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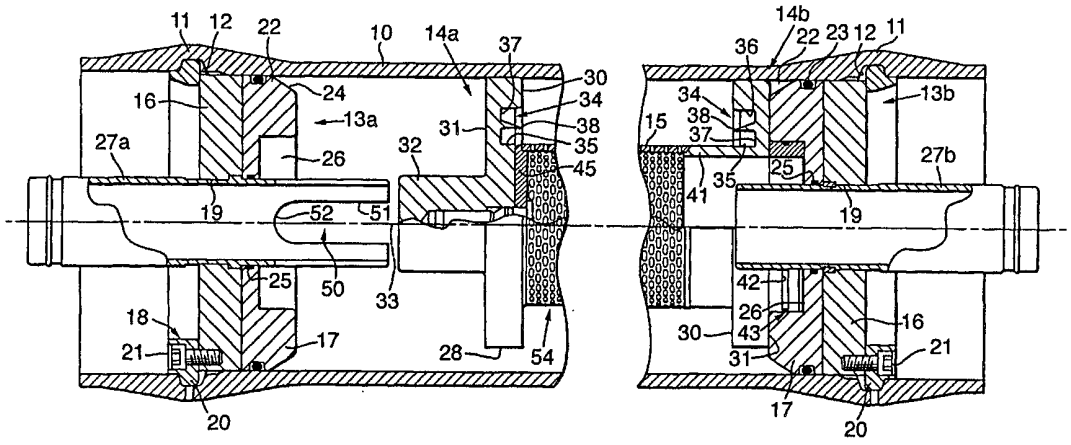

(57) Abstract

A filter assembly comprises a high pressure housing containing a filter, which may be a fibrous filter, carried by mountings and end members. This assembly acts as a prefilter for fluids at high pressures (for example, in excess of 200 kPa). The filter assembly can be used as a pre–filter to a reverse osmosis filter in, for example, a system for desalinating salt water or other salt–containing fluid.

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FLUID FILTER SYSTEMS AND ASSEMBLIES

The invention relates to filter systems and assemblies and to methods of desalinating fluids.

In many filter systems pre-filters are provided to remove larger particles from fluid to be filtered before the primary filtration takes place in a main filter. Many primary filtration processes operate at high pressure, for example at pressures greater than 14 kPa. In such systems, it is customary to pass the fluid to be filtered through the pre-filter at low pressure and then pass the pre-filtered fluid through the main filter at high pressure. An example of an arrangement of this kind is a filter system for desalinating fluids.

According to a first aspect of the invention, there is provided a filter system comprising in series a high pressure pump followed by a high pressure housing containing a pre-filter formed by a large diameter coreless filter element and then a high pressure vessel containing a reverse osmosis or nanofiltration filter.

In this specification, "large diameter" refers to a filter element having an outside diameter greater than 76mm (3"), preferably greater than 152mm (6").

According to a second aspect of the invention, there is provided a filter assembly comprising a high pressure housing containing a sub-assembly including a filter element having opposed end faces, each end face engaging a respective end member, the sub-assembly being located in the housing between first and second mountings, the first and second mountings being fixed relative to the housing.

According to a third aspect of the invention, there is provided a filter assembly comprising a high pressure housing containing a sub-assembly including a filter between first and second mountings fixed relative to the housing, the first mounting providing a passage for fluid from the filter and the second mounting providing a passage for fluid to the filter assembly.

According to a fourth aspect of the invention, there is provided a method of desalinating fluids comprising pumping a salt-containing fluid with a high pressure pump through pre-filter and then through a reverse osmosis filter.

The following is a more detailed description of an embodiment of the invention, by way of example, reference being made to the accompanying drawings in which:-

Figure 1 is a longitudinal cross section through a first filter comprising a high pressure housing for a pre-filter containing two mountings and two end members,

Figure 2 is a section through the filter of Figure 1 showing an end elevation of an end member,

Figure 3 is a longitudinal cross-section through a second filter comprising a high pressure housing carrying two mountings and including a prefilter mounted by one of the mountings and a mounting ring,

Figure 4 is an end elevation of the second filter with the right half of the elevation being sectioned to show a part of the mounting ring, and

Figure 5 is a schematic diagram of the incorporation of the filter of Figures 1 and 2 or Figures 3 and 4 in a system for desalinating a fluid.

