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(54) Method to increase the potential of a falling film tube bundle heat exchanger

(57) The present invention relates to a method for increasing the capacity of a first tube bundle heat exchanger of the descending film type:
by arranging in series to said first heat exchanger (1) at least a second tube bundle (25) heat exchanger (21) with vertical tubes (25a) and of the descending film type, equipped with a distribution chamber (28) for a liquid to be fed to the respective tube bundle (25) and
by freely feeding by force of gravity said distribution chamber (28) with the liquid coming out of said first heat exchanger (1).

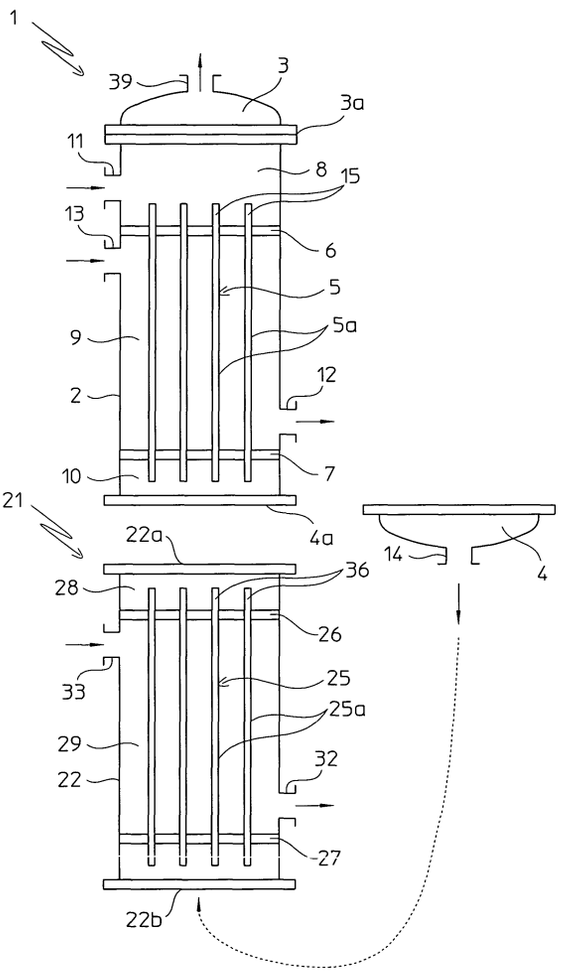


Fig.2

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Description

Field of application

[0001] In its most general aspect the present invention relates to a tube bundle heat exchanger, with vertical tubes, useful for carrying out heat exchange between two fluids, with the so-called descending film technique.

[0002] According to this technique, one of said fluids falls down along the inner wall of the tubes, without filling them, forming a thin film which leaves a rather large empty space at the centre of the tubes themselves and for their entire length; the other fluid circulates in the exchanger coming in contact with the outer wall of each single tube of the tube bundle being considered.

[0003] In particular, this invention relates to a method for increasing the heat exchange surface and, thus, the potentiality of a tube bundle heat exchanger of the above mentioned type.

Prior Art

[0004] It is known that the aforementioned technique of employing descending film heat exchange is widely and advantageously used in the chemical industry in general, and even more in the field of the food industry, for example for the concentration of solutions through evaporation of the solvent, or for the condensation of vapors and so on.

[0005] In order to carry out said technique, devices are used, variously named after their main function, such as, for example: concentrators, evaporators, condensers, etc.; anyway, all of them are essentially consisting of or comprise a descending film tube bundle heat exchanger with vertical tubes.

[0006] For this reason and only in order to simplify the description and the following claims, with the terms "descending film tube bundle heat exchanger with vertical tubes" all of the aforesaid devices are meant to be identified. Furthermore, always for explicative purposes, reference will be made to the concentration through evaporation of liquid solutions, without thus limiting the field of application of the present invention.

[0007] An exchanger of the aforesaid type comprises a mantle having a vertical axis, closed at its opposite ends by respective walls or base plates, a tube bundle longitudinally supported in said mantle through tube plates, respectively upper and lower, circumferentially fixed to said mantle in a gas-tight manner. Due to the presence of said tube plates, in the heat exchanger three chambers are defined, axially arranged the one after the other; a first chamber, between the closed upper end of the mantle and the upper tube plate; a second chamber, between the tube plates and a third chamber, between the lower tube plate and the lower closed end of the mantle. The liquid solution to be concentrated is fed into the first chamber and from there in the single tubes of the tube bundle, externally impinged on by the second heat exchange fluid, whereas in the third chamber, the concentrated solution is discharged.

