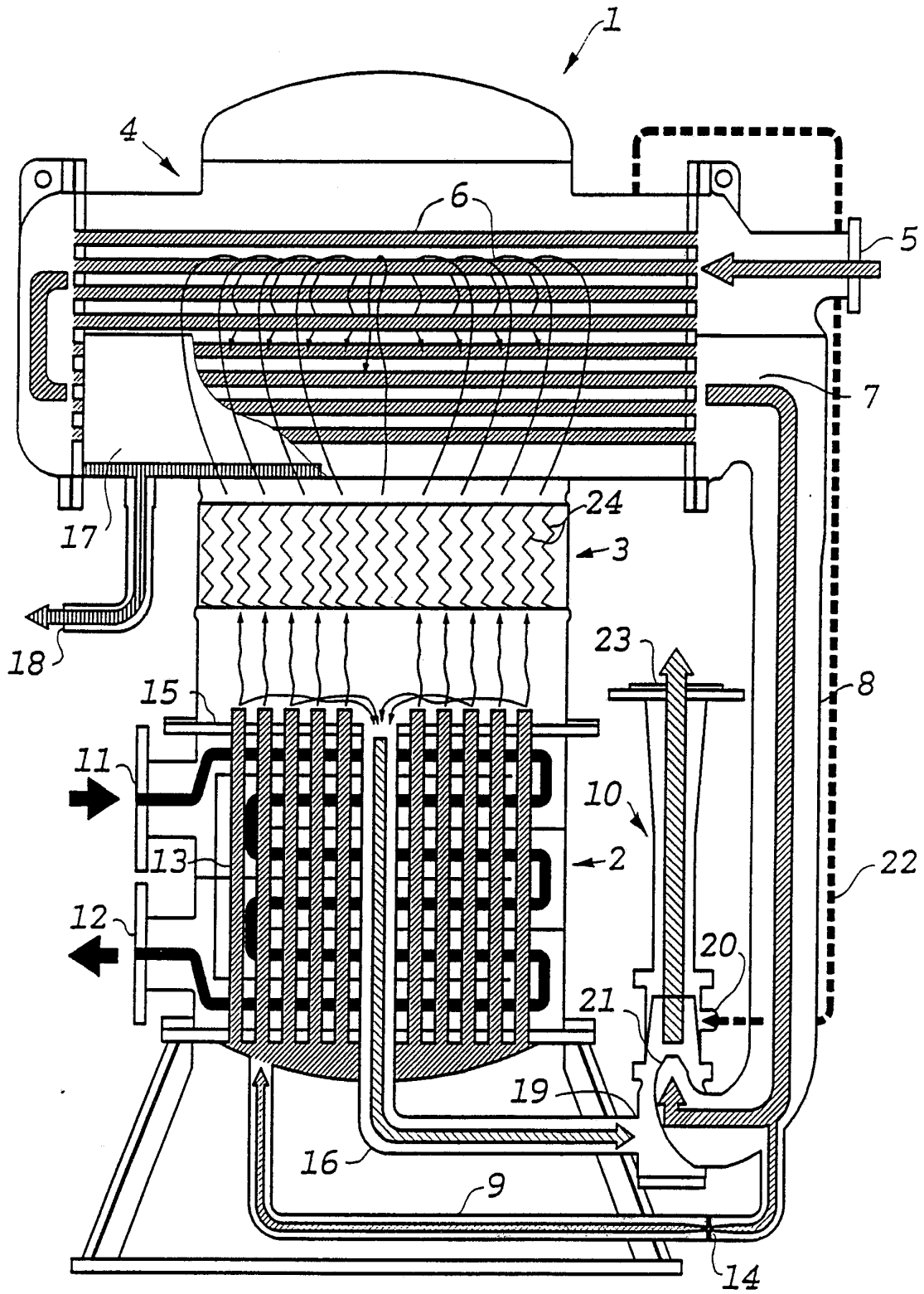


Fig.1

2/3

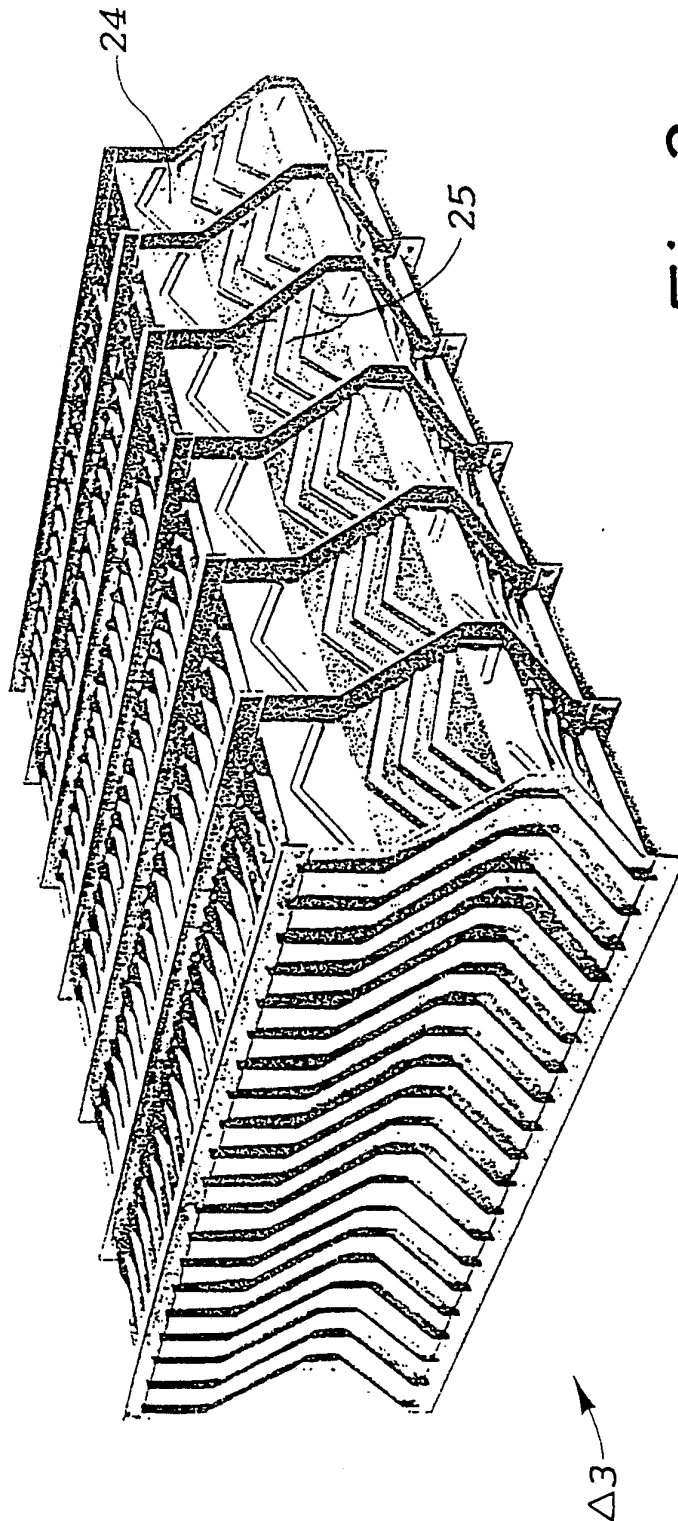


Fig. 2

3/3

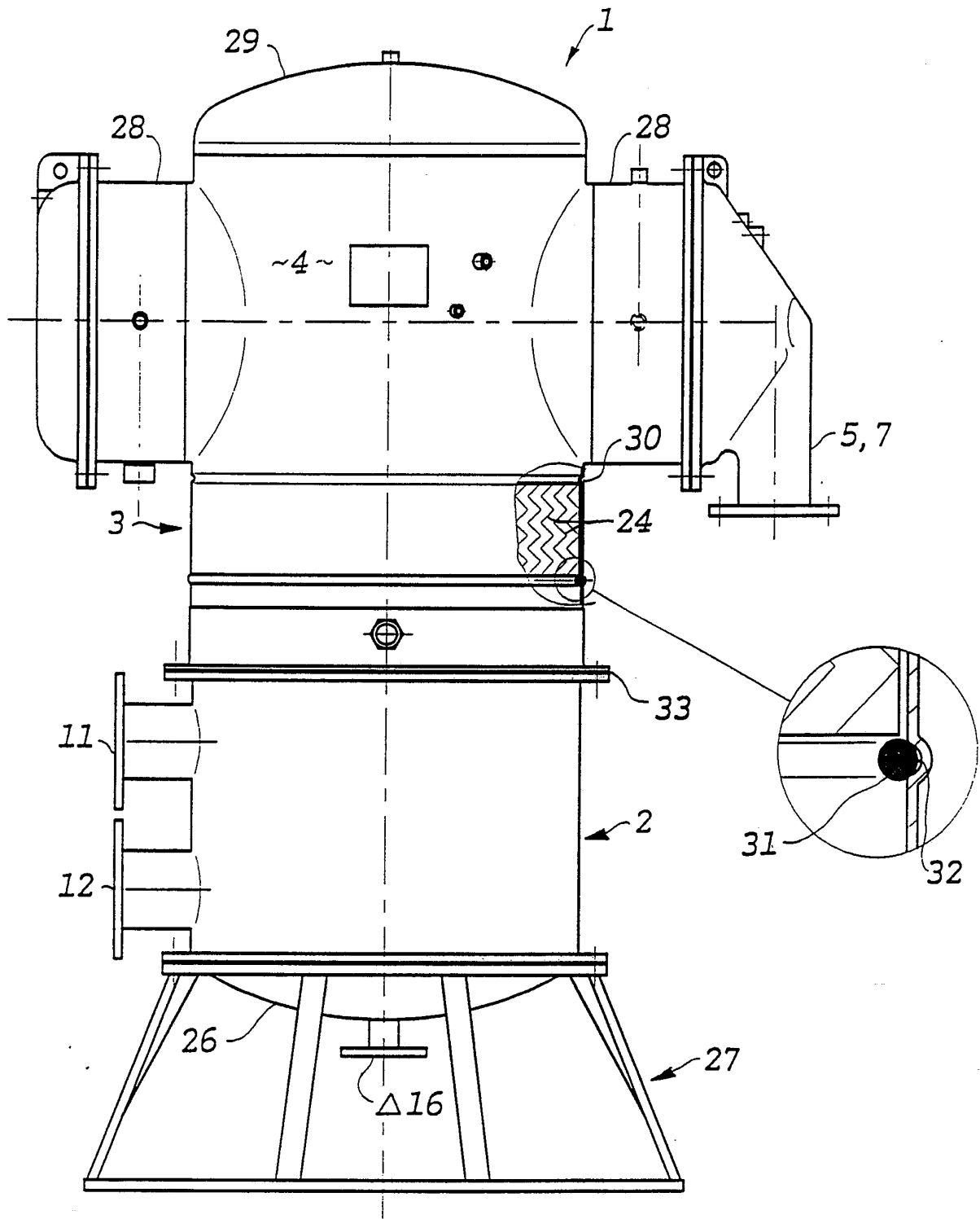



Fig.3

# INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 91/00223

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: C 02 F 1/16, B 01 D 45/08 // B 63 J 1/00		
<b>II. FIELDS SEARCHED</b> Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC5	B 01 D; C 02 F; B 63 J	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched <sup>8</sup>		
SE,DK,FI,NO classes as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category *	Citation of Document, <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	SE, B, 401323 (U REGEHR) 2 May 1978, see page 1, line 12 - line 14; page 2, line 18 - line 24; page 2, line 32 - page 3, line 1; figures 1,2  --	1-4
Y	SE, C, 211999 (AMERICAN MACHINE & FOUNDRY COMPANY) 4 April 1967, see page 1, column 2, line 13 - line 20; page 2, column 1, line 13 - line 19; page 2, column 1, line 43 - line 50; page 3, column 1, line 35 - line 38; page 3, column 1, line 53 - line 60; figure 2  --	1-4
