PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B04B 5/08 | A1

(11) International Publication Number: **WO 99/56882**

(43) International Publication Date: 11 November 1999 (11.11.99)

(21) International Application Number: PCT/SE99/00694

(22) International Filing Date: 28 April 1999 (28.04.99)

(30) Priority Data:
9801567-0 4 May 1998 (04.05.98) SE

(71) Applicant *(for all designated States except US)*: ALFA LAVAL AB [SE/SE]; Hans Stahles väg, S-147 80 Tumba (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: BORGSTRÖM, Leonard [SE/SE]; Rönnbärsvägen 8, S-135 42 Tyresö (SE). CARLSSON, Claes, Göran [SE/SE]; Skogshemsvägen 63B, S-146 36 Tullinge (SE). FRANZÉN, Peter [SE/SE]; Månstorpsvägen 22, S-146 45 Tullinge (SE). INGE, Claes [SE/SE]; Kristinavägen 15, S-131 50 Saötsjö-Duvnäs (SE). LAGERSTEDT, Torgny [SE/SE]; Döbelnsgatan 89, S-113 52 Stockholm (SE). MOBERG, Hans [SE/SE]; Björngårdsgatan 16B, S-118 52 Stockholm (SE). SZEPESSY, Stefan [SE/SE]; Repslagargatan 18, S-118 46 Stockholm (SE). MYRVANG, Tommy [SE/SE]; Bergsunds Strand 7, S-117 38 Stockholm (SE).

(74) Agent: CLIVEMO, Ingemar; Alfa-Laval AB, S-147 80 Tumba (SE).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.

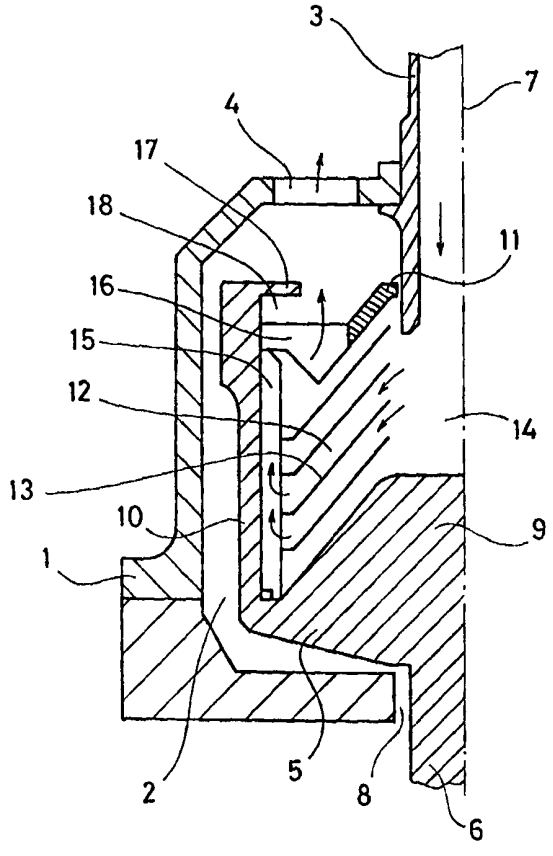
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

In English translation (filed in Swedish).

(54) Title: METHOD AND APPARATUS FOR CLEANING OF A GAS OR A GAS MIXTURE

(57) Abstract

Upon cleaning of a gas or a gas mixture from particles suspended therein a centrifugal rotor (5) is used having in its separation chamber a stack of frusto-conical separation discs (13). The gas or gas mixture is introduced into the rotor through a central inlet (3) and is conducted from the central part of the centrifugal rotor radially outwardly through interspaces between the separation discs (13). Gas having been freed from particles is conducted out of the rotor directly from the separation chamber through outlets (16) which are situated longer from the rotational axis (7) of the rotor than is the central inlet (3). Thereby, the gas or gas mixture need not be pressurised in order to be introduced into and pass through the centrifugal rotor.



