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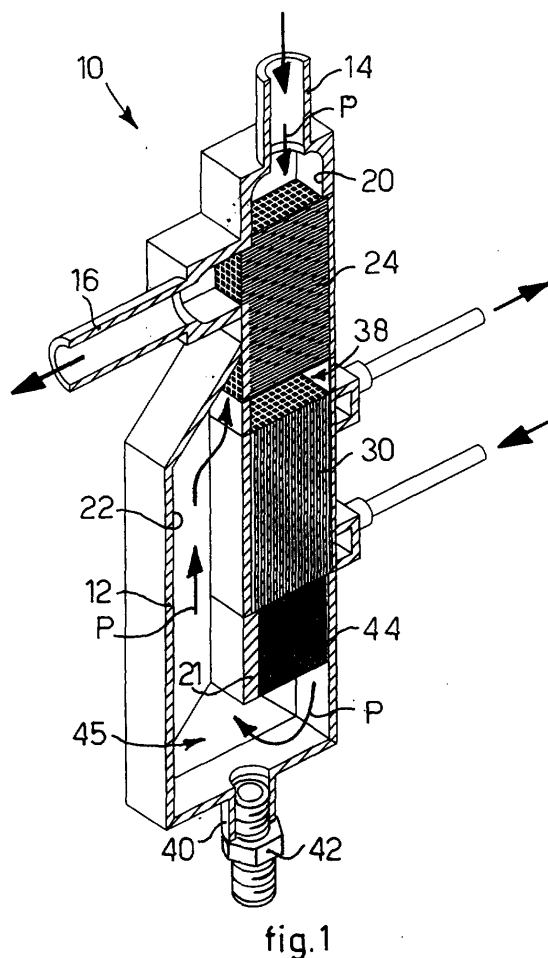
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(54) **Apparatus for drying compressed air**

(57) Apparatus for drying compressed air, comprising: a box-like containing body (12) having an inlet mouth (14) for the compressed air, an outlet mouth (16) for the dried air and conveyor channels (20, 22) for the compressed air in order to define a path (P) for the compressed air between the inlet mouth (14) and the outlet mouth (16); a first heat exchanger (24) arranged along the path (P) in which the compressed air introduced exchanges heat with the dried air before the dried air exits from the box-like body (12); a second heat exchanger (30) arranged along the path (P), downstream of the first heat exchanger (24), and associated with a cooling circuit (32), to condense the water contained in the compressed air; a collection zone (40) for the condensed water arriving from the second heat exchanger. The first and second heat exchangers (24, 30) are arranged in a substantially vertical position along the path (P).



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Description

FIELD OF THE INVENTION

[0001] The present invention concerns an apparatus for drying damp compressed air, completely or mostly eliminating the humidity contained therein. The damp compressed air is introduced inside the apparatus along a defined conveyance path and, after being dried, is expelled at a substantially unchanged pressure.

BACKGROUND OF THE INVENTION

[0002] An apparatus for drying compressed air is known, which eliminates most of the relative humidity, present to about 100%, caused by the reduction in the volume of air during compression.

[0003] The apparatus comprises a box-like containing body, into which damp, warm compressed air is introduced, and from which, after being dried along a defined drying path, it is expelled. Along the path a first heat exchanger and a second heat exchanger, or evaporator, are arranged, the second arranged downstream of the first.

[0004] In the first heat exchanger the compressed air introduced exchanges heat, in a so-called pre-exchange step, with the dried air, before the latter exits from the box-like body. In the second exchanger the air is cooled by exchanging heat with a cooling circuit, in order to lower the temperature and cool the humidity to a condensation point, or dew point. The dried and cooled air is subsequently conveyed along the aforesaid path towards the first exchanger where it is again heated before exiting. Downstream of the second heat exchanger a condensation separator is arranged, which separates and expels the condensed water from the compressed air.

[0005] A first disadvantage of the known apparatus is that the first exchanger and the second exchanger are arranged in a substantially horizontal position inside the box-like containing body and, because of this arrangement, any possible condensation, which forms in the heat exchangers, remains in contact with the surfaces of the exchangers themselves, with the risk of limiting the drying process and causing a possible formation of ice on the walls of the pipes of the exchangers.

[0006] Moreover, in the known apparatus the heat exchangers in the box-like body are arranged so as to determine generally a tortuous drying path, which causes high losses of load of the compressed air.

