



(11) **EP 3 572 752 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**27.11.2019 Bulletin 2019/48**

(51) Int Cl.:  
**F28D 7/16 (2006.01) F28F 9/02 (2006.01)**

(21) Application number: **19175870.5**

(22) Date of filing: **22.05.2019**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

• **Roen Est S.p.A.**  
**34077 Ronchi dei Legionari GO (IT)**

(72) Inventors:  
• **BARBE', Cesare**  
**27029 Vigevano (PV) (IT)**  
• **LUPPI, Mauro**  
**34070 Turriaco (GO) (IT)**

(30) Priority: **22.05.2018 IT 201800005579**

(74) Representative: **Barbaro, Gaetano et al**  
**Società Italiana Brevetti S.p.A.**  
**Via G. Carducci, 8**  
**20123 Milano (IT)**

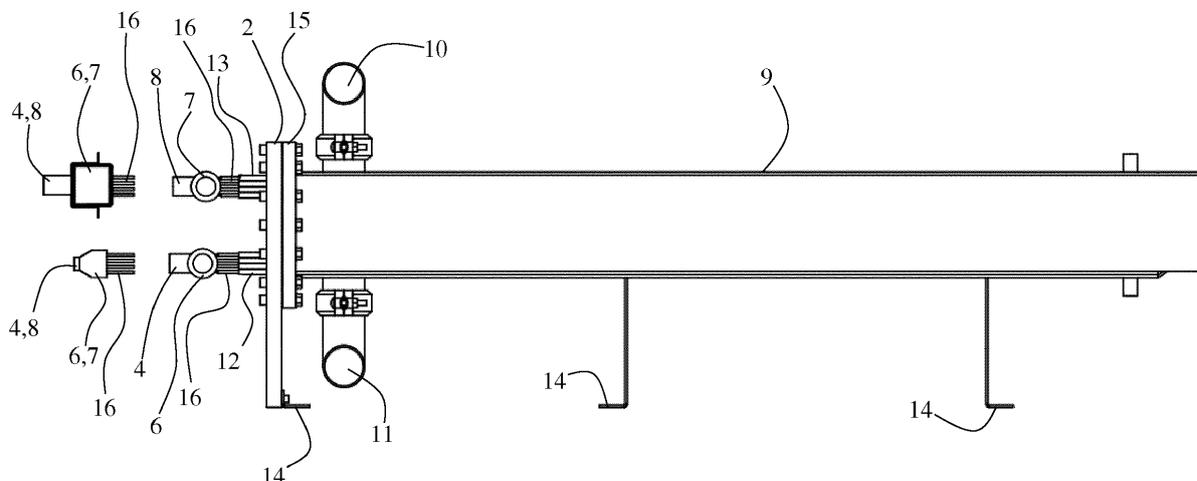
(71) Applicants:  
• **Eurochiller S.r.l.**  
**27030 Castello d'Agogna (PV) (IT)**

(54) **TUBE BUNDLE HEAT EXCHANGER**

(57) A tube bundle heat exchanger of the dry expansion type has a delivery/suction chamber which is substantially a single piece, without bolted parts, and is installed outside the exchanger and is not delimited by any wall in direct contact with a liquid contained inside the shell, but it is exposed to the atmosphere and is lapped by the air of the environment in which the exchanger is located. The delivery/suction chamber is directly fixed to

the tubes of the tube bundle, which have singularly accessible terminations that are fixed to the tube plate of the shell and are in fluid communication in a waterproof manner to the delivery chamber through corresponding connections.

It is also disclosed an evaporator made by filling with water the containment volume, defined by the shell, in which the tube bundle is contained.



**FIG. 3**

**EP 3 572 752 A1**

## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to heat exchangers and more particularly to a tube bundle heat exchanger of dry expansion type where a fluid changing its state under pressure is contained in a delivery chamber to be heated/cooled with change of state by means of another fluid at liquid state, contained in the shell, and where the delivery chamber and the suction chamber of the heat exchanger and are delimited from distinct and separate walls from each other and from the shell, and they are all lapped by air of the atmosphere of the surrounding environment outside the shell of the exchanger.

### TECHNOLOGICAL BACKGROUND

**[0002]** The tube bundle and shell heat exchangers are well known and widely used to cool/heat fluids. These exchangers comprise a shell surrounding a tube bundle, in which a first fluid, for example water, or a mixture of glycols or yet another suitable liquid (e.g. oil), which flows in the space delimited between the inner surface of the shell and the outer surfaces of the pipes, is heated/cooled by a second fluid that flows inside the tube bundle, for example a pressurized fluid that changes state (like Freon) when it crosses the tube bundle. Among the heat exchangers, evaporators are called dry expansion evaporators when the heat exchange surface is lapped externally by the first fluid, that transfers or absorbs heat, for example water.

**[0003]** In order to inject the second fluid under pressure, which will change state, through the tube bundle, maximizing the heat exchange efficiency, it is necessary to ensure that it is equally distributed between the plurality of tubes. For this reason, a structure of the type shown in Figure 1 is commonly used. The tubes 1 of the tube bundle are fixed in a waterproof manner to a tube plate 2 of a shell 9 of the evaporator, which is fixed by means of a flange 15 to the tube plate 2 and which defines a containment volume intended to contain the tube bundle 1 immersed in a first fluid in the liquid state to be cooled/heated. The tube plate 2 has through holes 3 which pass through its thickness and has the tubes (of the tube bundle 1 in the containment volume) inserted in the respective through holes 3 and fixed to them.