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.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

Method and apparatus for cleaning of a gas or a gas mixture

The present invention relates to a method of cleaning a gas or a gas mixture from solid or liquid particles suspended therein by means of a centrifugal rotor rotating around a rotational axis and defining a separation chamber and having therein a stack of frusto-conical separation discs with radially inner and outer edges, which separation discs are arranged coaxially with the centrifugal rotor and axially spaced from each other, the gas or gas mixture being introduced into the centrifugal rotor through a central rotor inlet and then conducted through the interspaces between the separation discs in a direction from the rotational axis towards the radially outer edges of the separation discs.

There is a need for gas cleaning within many different areas and centrifugal rotors of different kinds have been proposed for obtainment of such cleaning. However, it seems to be unusual that centrifugal rotors containing conical separation discs have been used in connection with cleaning of gases. Centrifugal rotors of this kind are mainly used for separation and cleaning of liquids and for such separation and cleaning they have proved very effective.

It has now proved that a centrifugal rotor containing conical separation discs can give a very good separation result also in connection with cleaning of a gas or a gasmixture from solid or liquid particles suspended therein. However, a centrifugal rotor of this kind intended for liquid is not directly suitable for gas cleaning. Thus, a centrifugal rotor of the kind shown in US-A 2,578,485 would give an undesirably large through flow resistance for a gas flowing therethrough, although a centrifugal rotor of this kind has been suggested to be used also for gas cleaning. As a rule, it is desired in connection with gas cleaning that a gas or a gas mixture to

be cleaned can be supplied to the used cleaning equipment at a pressure as low as possible, preferably without having to be pressurised.

The object of the present invention is to provide a method of cleaning a gas or a gasmixture by means of a centrifugal rotor of the initially defined kind, comprising a stack of frusto-conical separation discs, which method can be carried out without the gas or the gas mixture having to be at an overpressure when introduced into the centrifugal rotor.

This object can be a achieved according to the present invention in that a gas or a gas mixture, having flowed through the interspaces between the separation discs and become freed from particles, is conducted out of the centrifugal rotor directly from the separation chamber at a distance from the rotational axis of the centrifugal rotor, said distance being larger than the distance between the rotational axis and the rotor inlet. It is meant hereby that the gas or the gas mixture should be conducted out of the centrifugal rotor without first being returned to central parts thereof. Hereby, a centrifugal rotor may be given a large capacity without having to be made too big and without the gas or gas mixture having to be pressurised before being introduced into the centrifugal rotor.

Preferably, the separation discs are utilised to a maximum by gas or gas mixture being conducted between the separation discs all the way from their radially inner edges to their radially outer edges. It is further suitable to conduct the gas or gas mixture freed from particles out of the centrifugal rotor at a radial level corresponding substantially to that of the radially outer edges of the separation discs. For this reason the centrifugal rotor preferably is provided with a large number of outlet openings in this area, distributed around the rotational axis of the centrifugal rotor.

The invention also concerns a gas cleaning apparatus for cleaning of a gas or a gas mixture from solid or liquid particles suspended therein. A gas cleaning apparatus of this kind comprises a centrifugal rotor of the aforementioned kind, which in addition to an outlet for cleaned gas or gas mixture also, preferably, has an outlet for particles having been separated from the gas or gas mixture, e.g. a liquid outlet for a continuous phase of liquid having been formed in the centrifugal rotor by separated liquid particles having coalesced.

The invention is further described in the following with reference to the accompanying drawing, which in figures 1 and 2 shows different embodiments of a gas cleaning apparatus according to the invention. Details corresponding to each other have the same reference numerals in the two figures.

Figure 1 shows schematically a gas cleaning apparatus according to the invention. It comprises a stationary housing 1 delimiting a chamber 2. The housing 1 supports centrally a likewise stationary inlet pipe 3 and has an outlet opening 4 or several such outlet openings distributed around the inlet pipe 3.