[0008] It is known that the good operation, and hence, the yield of this type of heat exchangers, essentially depends from the good distribution of the liquid (solution to be concentrated) falling down inside the tubes of the tube bundle and by the ability of forming a liquid film in contact with the inner wall of each tube, thus avoiding that in some portion thereof, said liquid may fill, even only partially, the "empty" central zone of the tube, detaching itself from its wall.

[0009] To this end, in the first chamber, or upper chamber of the descending film heat exchanger, the installation of particular liquid distributors, also called ferules, is provided, one for each tube in the tube bundle, which have the task of forming a liquid head in said first chamber and of feeding such liquid in the individual tubes, tangentially to their inner wall. By virtue of the presence of the so-called ferules, the upper chamber of the heat exchangers taken here into consideration, will be named as "distribution chamber" in the following description and attached claims.

[0010] Although advantageous from various points of view, the descending film heat exchangers structured in the above schematically described way, have distinguished drawbacks, which appear above all when it is necessary to cope with the increase of the production capacity.

[0011] In fact, in that case, the prior art teaches either to use other film heat exchangers of the type considered, preferably associating them in parallel with the existing one, or to completely replace the heat exchanger with a new one of suitably increased size in order to have an increased heat exchange area; in the first case it is at least necessary to proceed with a substantial higher complexity of the configuration of the chemical plant into which the exchangers need to be installed; in the second case, remarkably increased costs need to be borne both as investment and operating costs.

Summary of the invention

[0012] The problem underlying the present invention is that of providing a method for increasing the production capacity (potentiality) of a tube bundle heat exchanger of the so-called descending film type, suitable for overcoming, in a simple and cost-effective manner, all the drawbacks mentioned with reference to the prior art.

[0013] This problem is solved, according to the present invention, by a method characterized in that at least a second tube bundle heat exchanger with vertical tubes is arranged in series with said first heat exchanger, said second exchanger being equipped with a respective liquid distribution chamber and in that the liquid coming out of said first heat exchanger is fed freely by the force of gravity.

[0014] The advantages and the features of the method according to the present invention will become clearer from the description of an exemplificative embodiment thereof, made herein below with reference to the attached drawings, for indicative and non-limiting purposes.

Brief description of the drawings

[0015]

Figure 1 schematically illustrates a tube bundle heat exchanger of the descending film type, according to the prior art;

figures 2 and 3 schematically illustrate successive steps of the method according to the present invention for the revamping of the heat exchanger of figure 1, as revamped using the method of the present invention for an increased capacity;

figures 4 and 5 schematically illustrate in enlarged view respective details of the heat exchanger of figure 1 and figure 3.

Detailed description of a preferred embodiment

[0016] With reference to figure 1, a heat exchanger 1, of the so-called descending film type comprises, according to the prior art, a mantle 2, with a vertical axis A-A, closed at the opposite ends by respective upper 3 and lower 4 walls or bottoms, fixed thereto through respective flanges 3a, 4a; a tube bundle 5, with vertical tubes 5a, is longitudinally mounted in said mantle 2, with respective upper and lower tube plates 6, 7 circumferentially fixed in a gas-tight manner to the mantle itself.

[0017] By virtue of the presence of said tube plates 6, 7, in the heat exchanger 1 three chambers 8, 9 and 10 are defined, axially arranged the one after the other; the first chamber 8, lays between the upper bottom 3 and the upper tube plate 6; the second chamber 9 between the tube plates 6, 7 of said bundle 5, whereas the third chamber 10 lays between the lower tube plate 7 and the lower bottom 4 of said mantle 2.

[0018] The first chamber 8 (distribution chamber) is in fluid communication with the outside through a duct 11, provided for the feeding of a solution to be concentrated; the second chamber 9, or intermediate chamber, is in communication with the outside of the mantle 2 through an upper duct 13, for feeding into said chamber a second heat exchange fluid, for example steam at a predetermined temperature, useful for carrying out the desired concentration of the aforesaid solution; a lower duct 12 provides for discharging from said second chamber 9 the second heat exchange fluid; and finally, the third chamber 10, which is a kind of collection reservoir for the concentrated solution, in communication with the outside through a duct 14 for discharging said solution.