**[0004]** To distribute the second fluid among the tubes 1, the holes 3 in the tube plate 2 are made so as to flow into a delivery chamber to which the tubes of the tube bundle draw: the second fluid, conveyed through a delivery conduit 4, passes in the delivery chamber and from there it is distributed equally among all the tubes 1 passing through the holes 3.

**[0005]** Typically, the delivery chamber is made by a head wall 5 shaped so as to define at least one concave profile 6 on the surface facing the tube plate 2 of the shell, as shown in Figure 2. The head wall 5 is bolted against

the tube plate 2 of the shell, so that the concave profile 6 of the head wall 5 forms with the tube plate 2 a cavity that is filled with the second fluid from the duct 4, to distribute the second fluid, which will change its state, among the various tubes of the bundle 1 that flow into it. On the same head wall 5 other concave profiles 7 are defined which form, with the tube plate 2, the suction chambers in which the second fluid is collected, which is sucked from the return conduits 8.

**[0006]** Although this embodiment is commonly considered satisfactory, the applicants have set themselves the goal of reducing production costs of evaporators while maintaining their performance unchanged.

**[0007]** Among the expenses that mostly affect the final cost of this type of heat exchangers, there is the expense to certify the product in accordance with the Pressure Equipment Directive 2014/68/EU currently in force in Italy. This directive, commonly called PED, by the English name Pressure Equipment Directive, provides various certification procedures depending on a risk category of the general equipment under pressure.

**[0008]** Applicants have noted that the delivery chamber and the suction chamber, realized inside of the tube plate, oblige to require the more onerous certification procedure, impacting significantly on the final costs of the apparatus. Therefore, the problem of how to make the delivery chamber and the suction chamber was addressed, without incurring in the expensive legal obligations provided for by the regulations currently in force and without penalizing the efficiency of heat exchange of the entire evaporator.

**[0009]** The prior document FR1335130, on the basis of which the preamble of claim 1 is formulated, shows a heat exchanger in which the delivery chamber and the suction chamber are not delimited by distinct and separate walls, but coexist inside to a same dome-shaped tube plate, equipped with internal separation partitions. Moreover, as in the prior art heat exchanger of Figure 1 discussed above, also the heat exchanger described in FR1335130 document has the tube plate (indicated by reference number 7) separated by a tube plate (indicated with reference numeral 4), thus it is subject to the most onerous certification procedure too.

**[0010]** The document US2006/266504 shows (see Figures 2 and 4) the tube plate (indicated with the reference 201) illustrated in the attached figure 1, bolted to a tube plate (indicated with the reference 115) to define two delivery chambers and two suction chambers.

**[0011]** The document US2005/061025 describes (see Figure 1) a head wall (indicated with the reference 36) in the form of a dome fixed by means of a flange (indicated with the reference 12) to a tube plate 28, defining inside it a delivery chamber and a suction chamber, as in the known exchanger of Figure 1 described above.

**[0012]** US3,800,867 discloses an evaporator having a dome-shaped head wall fixed to a tube plate and defining inside, together with the tube plate, a delivery chamber and a suction chamber.

## SUMMARY

**[0013]** The Applicants have found that the so-called dry expansion evaporators are subject to expensive certifications since the delivery/suction chamber, in which the second fluid is collected, which is distributed among the various tubes of the tube bundle in which it undergoes a passage of state, to be then conveyed into the suction chamber which supplies the fluid now transformed into gas to an external device, it is delimited by at least one wall in direct contact with the first fluid in the liquid state contained within the shell of the evaporator. Moreover, the delivery chamber is defined by bolting the end wall against the tube plate of the shell, for which the removable union of these two parts must be certified as perfectly waterproof and perfectly safe.

**[0014]** To obviate these drawbacks, the Applicants have realized a tube bundle heat exchanger of dry expansion type in which there is no head wall, but there is a delivery chamber and a suction chamber to which a respective delivery/return conduit is connected. The delivery/suction chamber is substantially a single piece, without bolted parts, and it is installed outside the shell of the heat exchanger and it is not delimited by any wall in direct contact with the first fluid in the liquid state to be cooled/heated, but it is lapped by the atmosphere air of the environment in which the exchanger is located. The supply/suction chamber is fixed to the tubes of the tube bundle, which have singularly accessible terminations fixed to the tube plate of the shell and which are in fluid communication with corresponding openings of the delivery chamber.

**[0015]** According to one aspect, the delivery/suction chamber is in the shape of a funnel having a fitting from the tapered end of the funnel to the delivery/return conduit and a plurality of outlet holes from the enlarged end of the funnel, each hole being connected to a respective tube of the tube bundle.

**[0016]** According to one aspect, the delivery/suction chamber has an inlet opening to which there may be connected a supply conduit of a second fluid under pressure, which will change state, and a plurality of tubular outputs in fluid communication with respective tubes of the tube bundle, in which the tubular outputs are directly fixed to the respective terminations of tubes by brazing, welding, gluing, mechanical expansion or mechanical connection.

**[0017]** According to one aspect, a heat exchanger of the present disclosure comprises several delivery/suction chambers, each having a tubular inlet, to be connected to a delivery/aspiration duct of a second pressurized fluid, which will change state, and a plurality of tubular outlets directly fixed to respective pipe terminations by brazing, welding, gluing, mechanical expansion or mechanical connection.