A	GB, A, 2077604 (SERCK GMBH) 23 December 1981, see page 1, line 82 - line 106; figure 1  --	1-5
* Special categories of cited documents: <sup>10</sup> "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "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) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "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		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
5th March 1992	1992-03-10	
International Searching Authority	Signature of Authorized Officer	
SWEDISH PATENT OFFICE	 Bengt Christensson	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	EP, A1, 0211516 (KOCH ENGINEERING COMPANY INC) 25 February 1987, see page 2, line 1 - line 6; page 2, line 15 - line 20; figures 1,2; claim 1 --	1-5
A	EP, A1, 0074441 (PARMATIC FILTER CORPORATION) 23 March 1983, see page 11, line 8 - line 11; page 11, line 24 - line 34; figure 2 --	1-5
A	US, A, 3864215 (ALANSON J. ARNOLD) 4 April 1975, see figure 1 --	1-5
A	DE, C, 739470 (ATLAS-WERKE AKTIENGESELLSCHAFT) 27 September 1943, see figure 1 --	1-5
A	US, A, 1067010 (JOSEPH E. DUNN) 8 July 1913, see figure 1 -- -----	1-5

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.PCT/DK 91/00223**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on **30/12/91**.  
The Swedish 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	Publication date	Patent family member(s)	Publication date
SE-B- 401323	78-05-02	BE-A- 804775	74-01-02
		CA-A- 1010381	77-05-17
		CH-A- 561562	75-05-15
		DE-A-C- 2246475	74-04-11
		FR-A-B- 2200037	74-04-19
		GB-A- 1446604	76-08-18
		JP-C- 980242	79-12-18
		JP-A- 49093963	74-09-06
		JP-B- 54014778	79-06-09
		NL-A- 7312977	74-03-26
		US-A- 4072478	78-02-07
-----	-----	-----	-----
SE-C- 211999	67-04-04	NONE	
-----	-----	-----	-----
GB-A- 2077604	81-12-23	DE-A- 2952169	81-07-02
		EP-A- 0042844	82-01-06
		WO-A- 81/01839	81-07-09
-----	-----	-----	-----
EP-A1- 0211516	87-02-25	US-A- 4601731	86-07-22
-----	-----	-----	-----
EP-A1- 0074441	83-03-23	NONE	
-----	-----	-----	-----
US-A- 3864215	75-04-04	NONE	
-----	-----	-----	-----
DE-C- 739470	43-09-27	DE-C- 739469	00-00-00
		DE-C- 862752	00-00-00
		FR-A- 875589	00-00-00
-----	-----	-----	-----
US-A- 1067010	13-07-08	NONE	