[0019] Further on, the upper bottom 3 is equipped with a duct 39 for discharging the possible vapors produced by the tube bundle 5.

[0020] Generally, tubes 5a of the tube bundle 5 have flared and/or welded end portions into the respective tube plates 6, 7 and open into the distribution chamber 8 and in the third chamber 10, respectively, which, thus, are in fluid communication with each other.

[0021] In order to guarantee the formation of a liquid film in contact with the inner wall of each tube 5a, avoiding that in some part of it, said liquid may fill, even only partially, the central "empty" zone of the tube, detaching from its wall, in the distribution chamber 8 of said exchanger 1, a plurality of distributors 15 is operating, each one for each tube 5a of the tube bundle 5.

[0022] In particular (fig. 4), each distributor 15, also called ferule, essentially consists of a crop end of tube 16, of a predetermined length, having one end 16a gas tightly engaged in the mouth of a respective tube 5a, and the other end 16b, free and open into said chamber 8.

[0023] In an intermediate position, said crop end of tube 16 is equipped with one or more radial through holes 17, whose distance from the tube plate 6 is predetermined according to the liquid head (solution to be concentrated) which one wishes to maintain inside the distribution chamber 8.

[0024] When the liquid surface reaches the height of said holes 17, the solution to be concentrated starts to overflow through them inside the tubes 5a, forming the desired falling liquid film in contact with the inner wall of said tubes 5a.

[0025] In order to increase the production capacity of a tube bundle heat exchanger of the above described type, the method according to the present invention provides for the use of a heat exchange module 21 (fig. 2).

[0026] In particular, according to an embodiment of the present invention, such module 21 comprises a cylindrical tubular casing 22, open at is opposite ends and having an outer diameter equal to the diameter of the mantle 2 of the heat exchanger 1. A tube bundle 25, with parallel tubes 25a, is longitudinally supported in said tubular casing 22, by the tube plates 26 and 27 themselves, circumferentially fixed, in a fluid-tight arrangement, in said casing 22, in a predetermined distanced relationship from the open ends thereof. Between said tube plates 26 and 27, a chamber 29 is defined, in fluid communication with the outside through two ducts 32, 33.

[0027] The heat exchange module 21 thus arranged is connected in an axial alignment with the heat exchanger 1, in a head-tail arrangement, so as to form a single body with it (figure 3) in which the tube bundles 5 and 25 are in a mutual predetermined distanced relationship.

[0028] For such a connection, in particular, the heat exchanger 1 is deprived of the lower bottom 4, and the

tubular casing 22 is fixedly connected to the flange 4a, now free, for example through a respective flange 22a, which it is equipped with. In this way, according to another embodiment of the present invention, between the tube plates 7 and 26, respectively of the tube bundles 5 and 25, a chamber 10-28 is defined, which is, at the same time, chamber for receiving partially concentrated solution coming out of the tubes 5a and distribution chamber of said solution for the tube bundle 25, as will be clearer from the following description.

[0029] The lower bottom 4 of the exchanger 1, is then installed onto the lower free end of the tubular casing 22 (flange 22b), forming with the tube plate 27 thereof, a lower chamber, intended to receive the solution concentrated to the desired value.

[0030] Through the aforesaid connection, a single new heat exchanger 1-21 is obtained (fig. 3) with a double tube bundle 5-25, with vertical tubes 5a-25a and in its whole of the falling flow type. Therefore, an exchanger 1-21 is obtained having a heat exchange surface doubled with respect to the exchanger 1 or, at least, a heat exchange surface increased by the heat exchange surface assigned, at the design stage, to the tube bundle 25 of the tubular casing 22. And the increase of potentiality (or productivity) is directly linked to this increase of heat exchange surface.

[0031] Into the distribution chamber 28 of this heat exchanger 1-21, chamber which lays between the tube bundles 5 and 25, both the lower ends of the tubes 5a of the tube bundle 5 and the upper ends of the tubes 25a of the tube bundle 5 are open.

[0032] In said distribution chamber 28 a plurality of ferules is active, one for each tube 25a of the tube bundle 25. The radial through holes 37 of such ferules 36 (fig. 5) are at a distance from said tube plate 26, predetermined according to a pre-calculated liquid head, which is wished to be maintained inside the distribution chamber 28.