**[0018]** An evaporator is realized by filling with water the containment volume defined by the shell, in which the tube bundle is contained.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]**

5 Figure 1 illustrates how a delivery/suction chamber is formed in known-type evaporators with a head wall bolted to a tube plate of the shell.

Figure 2 shows the surface of the head wall with the recesses which form, with the outer surface of the tube plate of the shell, at least one delivery chamber and one a suction chamber.

10 Figure 3 is a profile view of an evaporator according to this disclosure in which the delivery/suction chamber is completely lapped by the air, exposed to the atmosphere of the environment in which the evaporator is installed.

15 Figure 4 is a perspective view of the evaporator of Figure 3.

Figures 5a to 5c are profile views of different embodiments of delivery chambers or of suction chambers usable in heat exchangers of the present disclosure. Figures 6a to 6c are views in perspective and in transparency of the delivery chambers or of suction chambers of Figures 5a to 5c.

20 Figure 7 shows another evaporator according to this disclosure.

Figure 8 is an exploded view of a detail of the exchanger of Figure 7, with plug-in and threaded removable tubular outlets for coupling with a delivery chamber or a suction chamber.

25 Figure 9 shows a plug-in removable tubular outlet and a threaded removable tubular outlet, for coupling a respective tube of the tube bundle with a delivery chamber or a suction chamber.

## DETAILED DESCRIPTION

**[0020]** An evaporator of the dry-expansion tube bundle type according to the present disclosure is illustrated in 30 Figures 3 and 4. As common evaporators, it has an outer shell 9 which defines a containment volume filled of a first fluid in a liquid state to be cooled/heated, in which a tube bundle 1 is immersed, inside which a second fluid circulates under pressure (for example freon or other similar fluids) to be heated/cooled with change of state. The first fluid in the liquid state is entered through the inlet duct, which for example may be the duct 10 (or the duct 11) placed above (below) the evaporator in the example of the figures, and is discharged through the outlet duct, which for example can be the duct 11 (or the duct 10) located below (above) the evaporator in the example of the figures.

**[0021]** Preferably, the tubes 1 of the tube bundle are U-shaped so that the inlet ends 12 of the second fluid in the tube bundle 1 and the outlet ends 13 of the second fluid from the tube bundle all pass through the same tube plate 2 of the shell 9, as shown in the figures. However, what will be said also applies when the tubes are sub-

stantially straight and cross the shell 9 longitudinally, entering from the tube plate 2 and coming out of a wall longitudinally opposite to the tube plate.

**[0022]** Conveniently, within the containment volume defined by the shell 9 of the evaporator, separating partitions (not shown) will be installed which define a zig-zag path of the first fluid in the liquid state to be cooled/heated so that it passes through the inlet duct 10 to the outlet duct 11, passing repeatedly between the tubes in a countercurrent direction with respect to the pressurized gas circulating in the pipes, so as to maximize the heat exchange efficiency. However, the configuration in equicurrent can be realized by reversing the flow of one of the two fluids.

**[0023]** The evaporator can be supported by feet 14, fixed to the tube plate 2, which keep it raised from ground, as shown in figures 3 and 4, or it may have rings fixed to the shell 9, as shown in figures 7 and 8, in order to be supported by hooks.

**[0024]** A characteristic of the evaporator of this disclosure is the fact that it has no head wall 5, of the type shown in Figure 1, which instead is present in known evaporators. As can be seen in Figures 3, 4, 7 and 8, the tube plate 2 is flanged and is bolted to a flange 15 of the shell 9, but does not define any delivery chamber. Unlike the known evaporators of the type shown in Figure 1, the tubes of the tube bundle located inside the shell have individually accessible ends 12 and 13 fixed to the tube plate 2. The individually accessible external ends 12 and 13 do not cause leakage of the second fluid through the tube plate 2 pierced by the shell 9, as they are made to adhere to the holes in the tube plate 2 for example by gluing or brazing or welding.

**[0025]** According to one aspect, illustrated in Figures 3 and 4, the ends 12 and 13 cross the tube plate 2 of the shell 9 and protrude therefrom.

**[0026]** Like the delivery chambers of known evaporators, the evaporator of the present disclosure has one or more delivery chambers 6 connected to a delivery conduit 4 through which the second pressurized fluid is conveyed, which will change state as it passes through the tube bundle. The tubes of the tube bundle flow into the delivery chamber 6, and are individually fixed to it through corresponding waterproof connections.

**[0027]** Unlike known evaporators, the delivery chamber 6, as well as the suction chamber 7, is defined by surfaces distinct and separated from the shell 9, completely lapped by, immersed in, the air of the atmosphere of the environment in which the evaporator is located. According to one aspect, the walls of the delivery chamber 6 and of the suction chamber 7 are also at a distance from the shell 9 of the evaporator so as not to be physically in contact with it. In practice, the delivery chamber 6 and the suction chamber 7 are bounded by distinct and discrete bodies, do not have any wall that is externally wet from the first fluid to the liquid state contained in the shell and each of them appears as a single body with physically distinct walls that are separated by the shell 9

of the evaporator. Moreover, the tubes of the tube bundle, that protrude from the tube plate 2 the shell 9, are fixed in a waterproof manner to corresponding connections of the delivery chamber 6, thus the delivery chamber 6 is entirely part of the circuit through which the second pressurized fluid to be heated/cooled circulates with state change and does not share any wall with the circuit of the first fluid at the liquid state to be cooled/heated contained in the shell.