A centrifugal rotor 5, which is supported at the top of a vertical driving shaft 6, is arranged in the chamber 2, rotatable around a vertical rotational axis 7. The driving shaft 6 extends out of the chamber 2 through an opening 8 in the lower part of the housing 1.

The centrifugal rotor 5 has a lower end wall 9, a surrounding wall 10 and an upper end wall 11. These walls delimit in the centrifugal rotor a separation chamber 12, in which there is placed a stack of frusto-conical separation discs 13 concentric with the centrifugal rotor 5.

The separation discs 13 are kept axially spaced from each other by means of spacing members (not shown), so that interspaces are formed there between for through flow of gas to be cleaned.

Centrally in the stack of separation discs 13, i.e. radially inside the inner edges of separations discs, there is formed an inlet chamber 14. The aforementioned stationary inlet pipe 3 extends into the inlet chamber 14 through a central opening in the upper end wall 11 of the centrifugal rotor and opens in the inlet chamber 14.

Between the radially outer edges of the separation discs 13 and the surrounding wall 10 there is left an annular space, in which several ribs or wings 15 extend axially, distributed around the stack of separation discs.

The upper end wall 11 of the centrifugal rotor has several outlet openings 16 distributed around the rotational axis 7 and placed at a distance therefrom which is substantially larger than the distance between the rotational axis 7 and the central inlet of the centrifugal rotor. The central inlet is represented in this case by the edge of the opening in the end wall 11, through which the inlet pipe 3 extends into the inlet chamber 14.

The surrounding wall 10 of the centrifugal rotor extends a distance also above the end wall 11 and has at its uppermost part an annular flange 17 extending inwardly towards the rotational axis 7. Axially between the flange 17 and the end wall 11 there is delimited an annular space 18, which communicates through the outlet openings 16 with the aforementioned annular space within the centrifugal rotor between the separation discs 13 and the surrounding wall 10.

The centrifugal rotor 5 in figure 1 is supposed to be drivable through its driving shaft 6 by any suitable means. It is presumed that necessary sealing members (not shown) are arranged between the driving shaft 6 and the housing 1 as well as between the upper end wall 11 of the centrifugal rotor and the inlet pipe 3. The gas cleaning apparatus according to figure 1 operates in the following manner.

After the centrifugal rotor 5 has been brought into rotation a gas (or a gas mixture), that is to be freed from particles suspended therein is introduced into the centrifugal rotor through the inlet pipe 3. Having entered the inlet chamber 14 the gas is distributed between the different interspaces between the separation discs 13 and flow further on therethrough. By its contact with the separation discs 13 and with the spacing members therebetween (not shown) the gas is caused to rotate at the speed of the centrifugal rotor while flowing in a direction away from the rotational axis 7. Members for entraining incoming gas in the rotation of the centrifugal rotor may be present also in the inlet chamber 14.

In the interspaces between the separation discs 13 particles suspended in the gas and being heavier than the gas are forced to move towards and into contact with the undersides of the separation disc 13. The gas having been freed from particles flows further on towards the outer edges of the separation discs and is guided, after it has passed these edges, axially upwardly between the ribs or wings 15 towards and out through the outlet openings 16 in the end wall 11. Through the outlet opening or openings 4 the cleaned gas flows further out of the housing 1.

The particles separated from the gas and having been thrown into contact with the undersides of the separation discs 13, slide on these undersides toward the outer edges of the separation discs. When arriving there they

are thrown further from these edges to the surrounding wall 10, on the inside of which they settle. If the particles or some of these are constituted by liquid-drops, they will coalesce and gradually form a continuous liquid phase on the inside of the surrounding wall 10. Thanks to the annular flange 17 separated liquid of this kind will remain in the centrifugal rotor, from which it can be removed in any suitable way either during the operation of the centrifugal rotor or upon interruption of the centrifugal rotor operation.