Referring first to Figure 1, the first filter comprises a housing, indicated generally at 10, which is in the shape of an elongate cylinder. The housing 10 is preferably formed from a fibreglass reinforced resin although other materials may be used. At axially spaced intervals along the housing 10, thickened portions 11 are provided. At the interior of the housing 10, each thickened portion 11 is provided with an annular groove 12.

The housing 10 accommodates first and second axially spaced mountings 13a,13b and a core assembly 54 formed by first and second axially spaced end members

14a,14b spaced by a core 15. The first and second mountings 13a,13b are identical and so only one mounting 13a,13b will now be described.

Each mounting 13a,13b comprises a body 16, an end portion 17 and a collar 18. The body 16 is generally annular in shape with an exterior diameter that is similar to the interior diameter of the housing 10. The body 16 is provided with a central hole 19. The collar 18 has a flange 20 which may be in two or three pieces and extends into a respective one of the grooves 12 in the housing 10 to locate the collar 18 axially in the housing 10 and is fixed to the body 16 by screws, one of which is shown at 21. Thus, the body 16 is located axially in the housing 10 adjacent a respective thickened portion 11. The end portion 17 is also generally annular with an outside diameter similar to the internal diameter of the housing 10. The end portion 17 is carried on a face of the body 16 opposite the face connected to the collar 18. The end portion 17 has an outer annular surface 22 carrying a sealing ring 23 that seals against the interior surface of the housing 10 to provide a seal between the mounting 13a,13b and the housing 10. The annular surface 22 terminates at one end in an inwardly chamfered portion 24. The centre of the end portion 17 is provided with a hole 25 in register with the hole 19 in the body 16 and the end portion hole 25 is surrounded by an annular rebate 26.

The first mounting 13a carries a tube 27a that extends axially along the housing 10, passes through the holes 19,25 and projects from both sides of the associated

mounting 13a. The tube 27a thus has a portion closer to the second mounting 13b and a portion further from the second mounting 13b.

The portion of the tube 27a closer to the second mounting 13b has a plurality of circumferentially spaced axially extending slots 50 extending along the tube from the end of the portion. There may be two slots 50 or any other convenient number. As seen in Figure 1, each slot 50 has parallel side edges 51 and an arcuate end edge 52 interconnecting the side edges 51.

As seen in Figure 1, this portion of the tube 27a extends axially beyond the associated mounting 13a.

The second mounting 13b carries a tube 27b that extends axially along the housing 10, passes through the holes 19,25 and projects from both sides of the associated mounting 13b. Both ends of the tube 27b are cut square.

The first and second end members 14a,14b are not identical.

The first end member 14a is generally annular but with three cutaway segments, seen in Figure 2, spaced equi-angularly around the first end member 14a. The exterior diameter of the first end member 14a is similar to the interior diameter of the housing so that portions 29 of the exterior periphery of the first end member 14a between the

segments 28 engage loosely against the interior surface of the housing 10 (again see Figure 2).

The first end member 14a has an inner face 30 and an outer face 31 lying in respective parallel planes normal to the axis 33 of the housing 10. A circular cross section boss 32 projects from the outer face 31 with its axis co-axial to the housing axis 33. The inner face 30 is formed with an annular channel 34 with an inner side wall 35, an outer side wall 36 and a base 37. A triangular cross section annular knife edge 38 projects from the base 37 in a direction with one face parallel to the housing axis 33.

The inner face 30 is, radially outward of the inner side wall 35, recessed and terminates in an axially extending hole that extends through the first end member 14a and into the boss 32.

The second end member 14b has a similar annular shape to the first end member 14a. It also has an inner face 30 and an outer face 31 with the channel 34 and the knife edge 38. The inner face 30 of the second end member 14b faces the inner face 30 of the first end member 14a.

The second end member 14b has no boss 32. Instead, the second end member 14b is formed integrally with a tube 41 that projects to both sides of the second end member 14b. The tube 41 has its axis co-axial with the housing axis 33 and thus provides a

passage from one side of the second end member 14b to the other. The portion of the tube 41 projecting from the outer face 31 of the second end member 14b is provided with a groove 42 carrying an O-ring seal 43 for a purpose to be described below.

The first and second end members 14a,14b are interconnected by the tubular core 15 which is formed from a plastics material. The tubular core 15 is perforate and has one end welded to a mounting 45 carried by the inner face 30 of the first end member 14a and the other end butts against the end of the tube 41 projecting from the inner face 30 of the second end member 14b. The outer surface of the core 15 is aligned with the inner side walls 35 of the channel 34.