**[0028]** As shown in Figures 3 and 4, also the suction chamber 7 will be realized as the delivery chamber 6, with a plurality of inflow openings of the second fluid, coming from the tubes of the tube bundle heat exchanger, and an outflow opening placed in fluid communication with a return conduit 8 of the second fluid. The two suction chambers 7 shown in Figures 3 and 4 have distinct walls separated from the shell 9 and at a distance from it, so that all the surfaces of the suction chamber 7 are lapped by the air of the environment in which the evaporator is installed and do not have any wall wetted by the first fluid in the liquid state.

**[0029]** According to one aspect, the suction chamber 7 (or the suction chambers, if there are at least two of them as shown in the figures) is realized as the delivery chamber 6, so as to avoid having to certify the evaporator according to the PED directive, minimizing to the maximum certification costs.

**[0030]** According to the embodiment shown in the figures, the delivery chamber 6 has a plurality of tubular outlets 16 which draw on the internal volume of the delivery chamber 6. Each of these tubular outlets 16 is fixed firmly and directly to a respective end 12 which comes out of the shell 9 so as to place the delivery chamber 6 in sealed fluid communication with each tube of the tube bundle. These tubular outlets 16 are fixed in a waterproof manner to the tube ends 12, for example by brazing, welding, gluing, rolling or mechanical connection.

**[0031]** In practice, with this embodiment it is even possible to distribute the second fluid for each tube of the tube bundle before it passes through the tube plate 2.

**[0032]** According to an embodiment not shown in the figures, the ends 12 and 13 of the tubes coming out of the tube plate 2 of the shell 9 are directly welded to the walls of the delivery chamber 6 or of the suction chamber 7. This embodiment, however, is less preferred since it is relatively difficult to weld all the tubes, which may be very numerous, to the same wall of the delivery chamber 6 or of the suction chamber 7.

**[0033]** According to one aspect, illustrated in Figures 7 and 8, the ends 12 and 13 (not shown) are fixed to the tube plate 2 and do not protrude therefrom. Substantially, the ends 12 and 13 are within the thickness of the tube plate 2 and do not protrude from the holes 3 towards the outside of the shell 9. The connection with the delivery chamber 6 and the suction chamber 7 is effected by means of the tubular outlets 16. These tubular outlets 16 may be integral with the delivery chamber 6 or the suction chamber 7, respectively, or, as shown in figures 8 and

9, they may be produced as separate tubular elements. According to one aspect, the tubular outlets 16 have:

- an apical portion 17a, configured to be engaged in a respective tube of the tube bundle 1;
- a protrusion 17b defining at least one abutment surface against the tube plate 2;
- a distal portion 17c, configured to be engaged in the delivery chamber 6 or in the suction chamber 7.

**[0034]** The apical portion 17a can be fixed to the respective tube of the tube bundle 1, expanded in the hole 3 of the tube plate 2, by gluing, or by mechanical expansion or mechanical connection. Conveniently, the apical portion 17a will have a truncated conical shape so as to guide the insertion of the tubular outlet 16 keeping it centered with respect to the hole 3 until the protrusion 17b is not against the tube plate 2.

**[0035]** In a similar manner, the distal portion 17c may also be frusto-conical, so as to guide the insertion into the suction chamber 7 (or the delivery chamber 6) as shown in figure 8, until the protrusion 17b does not come into contact. Alternatively, the distal portion 17c may be threaded, as best shown in Figure 9, so as to be fixed to the delivery chamber 6 (or suction chamber 7) by screwing, before engaging the apical portion 17a in the respective tube of the tube bundle 1. The latter solution appears preferable to firmly connect the delivery chamber 6 in fluid communication with the tubes of the tube bundle 1, while the first solution seems preferable to connect the delivery chamber 6 in fluid communication with the tubes of the tube bundle 1 because the presence of a thread would cause the light of the tubular outlet 16 to be reduced.

**[0036]** Conveniently, as shown in the figures, there may be several delivery chambers 6 each with its own tubular inlet, to be connected to a delivery conduit 4 of the second pressurized fluid. In this way, the number of branches that depart from each delivery chamber 6 is limited, which therefore can be realized as a standard component with a predetermined number of tubular outlets 16.

**[0037]** All that has been said for the delivery chamber can be repeated, *mutatis mutandis*, for the suction chambers 7 which collect the second fluid coming out of the tube bundle before make it return to a compressor through the return conduit 8.

**[0038]** The shape of the delivery chamber 6, as well as of the suction chamber 7, can be any, as schematically shown in the profile views of figures 5a to 5c and in the corresponding semitransparent perspective views of figures 6a to 6c, which illustrate delivery chambers 6 or suction chambers 7 in the form of a parallelepiped (figures 5a and 6a), in the form of a hollow cylinder (figures 5c and 6c), or in the shape of a funnel (figures 5b and 6b), all provided with tubular outlets 16. In the case illustrated in Figures 5b and 6b, the delivery chamber 6 (suction chamber 7) will have a tapered end for connection

with the delivery duct 4 (suction duct 8) of the second fluid and a plurality of outlet holes from the enlarged end of the funnel, each output hole being connectable to a respective tube of the tube bundle through a respective tubular outlet 16.