[0007] A further disadvantage of the known apparatus is that the volumes of the heat exchangers, in most cases, occupy a great deal of space inside the box-like body, such as to prevent both any reduction in the overall size of the apparatus, and any insertion of auxiliary devices, such as for example further condensation separation devices, electronic control devices or suchlike.

[0008] One purpose of the present invention is to

achieve an apparatus for drying compressed air wherein the arrangement of a first and second heat exchanger allows to reduce to a minimum the losses of load of the compressed air during a drying path.

[0009] Another purpose of the present invention is to achieve an apparatus for drying compressed air by means of which it is possible to obtain a complete separation of the condensed water, and in which the risk of the condensed water remaining on the walls of the respective heat exchangers is minimum.

[0010] A further purpose of the present invention is to achieve an apparatus for drying compressed air having a compact shape and minimum bulk.

[0011] The Applicant has devised, tested and embodied the present invention to achieve these purposes and to obtain other advantages, and to overcome the shortcomings of the state of the art.

SUMMARY OF THE INVENTION

[0012] The present invention is set forth and characterized in the main claim, while the dependent claims describe other characteristics or variants of the main idea of the invention.

[0013] In accordance with the above purposes, an apparatus according to the invention for drying damp compressed air comprises: a box-like containing body having inlet means for the damp compressed air, outlet means for the dried air and conveyor means to convey the compressed air to define a path of the compressed air between the inlet means and the outlet means; first heat exchanger means arranged along the path, in which the damp compressed air introduced is able to exchange heat with the dried air before the latter exits from the box-like body; second heat exchanger means arranged along the path downstream of the first heat exchanger means and associated with cooling means, in order to condense the water contained in the compressed air; collection means to collect the condensed water arriving from the second heat exchanger means. According to the invention, the first heat exchanger means and the second heat exchanger means are arranged in a substantially vertical position along the path.

[0014] This arrangement reduces the space occupied by the heat exchanger means and allows to obtain a compact box-like containing body, at the same time improving the drying and the separation of the humidity. The vertical arrangement encourages the just condensed water to drop due to gravity into the lower zone of the box-like body, without being retained inside the heat exchanger means.

[0015] Moreover, the vertical arrangement of the first and second heat exchanger means allows to limit possible losses of load inside the box-like body.

[0016] In a preferential embodiment of the invention, the compressed air is able to both enter and exit from the upper zone of the container. In this way, the path has a simple, substantially U-shaped form, without being tor-

tuous. The compressed air introduced from above descends downwards through the first and second heat exchanger means as far as the lower zone of the box-like body where it is deprived of the condensed water contained therein. Subsequently, after the condensation has been separated, the compressed air rises, now dried, towards the outlet means, passing through the first heat exchanger means.

[0017] In a preferential solution, to allow a first separation of the water condensed from the compressed air and to prevent damage due to heat dilations, the first heat exchanger means and the second heat exchanger means are separated from each other by an intermediate compartment, able to insulate them thermally and to ensure a first separation of the condensation.

[0018] Moreover, in one embodiment, in order to optimize the drying, along the path, downstream of the second heat exchanger means, there are separation means to separate the condensed water, so as to make it fall into a relative collection compartment.

[0019] The condensation separation means are advantageously arranged vertically along the path in order to encourage the separation of the condensation, and also to further encourage the condensation to fall due to gravity.

[0020] In one embodiment, the condensation separation means are aligned, directly in sequence, after the second heat exchanger means. According to a variant, the condensation separation means are arranged offset with respect to the second heat exchanger means.

[0021] According to another variant, the condensation separation means comprise an inclined wall arranged along the path and against which the compressed air is able to impact, to allow the water contained therein to separate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] These and other characteristics of the present invention will become apparent from the following description of a preferential form of embodiment, given as a non-restrictive example, with reference to the attached drawings wherein:

- fig. 1 is a sectioned, three-dimensional view of a drying apparatus according to the present invention;
- fig. 2 is a flow chart of the apparatus in fig. 1;
- fig. 3 shows a first variant of the apparatus in fig. 1;
- fig. 4 shows another variant of the apparatus in fig. 1.

DETAILED DESCRIPTION OF A PREFERENTIAL FORM OF EMBODIMENT OF THE INVENTION

[0023] With reference to figs. 1 and 2, a drying apparatus 10 according to the present invention to dehumidify damp compressed air comprises a hermetically

closed container 12. The damp compressed air is able to be introduced into the container 12, through an inlet mouth 14, and to be expelled, after being dried, through an outlet mouth 16.