The cartridge is assembled as follows. Initially, the second mounting 13b is located in the housing 10 as described above. The core assembly 54 is then mounted in the housing 10 between the first and second mountings 13a,13b. Initially, the second end member 14b is mounted directly on the second mounting 13b. The portion of the tube 41 projecting from the outer face 31 of the second end member 14b is sized to fit in the rebate 26 in the end portion 17 of the associated mounting 13b with the O-ring seal 43 engaging and sealing with the rebate surface. In this position, the tube 27b associated with the mounting 13b projects into the tube 41 of the end member 14b to provide fluid communication between the tube 27b and the interior of the core 15.

The first mounting 13a is then located in the housing 10 as described above. When so assembled, the slotted end of the tube 27a is adjacent to, but not abutting, the end face of the boss 32. The spacing is sufficient to allow axial expansion of the core assembly 54 but does not permit sufficient axial movement of the core assembly 54 to allow the second end member 14b to disengage from the associated mounting 13b. The first and second end members 14a,14b locate the core assembly 54 in an axial direction.

The core assembly 54 mounts a by-pass filter element. The filter element may be a coreless fibrous structure such as polyolefins, polyesters, polyamides, glass fibres, cellulose fibres or metal fibres. For example, the filter element may be a depth filter formed from fibres produced by a melt blowing process and having diameters from 1-20 micrometres, preferably 1-12 micrometres. Such a process is the subject of GB-A-2152471. In particular, the filter may be a fibrous mass of non-woven, synthetic, polymeric microfibres, the microfibres being substantially free of fibre-to-fibre bonding and secured to each other by mechanical entanglement or intertwining. The fibrous mass may have a substantially constant voids volume over at least a substantial portion thereof measured in the radial direction. The filter may be pleated as described in GB-A-2247849. The filter element is a large diameter filter element with an outside diameter greater than 76mm (3") and preferably greater than 152mm (6").

In the case of a coreless tubular fibrous filter, the thickness of the tube is the same as the radial width of the channel 34 so that each end of the filter can be inserted into a respective one of the channels 34 in the end members 14a,14b and have the associated knife edge 38 driven into a respective end surface of the filter. The first and second end members 14a,14b may be interconnected by a tie-rod (not shown).

In use, fluid to be filtered is pumped into the housing via the tube 27a in the first mounting 13a. The fluid exits via the slots 50 to enter the portion of the housing 10 between the mountings 13a,13b, passing between the housing 10 and the first end member 14a via the gaps created by the segments 28 and so reaching the exterior surface of the filter. The fluid is then filtered as it passes through the filter element and the filtered fluid enters the core 15. From there, the filtered fluid passes through the tube 27b of the mounting 13b carrying the second end member 14b before leaving the housing.

The housing 10 is a high pressure housing capable of accepting fluids at high pressures. For example, these pressures may be in excess of 200 kPa; they may be between 1300-6000 kPa or more.

It will be appreciated that the housing may carry two or more filter elements, each filter element being associated with respective first and second mountings 13a,13b and first and second end members 14. Filtered fluid from one filter element is fed to the

succeeding filter element where it is again filtered, and so on. It will be appreciated that the filter element need not be mounted in the high pressure housing 10 exactly as described above with reference to Figures 1 and 2. The filter element may be mounted in the housing 10 by any suitable means.

Referring next to Figure 3, the second filter comprises a high pressure housing, indicated generally at 110, which is in the shape of an elongate cylinder. The housing 110 is preferably formed from a fibreglass reinforced resin although other materials may be used. At axially spaced intervals along the housing 110, thickened portions 111 are provided. At the interior of the housing 110, each thickened portion 111 is provided with an annular groove 112.

The housing 110 accommodates first and second axially spaced mountings 113a and 113b and a sub-assembly including a prefilter and indicated generally at 114. The first and second mountings 113a,113b are identical and so only one such mounting 113a,113b will now be described.

Each mounting 113a,113b comprises a body 116, an end portion 117 and a collar 118. The body 116 is generally annular in shape with an exterior diameter that is similar to the interior diameter of the housing 110. The body 116 is provided with a central hole 119. A collar 118 has a flange 120 which may be in two or three pieces and extends into a respective one of the grooves 112 in the housing 110, to locate the

collar 118 axially in the housing 110, and is fixed to the body 116 by screws, one of which is shown at 121. Thus, the body 116 is located axially in the housing 110 adjacent a respective thickened portion 111. The end portion 117 is also generally annular with an outside diameter similar to the internal diameter of the housing 110. The end portion 117 is carried on a face of the body 116 opposite the face connected to the collar 118. The end portion 117 has an outer annular surface 122 carrying a sealing ring 123 that engages the interior surface of the housing 110 to seal between the mounting 113a,113b and the housing 110. The annular surface 122 terminates at one end and an inwardly chamfered portion 124. The centre of the end portion 117 is provided with a hole 125 in register with, and having the same diameter as, the hole 119 in the body 116.