**[0039]** With a delivery chamber 6 and an a suction chamber 7 delimited by walls completely separated from the shell 9 of the evaporator and fixed externally to the tubes of the tube bundle, the efficiency of the heat exchange is not penalized. Moreover, it becomes possible to market evaporators at lower costs because it is easier to realize them and avoid those construction features that impose higher certification costs.

## Claims

1. A tube bundle heat exchanger, comprising:

a shell (9) defining a containment volume, said shell (9) having an inlet duct (10) and an outlet duct (11) from the containing volume suitable for conveying a first fluid in a liquid state to be cooled or heated, and at least one perforated tube plate (2) with through holes (3) suitable for allowing tubes (1), of a tube bundle, pass throughout them in a waterproof manner, a tube bundle (1), each tube of said tube bundle being inserted in a waterproof manner through a respective hole of said through holes (3) of the perforated tube plate (2),

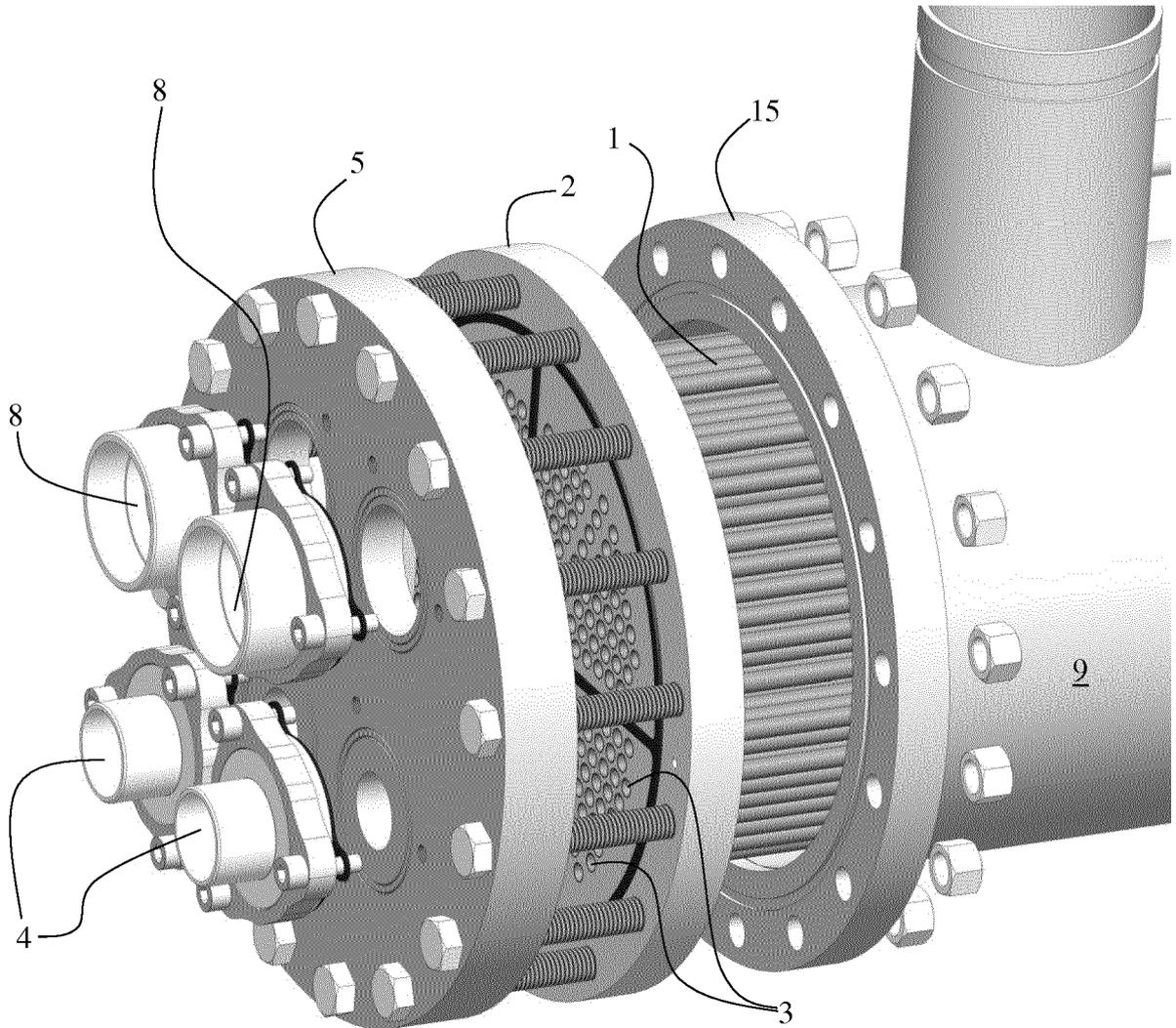
a delivery chamber (6) of a second fluid under pressure to be heated or cooled with a phase change, defining an inflow opening suitable for being placed in fluid communication with a delivery conduit (4) of the second fluid, and a plurality of outflow openings, each one of said outflow openings being suitable for being placed in fluid communication with a respective tube of the tubes (1) of the tube bundle,

a suction chamber (7) of the second fluid, defining a plurality of inflow openings, each one of said inflow openings being suitable for being placed in fluid communication with a respective tube of said tubes (1) of the tube bundle, and a drain opening suitable to be placed in fluid communication with a return conduit (8) of the second fluid,