[0024] In this case, the damp compressed air, with a relative humidity near 100%, is introduced at a pressure of about 7 bar and at a temperature of about 35°C.

[0025] Inside the container 12 a conveyor path P of the compressed air is defined, between the inlet mouth 14 and the outlet mouth 16. The path P is defined along a first vertical channel 20 and a second vertical channel 22, adjacent to the first and separated partly therefrom by means of a wall 21.

[0026] The apparatus 10 comprises a first heat exchanger 24, in which the so-called pre-exchange of air and air takes place, and a second heat exchanger 30, or evaporator, arranged downstream of the first. According to the invention, both the first and the second exchanger 24, 30 are arranged substantially vertically and aligned in the first channel 20.

[0027] This aligned and vertical position of the exchangers allows the compressed air to pass directly, without any deviation in the path, into the second heat exchanger 30, limiting to a minimum the losses of load.

[0028] In the embodiment shown here, both the first heat exchanger 24 and the second heat exchanger 30 are of a known type and comprise a plurality of braze welded aluminum pipes which respectively form air/air circuits or air/cooling fluid circuits. It is clear that the type of heat exchanger is not restrictive for the invention and it is also possible to use any other type of air/air and air/cooling fluid heat exchanger of a known type.

[0029] The first heat exchanger 24 comprises, in this case, first vertical pipes 26 in which the damp warm compressed air passes just after it has been introduced by the mouth 14. The damp warm compressed air exchanges heat with the dried air arriving from the second channel 20 and passing through second pipes 28 (fig. 2).

[0030] The warm compressed air cools slightly, descending to around 20°C and the dried air, which as will be described later arrives cold at around 3°C, is heated before leaving from the outlet mouth 16. To be more exact, the currents of warm and cold air take place completely in counter flow, thus ensuring maximum efficiency of the heat exchange.

[0031] The second heat exchanger 30 is associated with a cooling circuit 32, of a known type, comprising pipes 34 in which a cooling fluid flows, such as for example freon. The second exchanger 30 comprises, in this case, vertical pipes 36 in which the compressed air arriving from the first exchanger 24 passes, and which alternate with the pipes 34 of the cooling circuit 32. In contact with the cooling circuit 32 the compressed air cools to about 3°C and the water contained therein reaches the so-called dew point, and condenses.

[0032] In this case too, the currents of compressed air and of cooling fluid take place in counter flow, thus en-

suring maximum efficiency of the heat exchange.

[0033] The dried compressed air at 3°C is conveyed in the second channel 22 towards the first heat exchanger 24, to be reheated to about 30°C.

[0034] The first exchanger 24 and the second exchanger 30 are separated from each other by an intermediate compartment 38, which insulates them thermally to prevent damage caused by dilations of different entities. In the intermediate compartment 38 there is also a first separation of the water condensed from the compressed air arriving from the first exchanger 24.

[0035] The vertical arrangement one above the other of the heat exchangers 24, 30 also has the advantage that possible condensation water, which forms on the walls, respectively, of the pipes 26, 36 of the first heat exchanger 24 and of the second heat exchanger 30, falls due to gravity into the lower zone of the container 12, where there is a discharge pipe 40. To be more exact, the discharge pipe 40 is connected by means of a nipple 42 to a condensation discharger of a known type, and not shown in the drawings, which is not restrictive for the invention and can be of electronic type, volumetric with a float, timed or otherwise.

[0036] In the embodiment shown here, to facilitate the separation of the water and the compressed air, downstream of the second heat exchanger 30 there is a condensation separator 44, of a known type, such as for example a high efficiency demister. The condensation separator 44 is also arranged aligned vertically with the two heat exchangers 24 and 30, so that the compressed air, passing from the top towards the bottom, further encourages the separation of the condensation, and also guarantees that it falls due to gravity.

[0037] In the lower zone of the container 12, where there is the passage between the first and the second vertical channel 20, 22, along the path P, there is a collection compartment 45 for the fall of the condensation, which prevents the condensation from being possibly transported in the compressed air into the second channel 22.

[0038] Moreover, in the second channel 22, the dried compressed air passes at a relatively reduced speed, thanks to the fact that, in said channel, there are no restrictions in section, so that its cross section is constant. The reduced speed allows to limit the losses of load and prevent the condensation being transported.