Each mounting 113a,113b carries a tube 127 that extends axially along the housing 110, passes through the hole 119,125 and projects from both sides of the associated mounting 113a,113b.

As will be seen from Figure 3, the mountings 113a,113b are laterally reversed relative to one another so that the end portion 117 of one mounting 113a faces the end portion 117 of the other mounting 113b.

The prefilter sub assembly 114 comprises a cylindrical perforated basket 128 which may be of stainless steel or a plastics material. One end of the basket 128 is connected

to an annular head 129 which has a groove 130 on its outer surface carrying a sealing ring 131 that engages with the inner surface of the housing 110 to form a fluid-tight seal therebetween. The end of the basket 128 at the head 129 is closed by a plate 137 carrying a U-shaped handle 132. The plate 137 is provided with a plurality of arcuate holes (not shown) and each hole has an enlarged end. The head 129 has a corresponding plurality of screws 136 which are arranged to pass through the enlarged ends of the holes as the plate 137 covers the head 129. The plate 137 is then rotated using the handle 132 so that the screws 136 travel along the slots and engage the plate 137 to hold the plate 137 on the head 129. As seen in dotted lines in Figure 3, the basket 128 is provided, towards the end of the basket 128 remote from the head 129, with a solid annular internal plate 133 which forms a closure that closes the internal cross-section of the basket 128. The function of this will be described below.

The end of the basket 128 remote from the head 129 is centred by a mounting ring 134 (see Figure 4). The mounting ring 134 is a plate-shaped member with a central hole that is a tight fit around the exterior surface of the basket 128. The mounting ring 134 has three equi-angularly spaced radially outwardly projecting lobes 135 that are a tight fit against the interior surface of the housing 110. In this way, the basket 128 is centred in the housing 110 while the spaces between the lobes 135 allow the free passage of fluid through the annular space between the housing 110 and the basket 128.

The sub-assembly also includes a filter element contained in the basket 128. This may be formed in any of the ways described above with reference to Figures 1 and 2. The pleated fibrous filter material may include a spiral wrap to stop the pleats from moving apart. The filter material may have an absolute rating of between 1 μm - 1000 μm.

The filter material is attached at one end to a head (not shown). The filter element is inserted into the basket 128 by removal of the plate 137 and insertion of the filter element into the basket 128 until an end of the filter element abuts the plate 133. The plate 137 is then re-engaged with the basket 128 as described above. In this way, the filter element is held in the basket 128. The filter element may, for example, be 1500mm or more in length with an outside diameter greater than 76mm and preferably greater than 152mm.

As seen in Figure 3, the sub-assembly of the basket 128 together with the filter element is located in the housing 110 with the end of the basket 128 remote from the head 129 abutting the end portion 117 of the first mounting 113a. In use, fluid to be filtered is pumped into the housing 110 via the tube 127 in the second mounting 113b and then enters the space in the housing 110 between the second mounting 113b and the head 129 of the basket 128. From there, the fluid enters the interior of the filter assembly through the plate 137 and the head 129 and passes radially outwardly through the filter and thence through the perforations in the basket 128. The filtered

fluid then travels along the annular space between the exterior surface of the basket 128 and the interior surface of the housing 110 and past the gaps in the mounting 134 before re-entering the basket 128 at the portion of the basket 128 beyond the internal plate 133. From the interior of this portion of the basket 128, the fluid leaves the housing through the tube 127 in the first mounting 113a. This flow is not impeded by the mounting plate 134.

It will be appreciated that the pressure of the fluid acting on the plate 133 tends to keep the basket 128 in position on the first mounting 113a.

The housing 110 is a high pressure housing capable of accepting fluids at high pressures. For example, these pressures may be in excess of 200 kPa; they may between 1300-6000 kPa or more.

It will be appreciated that the housing may carry two or more sub-assemblies, each sub-assembly being associated with a respective first and second mountings 113a,113b. Filtered fluid from one sub-assembly is fed to the succeeding sub-assembly where it is again filtered, and so on. It will be appreciated that the sub-assembly need not be mounted in the high pressure housing 110 exactly as described above with reference to Figures 3 and 4, the filter assembly may be mounted in the housing 110 by any suitable means.