Since the outlet openings 16 of the centrifugal rotor 5 for cleaned gas rotating with the centrifugal rotor are situated at a radial level outside that at which gas entering the centrifugal rotor is caused to rotate with the centrifugal rotor, gas to be cleaned will be sucked from the inlet pipe 3 into the centrifugal rotor 5. In other words, the centrifugal rotor operation will create a certain under-pressure in the inlet pipe 3. Simultaneously, there is created a certain over-pressure around the centrifugal rotor 5 in the chamber 2. This means that the requirement for sealing between the inlet pipe 3 and the end wall 11 of the centrifugal rotor need not be particularly high. A leakage of gas through the slot between the inlet pipe 3 and the end wall 11 will occur, namely, in a direction from the chamber 2 to the interior of the centrifugal rotor, i.e. cleaned gas will flow into the centrifugal rotor. Uncleaned gas, thus, will not be able to leak the opposite way out into the clamber 2.

Figure 2 shows another embodiment of the gas cleaning apparatus according to the invention. This embodiment differs from that shown in figure 1 in the following respects.

The centrifugal rotor 5 in this case is journalled at its lower part in the stationary housing 1 by means of a bearing 19. Even at its upper part

the centrifugal rotor 5 is journalled in the housing 1 by means of a bearing 20. The centrifugal rotor 5 in figure 2 further has a different driving means than the centrifugal rotor in figure 1. Thus, the rotor has a partly hollow shaft 21, which extends downwardly and is arranged to receive pressurised air form a pressure source (not shown) situated outside the housing 1. The interior of the hollow shaft 21 communicates with two channels 22, which extend through the lower end wall 9 on diametrically different sides of the rotational axis 7 to the periphery of the centrifugal rotor. Here each of the channels 22 ends in a nozzle 23, which is facing in the circumferential direction of the rotor. Upon supply of pressurised air through the hollow shaft 21 to the channels 22 the centrifugal rotor will be brought into rotation by the reaction force actuating the centrifugal rotor when pressurised air is pressed out through the nozzles 23.

At its upper part the housing 1 is provided with an inlet 24 for gases to be freed from particles suspended therein. The inlet 24 opens into a chamber 25 surrounding the rotational axis 7 and communicating with the central inlet of the centrifugal rotor through the stationary inlet pipe 3. Between the outside of the inlet pipe 3 and inside of the end wall 11 of the centrifugal rotor there is shown a sealing member 26.

Even in the centrifugal rotor in figure 2 there is formed a space around the separation discs 13 between these and the surrounding wall 10. In this space separated particles may be collected and if the particles are constituted by liquid drops there is formed in this space, as illustrated in figure 2, a liquid body 27 having a cylindrical free liquid surface illustrated by a small triangle.

A number of axial channels 28 extend through the lower end wall 9 from the just mentioned space in the rotor to the outside thereof. The

channels 28 open into an annular, radially inwardly open groove 29 formed by an annular flange 30 on the underside of the rotor. Extending into the groove 29 is a so called paring pipe 31, which is supported by the lower part of the housing 1 in a way such that it can pare or pile liquid out of the groove 29 and conduct it to a reception place outside the housing 1. The flange 30 has a number of through holes 32 situated aligned with a channels 28, so that liquid may be conducted out of the rotor through the channels 28 during operation of the rotor without blocking the gas outlet 16, even if the discharge of liquid by means of the paring pipe 31 would fail. The flange 30 prevents unnecessary splashing of liquid in the chamber 2 as a consequence of the immersion of the paring tube 31 in the liquid present in the groove 29.

During interruption of the rotor operation liquid may run out of the rotor through the channels 28 and the groove 29 and further out of the housing 1 through a bottom outlet 33 therein.

The gas cleaning apparatus shown in figure 2 operates, apart from this, in the same way as that shown in figure 1.