[0039] According to a variant, shown in fig. 3, the condensation separator 44 is arranged in the lower zone of the second channel 22, so as to separate the condensed water only after a first separation due to gravity has occurred.

[0040] According to another variant, shown in fig. 4, instead of the condensation separator 44, in the lower zone of the separating wall 21 there is an oblique wall 47, facing towards the first channel 20, and able to encourage the water to separate and fall due to impact therewith.

[0041] It is clear, however, that modifications and/or

additions of parts can be made to the drying apparatus 10 as described heretofore, without departing from the field and scope of the present invention.

[0042] It is also clear that, although the present invention has been described with reference to specific examples, a person of skill in the field shall certainly be able to achieve many other equivalent forms of drying apparatus, all of which shall come within the field and scope of the present invention.

Claims

1. Apparatus for drying compressed air, comprising: a box-like containing body (12) having inlet means (14) for the compressed air, outlet means (16) for the dried air and conveyor means (20, 22) for said compressed air in order to define a path (P) for said compressed air between said inlet means (14) and said outlet means (16); first heat exchanger means (24) arranged along said path (P) in which the compressed air introduced is able to exchange heat with the dried air before said dried air exits from said box-like body (12); second heat exchanger means (30) arranged along said path (P), downstream of said first heat exchanger means (24), and associated with cooling means (32), to condense the water contained in said compressed air; collection means (40) to collect the condensed water arriving from said second heat exchanger means (30), **characterized in that** said first heat exchanger means (24) and said second heat exchanger means (30) are arranged in a substantially vertical position along said path (P).
2. Apparatus as in claim 1, **characterized in that** said path (P) is substantially U-shaped, and comprises a first vertical segment and a second vertical segment connected together in a lower zone, wherein said first and second heat exchanger means (24, 30) are arranged along said first vertical segment, and wherein said compressed air is able to enter from above, to descend passing through said first and second heat exchanger means (24, 30), and to rise towards said outlet means (16) passing through said second vertical segment, after giving up said condensed water contained therein, the collection of said condensed water taking place in said lower zone.
3. Apparatus as in claim 1 or 2, **characterized in that** said first heat exchanger means (24) and said second heat exchanger means (30) are separated from each other by an intermediate compartment (38), able to insulate them thermally and to allow a first separation of said condensed water.
4. Apparatus as in any claim hereinbefore, **character-**

ized in that it comprises condensation separation means (44, 47) arranged, along said path (P), downstream of said second heat exchanger means (30).

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5. Apparatus as in claim 4, **characterized in that** said condensation separation means (44) are arranged vertically along said path (P).

6. Apparatus as in claim 4 or 5, **characterized in that** said condensation separation means (44) are aligned with said first heat exchanger means (24) and with said second heat exchanger means (30).

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7. Apparatus as in claim 4, **characterized in that** said condensation separation means (44) comprise an inclined wall (47) arranged along said path (P) against which said compressed air is able to impact, to allow the separation of the water contained therein.

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8. Apparatus as in claim 4, **characterized in that** said condensation separation means (44) are arranged along said path (P) in an off-set position with respect to said second heat exchanger means (30).

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9. Apparatus as in any claim hereinbefore, **characterized in that** said conveyor means comprise a first channel (20) in which said first heat exchanger means (24) and said second heat exchanger means (30) are arranged, and a second channel (22), through which the dried compressed air is conveyed towards said first heat exchanger means (24), before exiting.

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10. Apparatus as in claim 9, **characterized in that** said second channel (22) is connected at the lower part with said first channel (20), by means of a collection compartment (45) for said condensed water.

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11. Apparatus as in claim 9 or 10, **characterized in that** the transverse section of said second channel (22) is substantially constant in order to prevent variations in the speed of said compressed air after the condensed water has been discharged.