It will be appreciated that the first and second end members 14a,14b of the embodiment of Figures 1 and 2 need not have the external shape as shown in Figure 2. They may have the same external shape of the mounting plate 134 shown in Figure 4.

The filter assembly described above with reference to Figures 1 and 2 or with reference to Figures 3 and 4 may be used together with a high pressure main filter such as a reverse osmosis filter. These filters operate at high pressure, for example pressures in excess of 200 kPa and possibly up to 1300 kPa or more. Such reverse osmosis filters are well known in the art and will not be described in detail.

A typical assembly of this kind is shown in Figure 5 for desalinating salt water. Salt water from a source 47 is pumped by a high pressure pump 48 to the filter assembly described above with reference to Figures 1 and 2 or to Figures 3 and 4. This pre-filters the salt water before it is passed to a reverse osmosis filter assembly 49. This reverse osmosis filter assembly 49 may use a housing 10,110 and mountings 13a,13b,113a,113b similar to those described above with reference to Figures 1 and 2 or to Figures 3 and 4, with the reverse osmosis filter being held between the mountings 113a,113b.

The use of such a system requiring only one pump - the high pressure pump 48 and the use of a similar housing 10,110 and mountings 13,113 for both the pre-filter and the reverse osmosis filter - reduces significantly the number of parts and thus the cost.

It will be appreciated that filter elements may be used that are other than the filter element described above with reference to the drawings. For example, the filter element may be any one of the kinds sold by Pall Corporation under the trade mark ULTIPLEAT. These are coreless filter elements of polypropylene or resin bonded glass fibres which may be positively charged. They may be pleated or unpleated.

Also, there may be more than one filter element between the end members 14a,14b,114a,114b. For example, two filter elements may be arranged end-to-end with a connector piece between them.

The filter assembly described above with reference to the drawings need not be used only for reverse osmosis. It could be used for nanofiltration. Further, although the assembly is particularly useful for desalinating salt water, it could desalinate any salt-containing fluid.

CLAIMS

1. A filter system comprising in series a high pressure pump followed by a high pressure housing containing a pre-filter formed by a large diameter coreless filter element and then a high pressure vessel containing a reverse osmosis or nanofiltration filter.

2. A filter system according to claim 1 wherein the high pressure is a pressure in excess of 650 kPa.

3. A filter system according to claim 1 or claim 2 wherein the high pressure housing is of the same material as the high pressure vessel.

4. A filter system according to claim 3 wherein the material is a resin reinforced with glass fibres.

5. A filter system according to any one of claims 1 to 4 wherein the filter element of the pre-filter is formed by a hollow cylinder of fibres or of resin bonded glass fibres or of polypropylene.

6. A filter system according to claim 5 wherein the filter element of the pre-filter is pleated or unpleated.

7. A filter system according to claim 5 or claim 6 wherein the fibres of the filter element of the pre-filter are a fibrous mass of non-woven, synthetic, polymeric microfibres, the microfibres being substantially free of fibre-to-fibre bonding and secured to each other by mechanical entanglement or intertwining.

8. A filter assembly comprising a high pressure housing containing a sub-assembly including a filter element having opposed end faces, each end face engaging a respective end member, the sub-assembly being located in the housing between first and second mountings, the first and second mountings being fixed relative to the housing.

9. A filter assembly according to claim 8 wherein each end member includes an element which engages and locates an associated end face of the prefilter.

10. A filter assembly according to claim 9 wherein the prefilter is formed by an unpleated cylinder of filter material, the element penetrating the associated end.

11. A filter assembly according to claim 10 wherein the penetrating element comprises an annular knife edge of generally triangular cross-section.

12. A filter assembly according to any one of claims 8 to 11 wherein the filter element is coreless, a core extending between the two end members to support the filter element.

13. A filter assembly according to claim 12 wherein the core provides a passage for filtered fluid from the filter, one end member including a passage in fluid connection with the core, to convey fluid to an outlet.

14. A filter assembly according to any one of claims 8 to 13 wherein the housing is generally cylindrical, each end member lying in a respective plane extending generally normal to the axis of the housing, one of said end members providing a passage for conveying fluid to be filtered to the pre-filter.

15. A filter assembly according to claim 14 wherein said one end member is generally annular with a periphery which locates in the housing, said end member having at least one segment of said annular shape removed to form said passage.