[0033] This liquid head is maintained substantially constant by the solution (already partially concentrated) which, according to a further feature of the present invention, is freely fed into said distribution chamber 28, by the force of gravity ("it rains"), from the tubes 5a of the tube bundle 5 laying above it.

[0034] In order to prevent such solution to fall into the tubes 25a of the underlying tube bundle 25, filling its central portion, i.e. in order to guarantee a regular formation of the desired liquid film falling inside the tubes 25a of said tube bundle 25, according to a feature of the present invention, said ferules 36 are closed on the top (fig. 5), whereas they are provided with radial apertures 40, in positions suitable for allowing the gaseous flow possibly freed from the tube bundle 25 to exit.

[0035] The main advantage achieved by the method of the present invention lays in the fact that it manages to increase the productive capacity (potentiality) of a tube bundle heat exchanger of the so-called descending film type in a simple and cost-effective way, without carrying out substantial changes onto the existing structure and arrangement of the chemical plant into which such exchanger is installed.

[0036] The invention thus conceived is susceptible to further variants and modifications all of which fall within the scope of protection of the invention itself: in order to increase the throughput of a tube bundle heat exchanger of the type considered, it is enough to arrange in series to such tube bundle an analogous tube bundle, provide the latter with a suitable liquid distribution chamber and feed by gravity said chamber with the liquid coming out of the first tube bundle.

Claims

1. Method for increasing the capacity of a first tube bundle heat exchanger of the descending film type, **characterized in that** it comprises the following operating steps:

   - arranging in series to said first heat exchanger (1) at least a second tube bundle (25) heat exchanger (21) with vertical tubes (25a) and of the descending film type, equipped with a distribution chamber (28) for a liquid to be fed to the respective tube bundle (25) and

   - freely feeding by force of gravity said distribution chamber (28) with the liquid coming out of said first heat exchanger (1).

2. Method for increasing the capacity of a first tube bundle (5) heat exchanger (1), of the descending film type, in which said tube bundle (5) is supported longitudinally in a substantially cylindrical mantle (2), with vertical axis, **characterized in that** it comprises the steps of:

   - installing into said mantle (2) at least a second tube bundle (25) with vertical tubes (25a), in series and axially aligned with the tube bundle (5) of said first heat exchanger (1), and in a predetermined distanced relationship from it,

   - defining between said tube bundles (5, 25) a liquid distribution chamber (28) for said second tube bundle (25), said distribution chamber (28) being in fluid communication with said first tube bundle (5),

   - installing in said distribution chamber (28) a plurality of tubular ferules (36), one for each tube (25a) of said second tube bundle (25),

   - feeding freely by gravity said distribution chamber (28) with the liquid coming out of said first tube bundle (5), thus forming in it a liquid head

defined by said ferules (36).

3. Heat exchange module to increase the capacity of a tube bundle (5) heat exchanger (1), of the so-called descending film type, wherein said tube bundle (5) is supported longitudinally within a substantially cylindrical mantle (2) provided with a vertical axis, **characterized in that** it comprises a cylindrical tubular casing (22), open at is opposite ends and having an outer diameter equal to the diameter of the mantle (2), of the heat exchanger (1), a tube bundle (25) with parallel tubes (25a), supported longitudinally within said tubular casing (22) through respective tube plates (26, 27), fixed circumferentially, in a fluid-tight manner inside said tubular casing (22), in a predetermined distanced relationship from the open ends thereof, between said tube plates (26, 27) a chamber (29) being defined, which is in fluid communication with the outside through two ducts (32, 33), a plurality of tubular ferules (36) engaged in respective tubes (25a), of said tube bundle (25) of the module, externally with respect to said tube plates (26, 27).

4. Module according to claim 3, **characterized in that** said tubular ferules (36) are closed above and are equipped with radial apertures (40), in positions suitable for allowing the exit of a gaseous flow, possibly freed from the tube bundle (25) of said module.