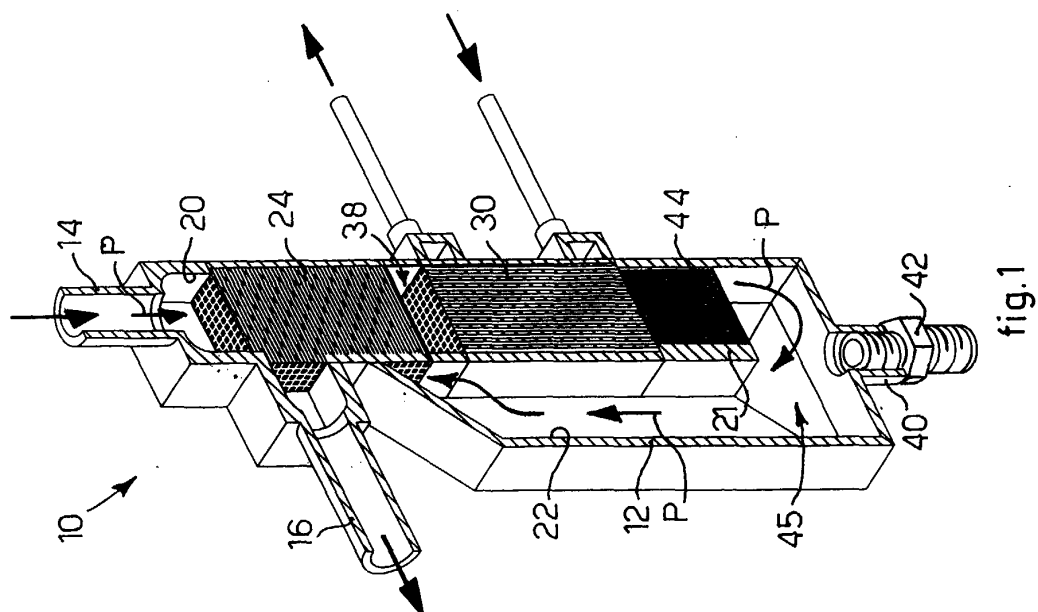
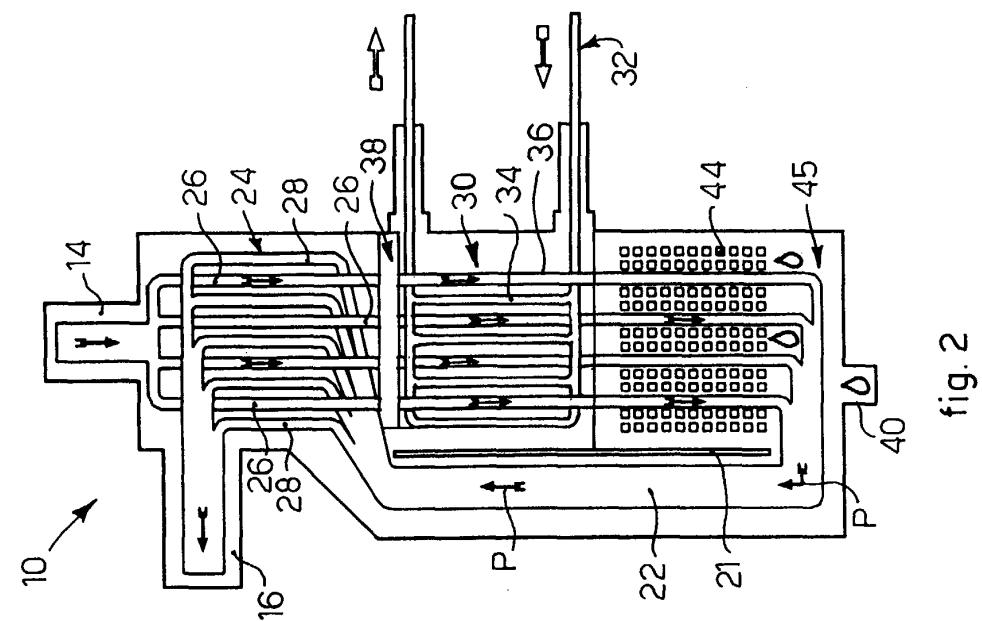
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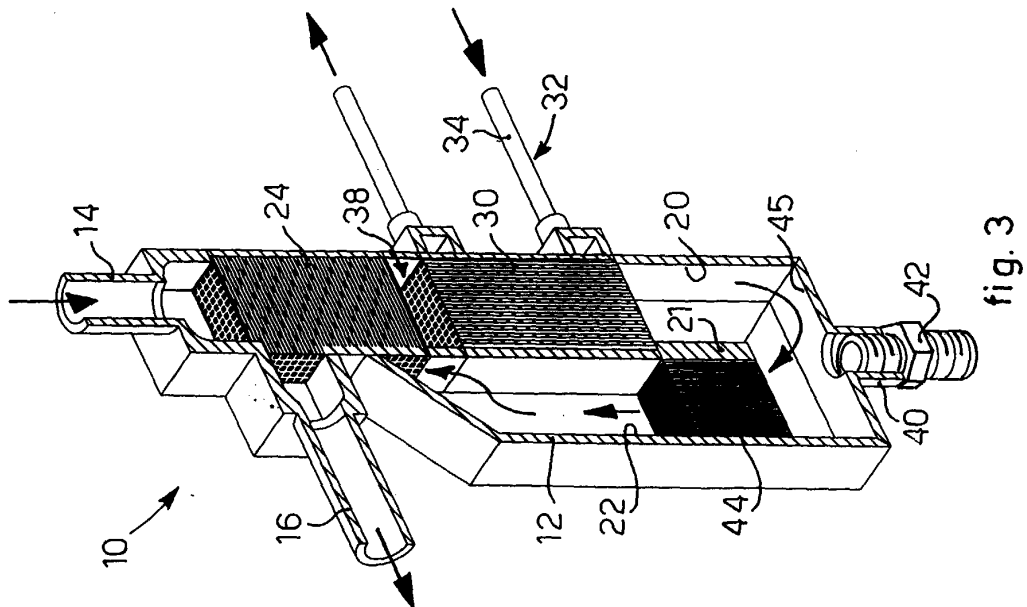
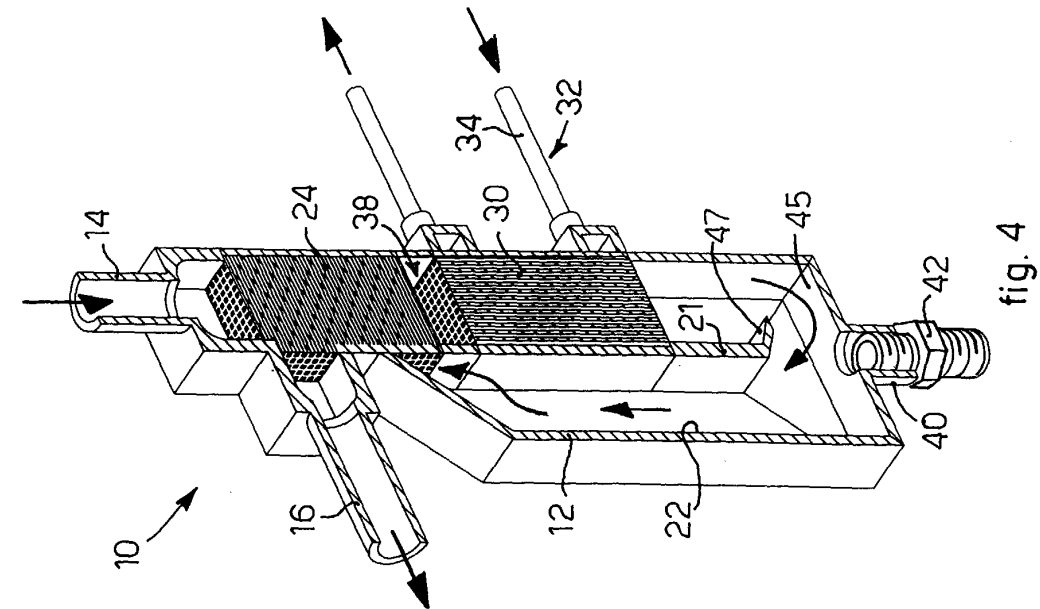
12. Apparatus as in claims 4 and 9, **characterized in that** said condensation separation means (44) are arranged in said first channel (20).

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13. Apparatus as in claims 4 and 9, **characterized in that** said condensation separation means (44) are arranged in said second channel (22).

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EUROPEAN SEARCH REPORT

Application Number
EP 03 42 5208

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 287 724 A (CLARK RALPH E) 8 September 1981 (1981-09-08) * column 3, line 57 - column 4, line 17 * * column 5, line 56 - column 6, line 43 * * column 8, line 17 - line 25; figure 1 * ---	1	F17D3/14
A	EP 1 081 445 A (O M I SRL) 7 March 2001 (2001-03-07) * abstract; figure * ---	1	
A	US 4 584 838 A (ABUJUDOM II DAVID N) 29 April 1986 (1986-04-29) * column 2, line 52 - column 3, line 13; figure 1 * -----	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7) F17D
Place of search THE HAGUE		Date of completion of the search 26 September 2003	Examiner Christensen, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 42 5208

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26-09-2003

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