16. A filter assembly according to any one of claims 8 to 15 wherein one end member is fixed relative to the first mounting member and the other end member is associated with a stop that permits only limited axial movement of the sub-assembly.

17. A filter assembly according to any one of claims 8 to 16 wherein the filter element is a large diameter coreless filter element.

18. A filter assembly comprising a high pressure housing containing a sub-assembly including a filter element between first and second mountings fixed relative to the housing, the first mounting providing a passage for fluid from the filter element and the second mounting providing a passage for fluid to the filter assembly.

19. A filter assembly according to claim 18 wherein the first and second mountings permit axial expansion of the filter element.

20. An assembly according to claim 18 or claim 19 wherein the sub-assembly comprises an outer casing enclosing the filter element, the outer casing being supported on one of said mountings.

21. An assembly according to claim 20 wherein the casing carries a member on an exterior surface thereof at a location intermediate the first and second mountings, the member extending between the casing and the housing to centre the casing in the housing.

22. An assembly according to claim 21 wherein the member allows fluid flow past the member along the housing.

23. An assembly according to claim 21 or claim 22 wherein the casing and the housing are of circular cross-section, the member including a circular aperture which fits around the casing and including a plurality of radially extending and angularly spaced projections, each projection having a radially outer end contacting an interior surface of the housing, gaps between the projections allowing fluid flow past the member.

24. An assembly according to any one of claims 20 to 23 wherein the casing has a first end and a second end and is perforate along the length thereof, an inlet for fluid being provided at the first end of the casing and the casing being closed by a closure towards the second end of the casing, with the filter element being located in the portion of the casing between the first end and the closure, the portion of the casing between the closure and the second end of the casing providing a path for filtered fluid from the filter element to an outlet.

25. An assembly according to claim 24 wherein the one end of the casing is supported on one of said mountings, the said mounting providing said outlet.

26. An assembly according to claim 24 or claim 25 when dependent on claim 19 wherein the casing is spaced from the other mounting to allow for said axial expansion, the other mounting providing said inlet.

27. An assembly according to any one of claims 18 to 26 wherein the filter element is a large diameter coreless element.

28. A filter assembly substantially as hereinbefore described with reference to Figures 2 and 3 or to Figures 4 and 5 of the accompanying drawings.

29. A method of desalinating a salt-containing fluid comprising pumping said salt-containing fluid with a high pressure pump through a pre-filter according to any one of claims 1 to 28.

30. A method of desalinating a salt-containing fluid substantially as hereinbefore described with reference to the accompanying drawings.

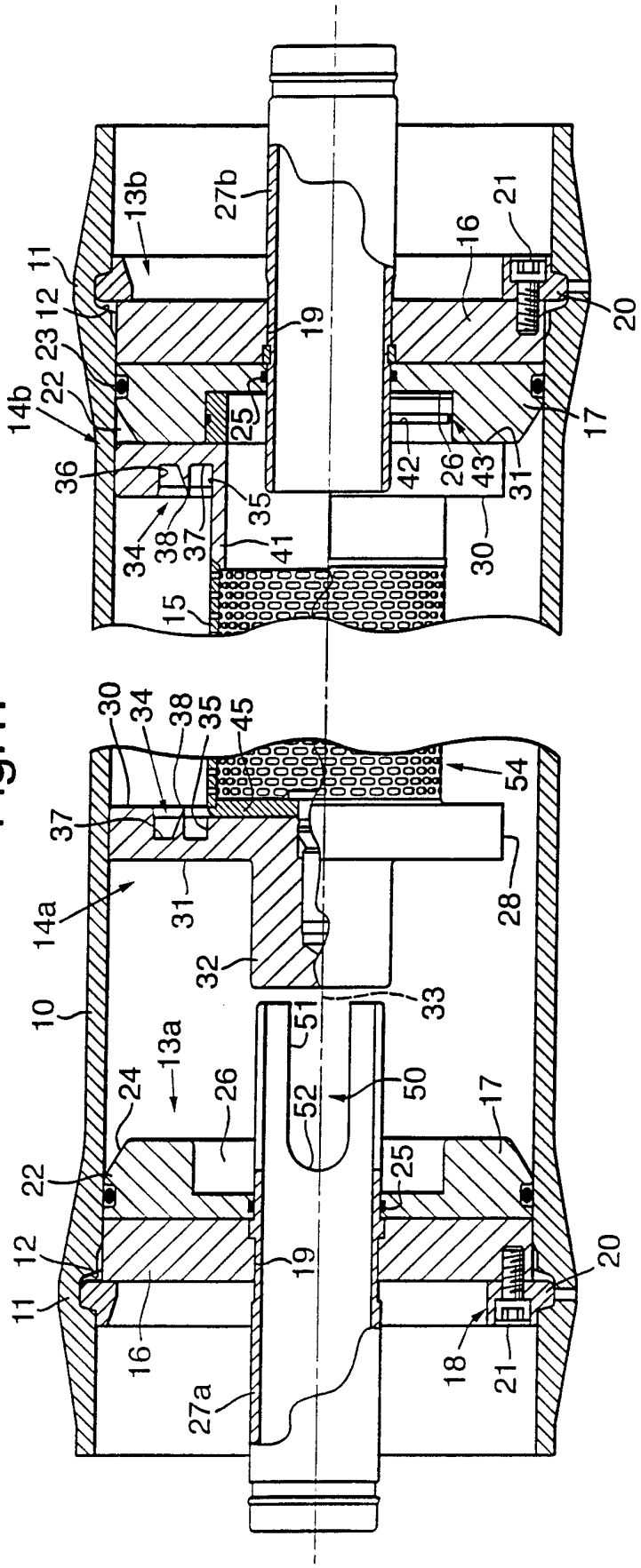
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Fig.1.