It could be mentioned that, by use of the frusto-conical separations discs, the separation technique used in the gas cleaning apparatus according to the invention is the same as that used in connection with cleaning of liquid in a centrifugal rotor that is provided with this kind of separation discs. Therefore, for achievement of a god separation efficiency the previously mentioned spacing members between the separation discs are preferably formed in the way that can be seen from WO 90/05028, whereby it is achieved that particles separated in the interspaces between the separation discs are thrown out in a concentrated form from these interspaces to the surrounding wall 10 of the rotor mainly in limited areas

of the separation chamber, distributed around the rotational axis of the rotor. The gas having been freed from particles may then flow between these areas axially towards the gas outlet openings 16 with a reduced risk of already separated particles being entrained by the clean gas out of the rotor. Upon need, said areas of the separation chamber may be delimited by means of wings or ribs similar to the wings or ribs 15, which extend axially and radially in the way illustrated at 28a, 29a in figure 2 of said WO/90/05028.

Claims

1. Method of cleaning a gas or a gas mixture from solid or liquid particles suspended therein by means of a centrifugal rotor (5) rotating around a rotational axis (7), said rotor (5) delimiting a separation chamber (12) and having therein a stack of frusto-conical separation discs (13) with radially inner and outer edges, which separation discs are arranged coaxially with the centrifugal rotor and are axially spaced from each other, the gas or gas mixture being introduced into the centrifugal rotor through a central rotor inlet (3) and then conducted through the interspaces between the separations discs (13) in a direction from the rotational axis (7) towards the radially outer edges of the separations discs, c h a r a c t e r i z e d by conducting gas or gas mixture, having flowed through the interspaces between the separation discs (13) and been freed from particles, out of the centrifugal rotor directly from the separation chamber (12) at a distance from the rotational axis, which is larger than the distance between the rotational axis (7) and the rotor inlet (3).

2. Method according to claim 1, in which a gas or a gas mixture is conducted between the separation discs (13) from their radially inner edges to their radially outer edges.

3. Method according to claim 1 or 2, in which the gas or the gas mixture freed from particles is conducted out of the rotor at a radial level corresponding substantially to that of the radially outer edges of the separation discs (13).

4. Gas cleaning apparatus for cleaning of a gas or a gas mixture from solid or liquid particles suspended therein, comprising

- a centrifugal rotor (5) that is rotatable around a rotational axis (7) and delimits a separation chamber (12) ,

- an inlet member (3) adapted to conduct said gas or gas mixture into a central space (14) in the centrifugal rotor and

- a stack of frusto-conical separation discs (13) having radially inner and radially outer edges, which separation discs are arranged in the separation chamber (12) coaxially with the centrifugal rotor and axially spaced from each other, so that interspaces are formed between the separations discs, the central space (14) in the centrifugal rotor communicating with these interspaces between the separations discs (13) in the vicinity of their radially inner edges,

c h a r a c t e r i z e d i n

- that the centrifugal rotor (5) has at least one outlet (16) for gas or gas mixture having been feed from particles, which outlet communicates with the interspaces between the separation discs (13) at parts thereof situated in the vicinity of the radially outer edges of the separation discs and leads directly from the separation chamber (12) of the centrifugal rotor to the outside of the centrifugal rotor at a distance from said rotational axis (7), which is larger than the distance between the rotational axis (7) and the radially inner edges of the separation discs.

5. Gas cleaning apparatus according to claim 4, in which the centrifugal rotor (5) has a surrounding wall (10) surrounding the separations discs (13) at a radial distance from their outer edges.

6. Gas cleaning apparatus according to claim 4 or 5, in which the centrifugal rotor (5) has two end walls (9, 11) and the separations discs (13) are arranged axially between these end walls (9, 11), said outlet (16) for gas or gas mixture extending through one (11) of the end walls.

7. Gas cleaning apparatus according to claim 6, in which said outlet (16) for gas or gas mixture is constituted by several outlet openings distributed around the rotational axis (7) of the centrifugal rotor.

8. Gas cleaning apparatus according to claim 7, in which the outlet openings are placed at a radial level corresponding substantially to that of the radially outer edges of the separations discs (13).