5. Method for increasing the capacity of a tube bundle (5) heat exchanger (1), of the descending film type, in which said tube bundle (5) is supported longitudinally in a substantially cylindrical mantle (2), with a vertical axis, **characterized in that**, in an axial alignment and in a substantially head-tail arrangement, a heat exchange module (21) is connected to said exchanger (1), said module comprising a cylindrical tubular casing (22) open at the opposite ends and having an outer diameter equal to the diameter of the heat exchanger (1), a tube bundle (25) with parallel tubes (25a), supported longitudinally within said tubular casing (22) through respective tube plates (26, 27), fixed circumferentially, in a fluid-tight manner inside said tubular casing (22), in a predetermined distanced relationship from the open ends thereof, between said tube plates (26, 27) a chamber (29) being defined, which is in fluid communication with the outside through two ducts (32, 33), and a plurality of tubular ferules (36) engaged in respective tubes (25a), of said tube bundle (25) of the module, externally with respect to said tube plates (26, 27), so as to form a single body (1, 21), the tube bundle (25) of said module (21) having the respective plurality of ferules (36) turned towards the tube bundle (5) of said heat exchanger (1).

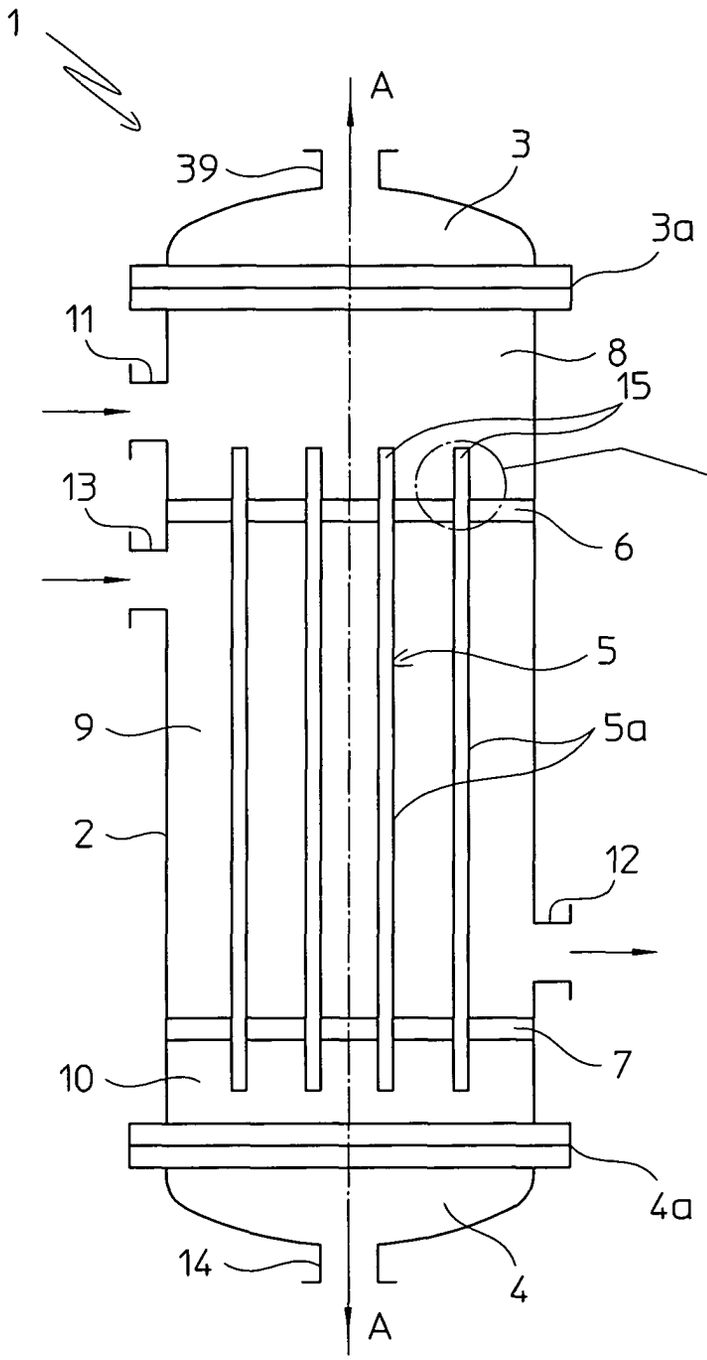


Fig.1
Prior Art

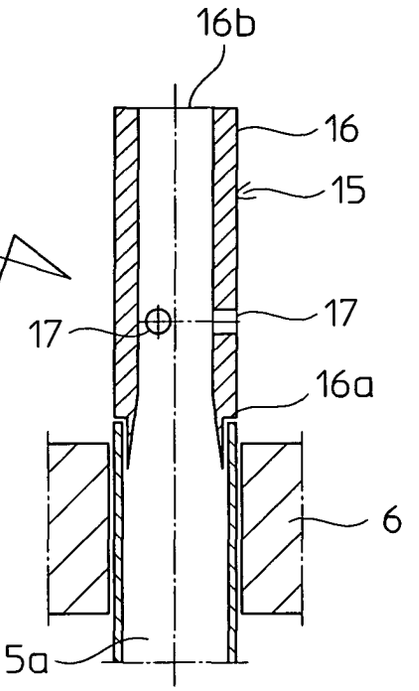


Fig.4

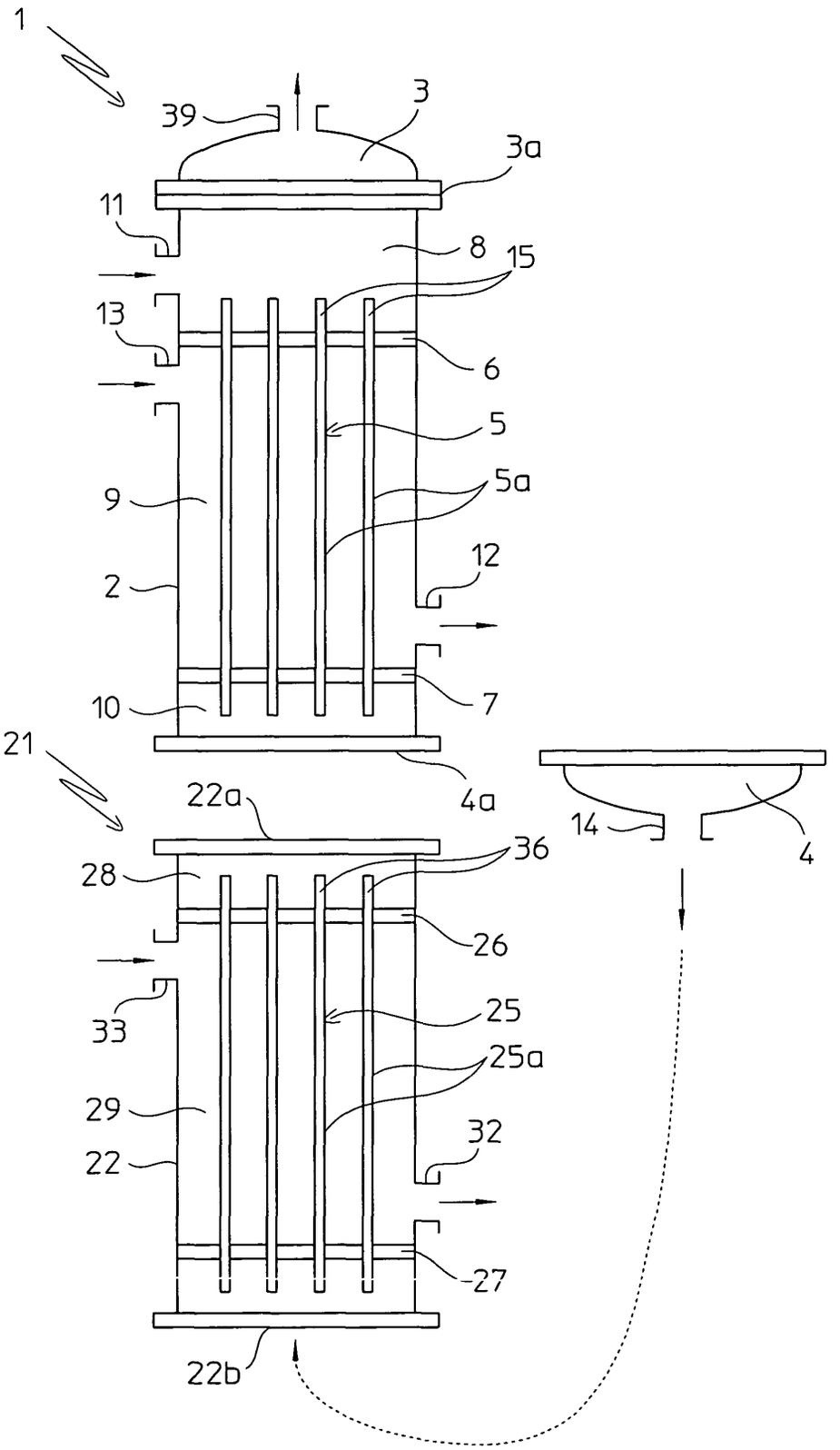

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3a
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22b