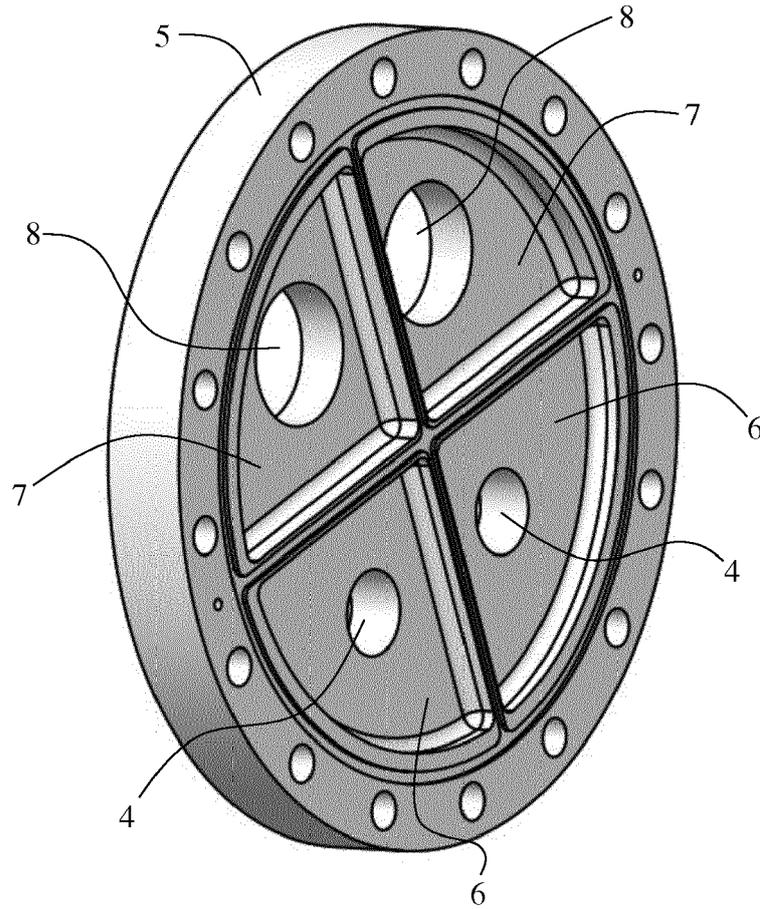
the tubes (1) of said tube bundle are inserted in the through holes (3) of said perforated tube plate (2) and have first ends (12) and second ends (13) which are fixed to the perforated tube plate (2) of the shell (9) of the heat exchanger; **characterized in that**

each chamber of said delivery chamber (6) and of said suction chamber (7) is delimited by respective walls and all said respective walls are distinct and separated among them and from

- said shell (9), so that all the respective walls of the delivery chamber (6) and of the suction chamber (7) are lapped by air of an environment in which the heat exchanger is installed; each end of said first ends (12) of the tubes (1) of the tube bundle is fixed in fluid communication and in a non-removable manner to a respective opening of said outflow openings of the delivery chamber (6) either by brazing, or by welding, or by gluing, or by mechanical expansion or by mechanical connection;
- each end of said second ends (13) of the tubes (1) of the tube bundle is fixed in fluid communication and in a non removable fashion to a respective opening of said inflow opening of the suction chamber (7) either by brazing, or by welding, or by gluing, or by mechanical expansion or by mechanical connection.
2. The heat exchanger according to the preceding claims, comprising a plurality of tubular outlets (16) fixed to the respective openings of said outflow apertures of the delivery chamber (6), each end of said first ends (12) of the tubes (1) of the tube bundle is fixed directly in a non-removable manner to a respective tubular outlet of said tubular outlets (16) either by brazing, or by welding, or by gluing, or by mechanical expansion or mechanical connection.
  3. The heat exchanger according to one of the preceding claims, comprising at least two identical delivery chambers (6), in which each delivery chamber (6) is delimited by walls separated by said shell (9) and at a distance therefrom, and has a plurality of outflow apertures each fixed and in fluid communication with a respective tube of a subset of the tubes (1) of the tube bundle.
  4. The heat exchanger according to one of the preceding claims, wherein the shell (9) comprises a flange (15), wherein said flange (15) is bolted on a perforated outer surface of the perforated tube plate (2).
  5. The heat exchanger according to one of the preceding claims, wherein said tubes (1) of the tube bundle are U-bent inside the containment volume, they enter in and exit from the containment volume through the same perforated tube plate and have said first ends (12) and second ends (13) that protrude outside the shell (9) of the heat exchanger.
  6. The heat exchanger according to claim 5, comprising a separating partition installed inside the shell (9) to define a refrigerating liquid circulation path, from the inlet duct (10) to the outlet duct (11), directed countercurrent or co-current with respect to a circulation path of the second fluid under pressure to be heated or cooled with phase transition in the tube bundle (1) from the first ends (12) to the second ends (13).
  7. The heat exchanger according to any one of claims 1 to 4, wherein said tubes (1) of the tube bundle are straight inside the containment volume, they enter in the tube plate and exit from a perforated wall opposite the tube plate and they have said first ends (12) and said second ends (13) which protrude outside the shell (9) of the heat exchanger.
  8. The heat exchanger according to one of the preceding claims, wherein said perforated tube plate (2) of the shell (9) is integral with the tubes (1) of the tube bundle, and is removably fixed to the shell (9) so as to flow to extract the tube bundle (1) from the shell (9).
  9. The heat exchanger according to one of the preceding claims, wherein all said respective walls of said delivery chamber (6) and of said suction chamber (7) are at a distance from said shell (9).
  10. The heat exchanger according to the previous claim, wherein the tubes (1) of said tube bundle cross the through holes (3) of said perforated tube plate (2) and have the first ends (12) and the second ends (13) that protrude from the perforated tube plate (2) outside the shell (9) of the heat exchanger.
  11. An evaporator, comprising a heat exchanger according to one of the preceding claims, wherein said containment volume is filled with a first liquid to be cooled or heated.