Fig.2.

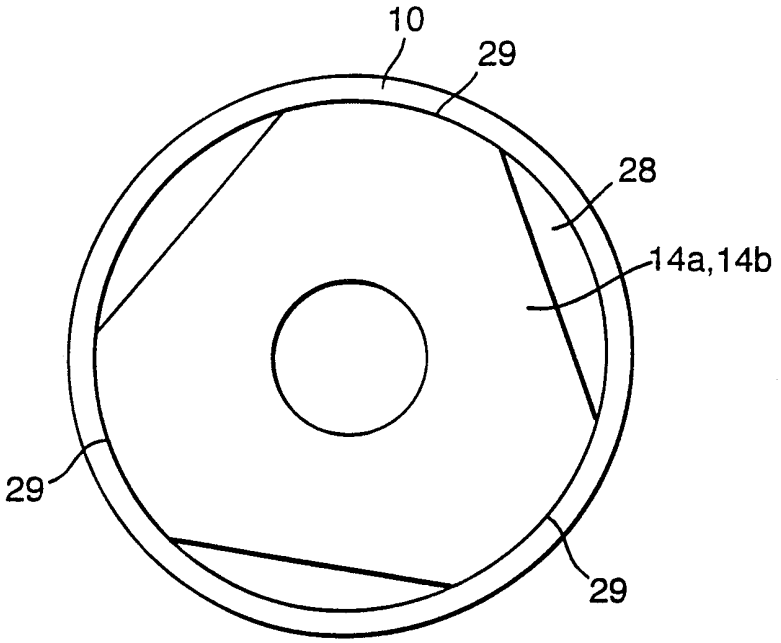
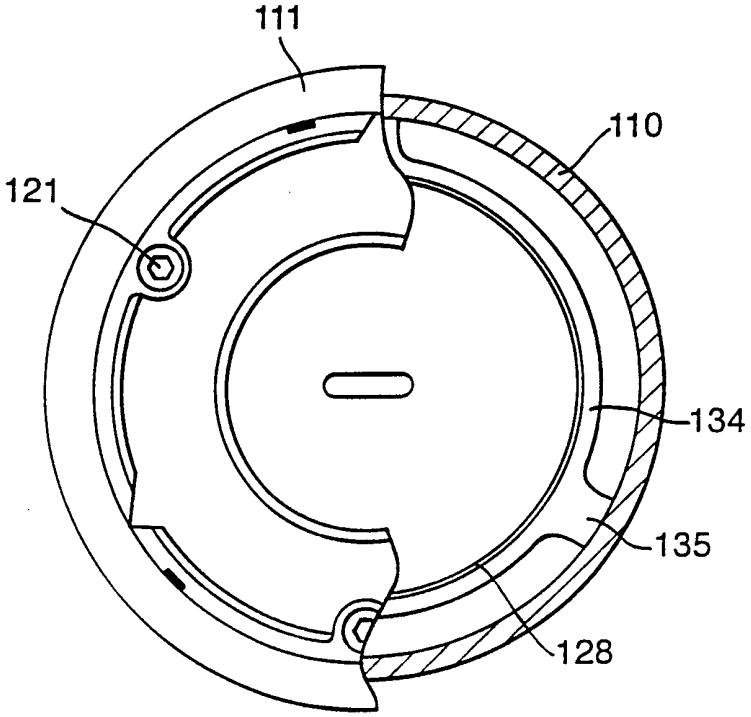


Fig.4.