Fig.2

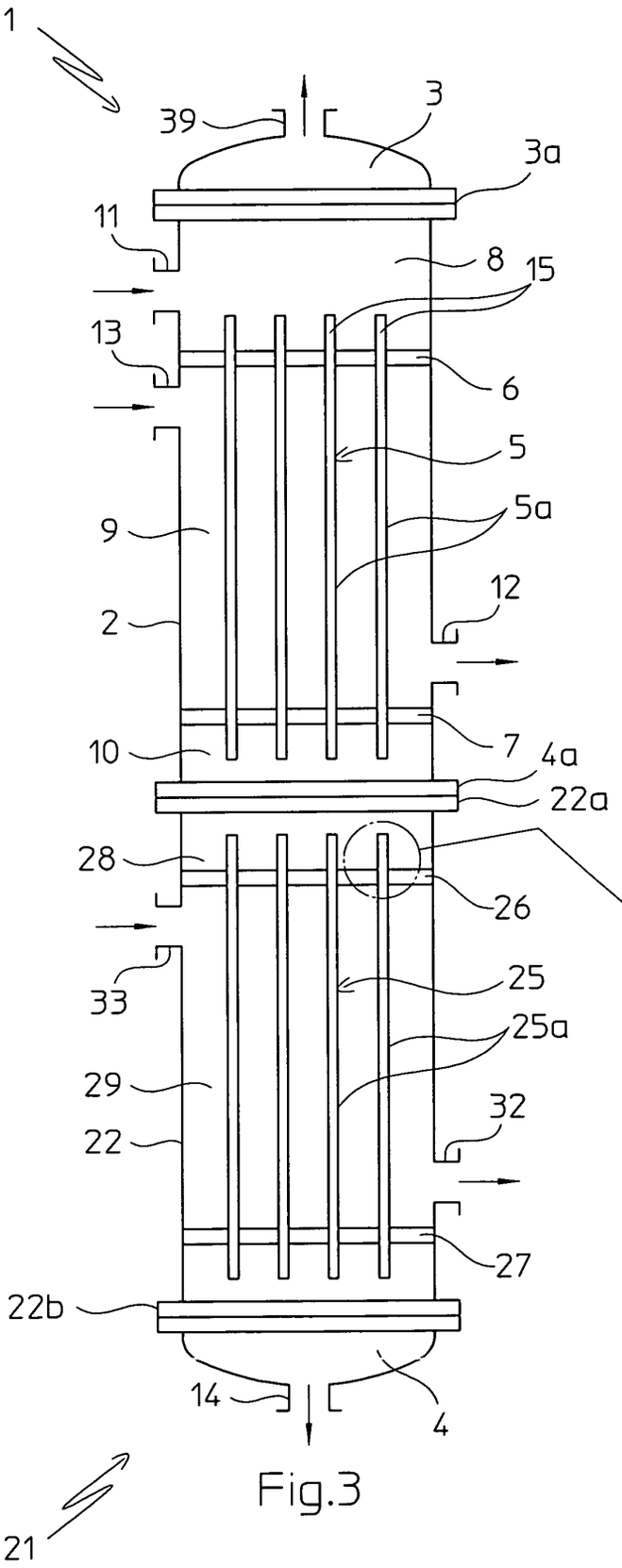

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Fig.3

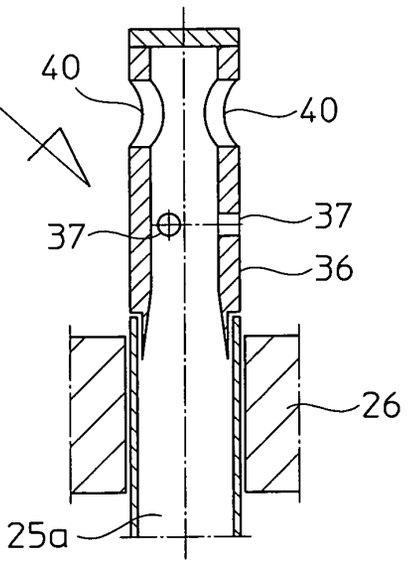

40
40
37
37
36
26
25a

Fig.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 00 9071

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 September 2003	Mootz, F

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