**FIG. 1**



**FIG. 2**

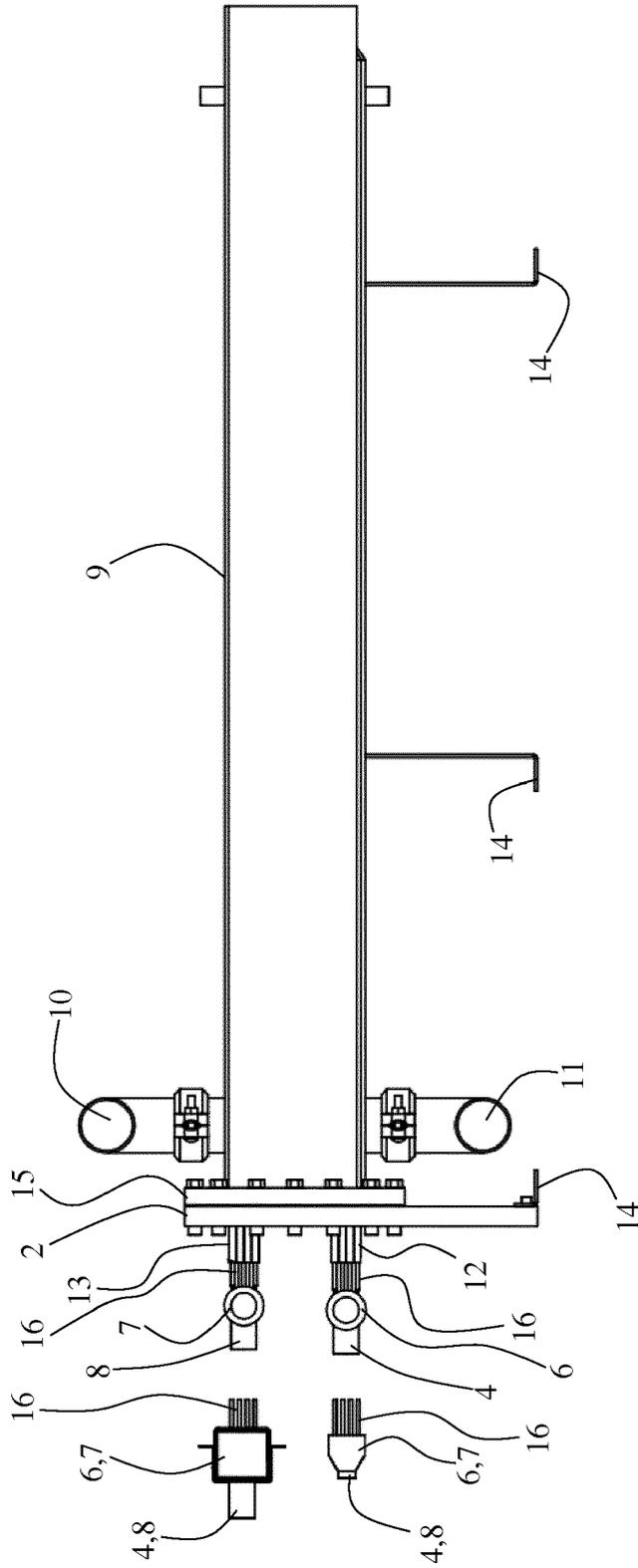
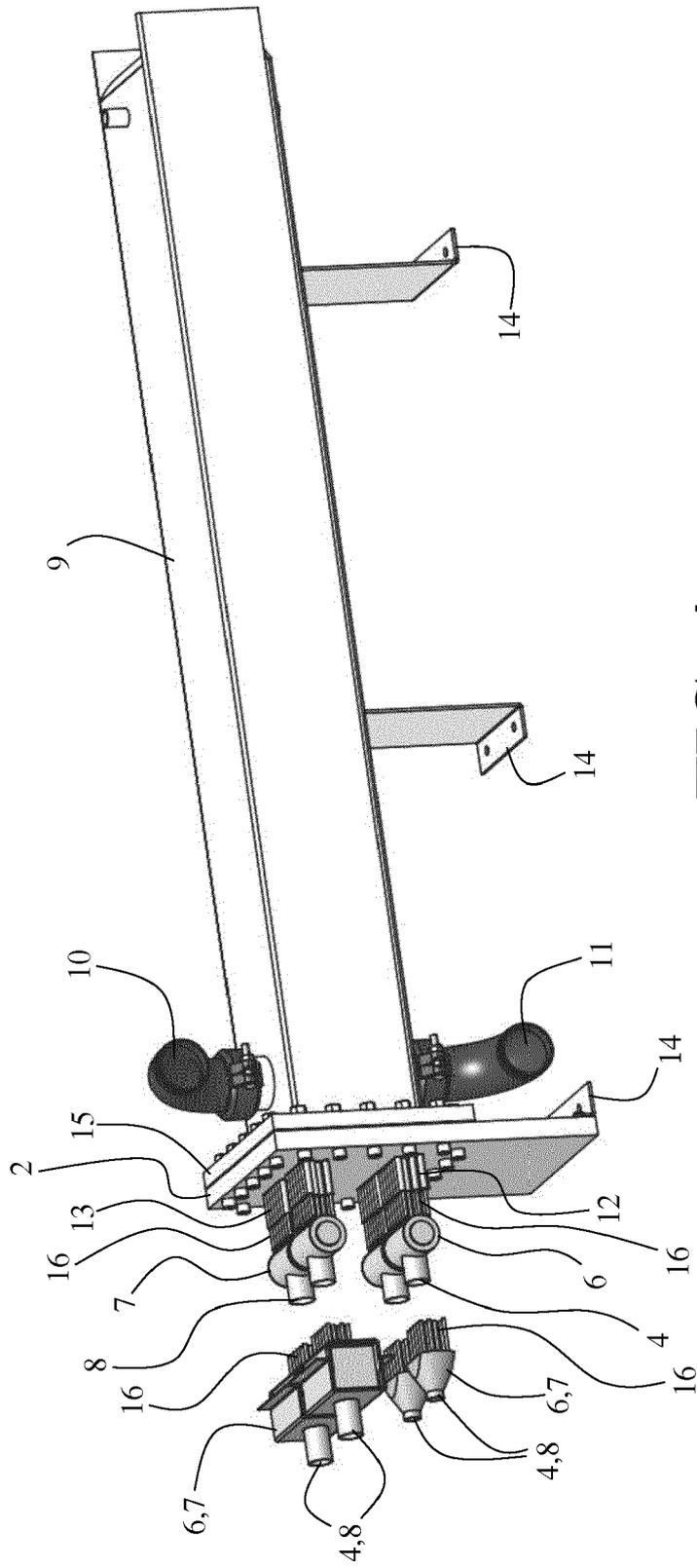
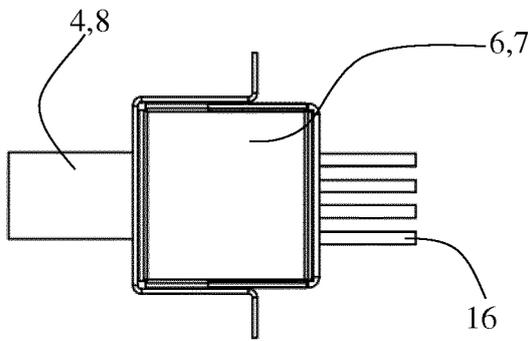