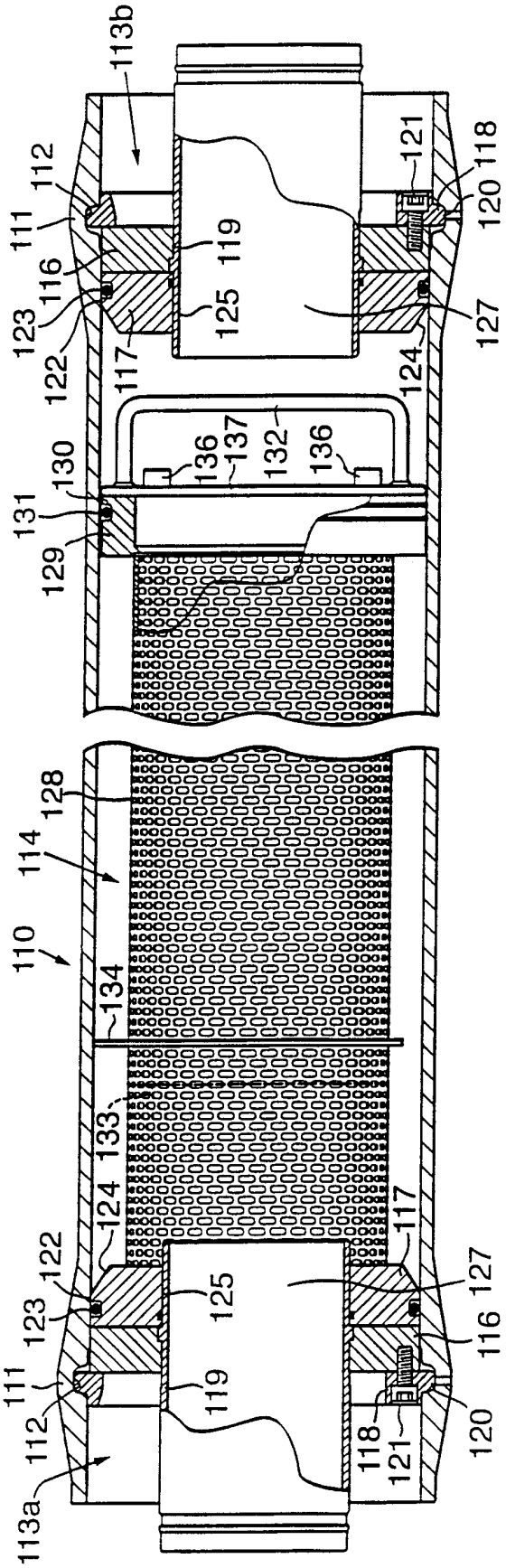

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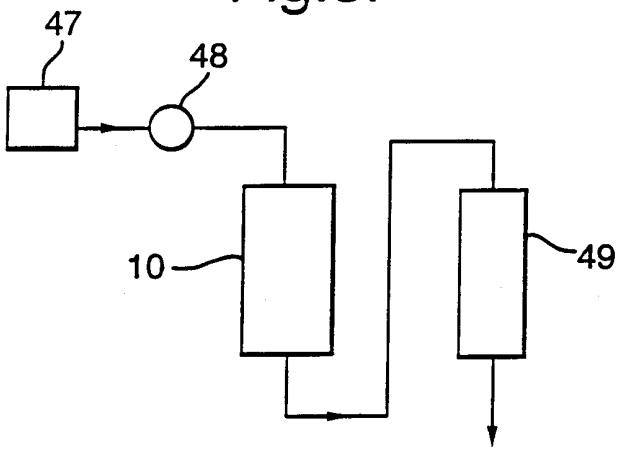
Fig.3.

Fig.5.



INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/GB 00/00998

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C02F1/44 B01D36/02 B01D29/23

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)
IPC 7 C02F B01D

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE WPI Week 197936 Derwent Publications Ltd., London, GB; AN 1979-65746 B XP002142819 & JP 54 096485 A (SAKAGUCHI Y), 30 July 1979 (1979-07-30) abstract ---	1,6
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A	US 5 490 929 A (K.YAMAMOTO) 13 February 1996 (1996-02-13) claim 1; figure 1 ---	8
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2000	31/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Bertram, H

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/GB 00/00998

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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