9. Gas cleaning apparatus according to any one of claims 6-8, in which the centrifugal rotor has its said outlet (16) for cleaned gas at one (11) of said two end walls and has a liquid outlet (28) situated in the area of the other (9) of said two end walls.

10. Gas cleaning apparatus according to claim 9, in which the liquid outlet (28) is situated at a larger distance from the rotational axis (7) than is the outlet (16) for cleaned gas.

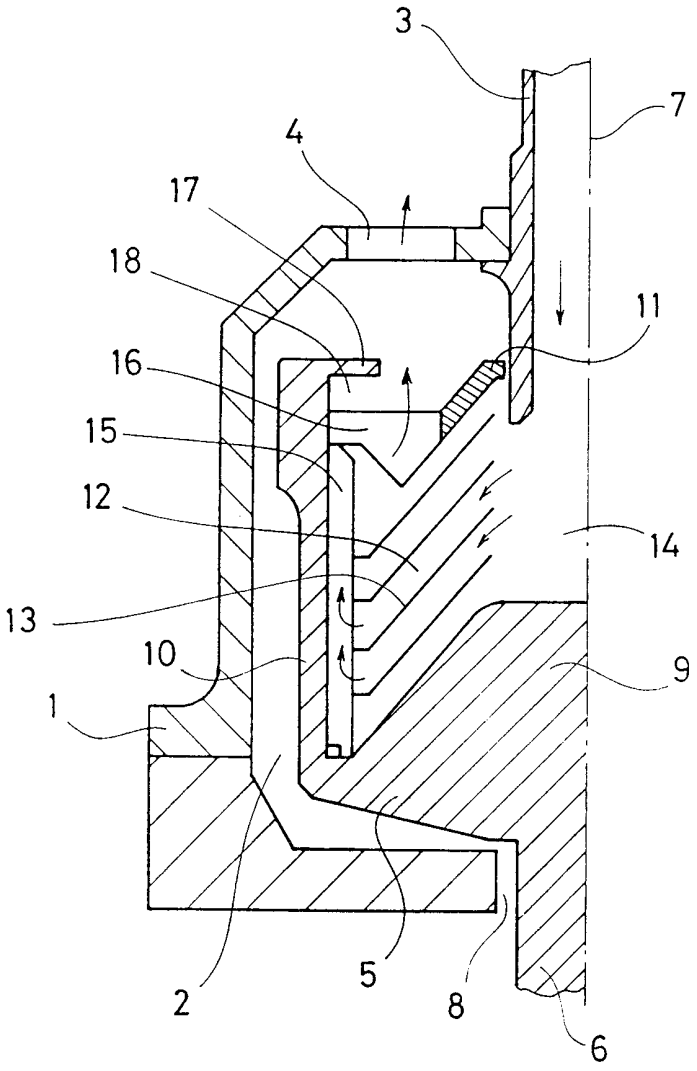


Fig. 1

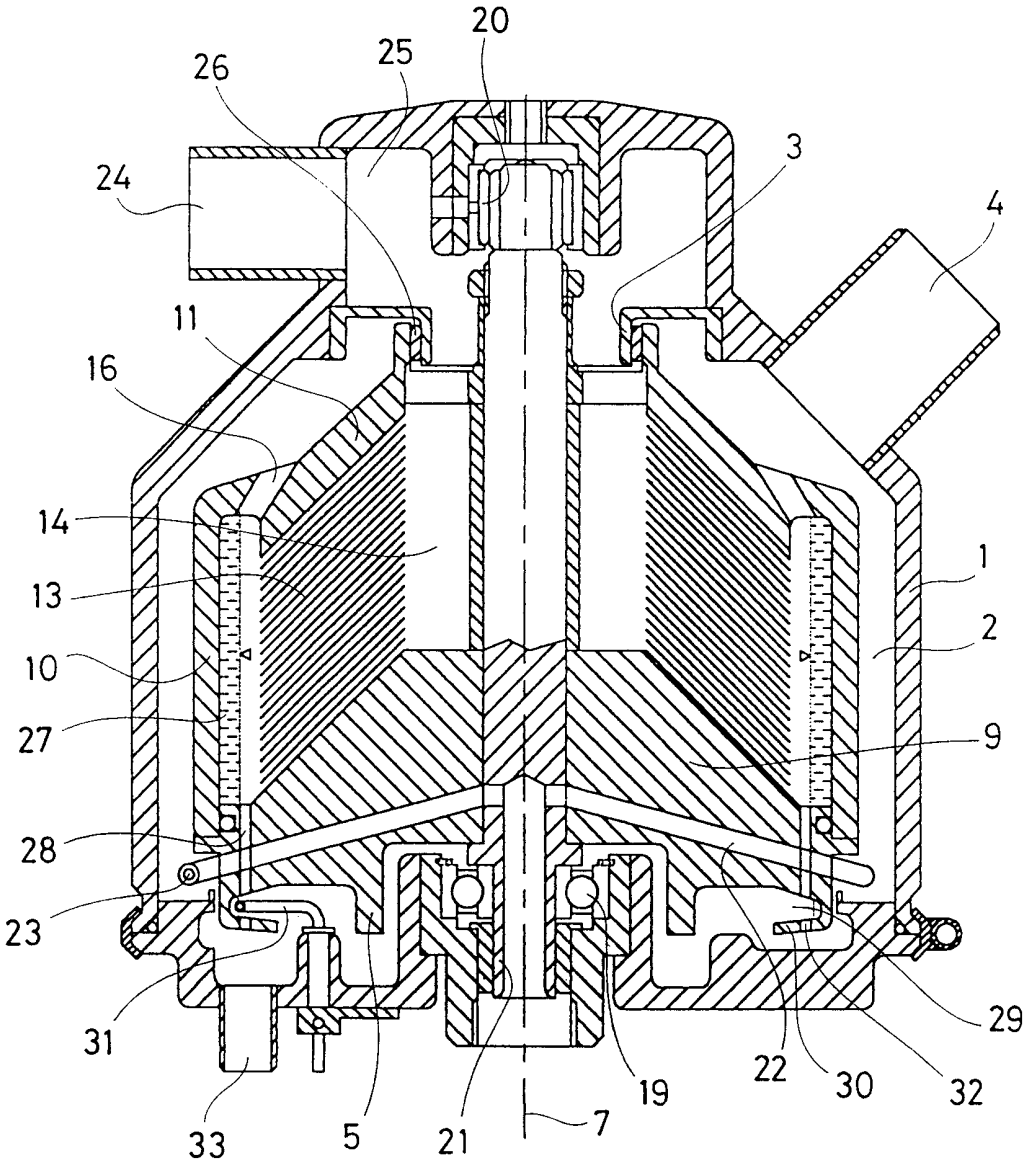


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/00694

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B04B 5/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B04B, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EDOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0011270 A1 (WEDEGE, E.), 28 May 1980 (28.05.80), page 2, line 21 - line 25, abstract --	1,4
A	US 3234716 A (R.J. SEVIN ET AL), 15 February 1966 (15.02.66), column 2, line 48 - line 70 --	1,4
A	US 2104683 A (H. VAN ROSEN ET AL), 4 January 1938 (04.01.38), page 3, column 2, line 25 - line 33; page 3, column 2, line 64 - line 70 -- --------	1,4

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier 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 when the document is taken alone
"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

Date of the actual completion of the international search	Date of mailing of the international search report
10 August 1999	10 -09- 1999
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Magnus Persson / MR Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/07/99

International application No.
PCT/SE 99/00694

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0011270 A1	28/05/80	US 4265648 A	05/05/81
US 3234716 A	15/02/66	BE 624585 A	00/00/00
US 2104683 A	04/01/38	NONE	