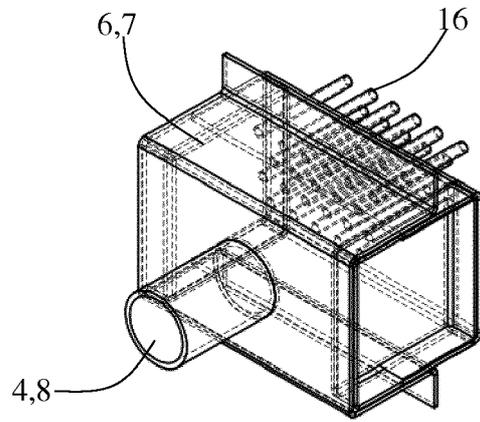
FIG. 3



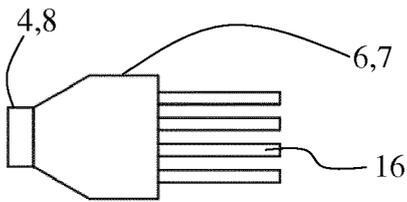
**FIG. 4**



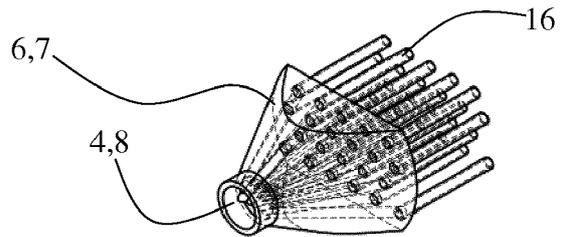
**FIG. 5a**



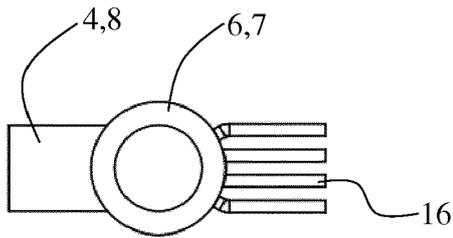
**FIG. 6a**



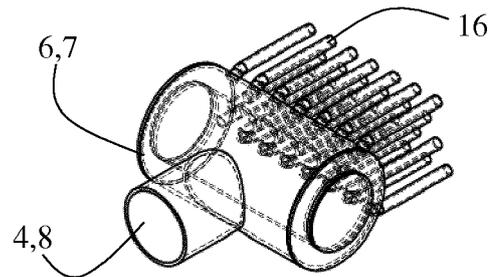
**FIG. 5b**



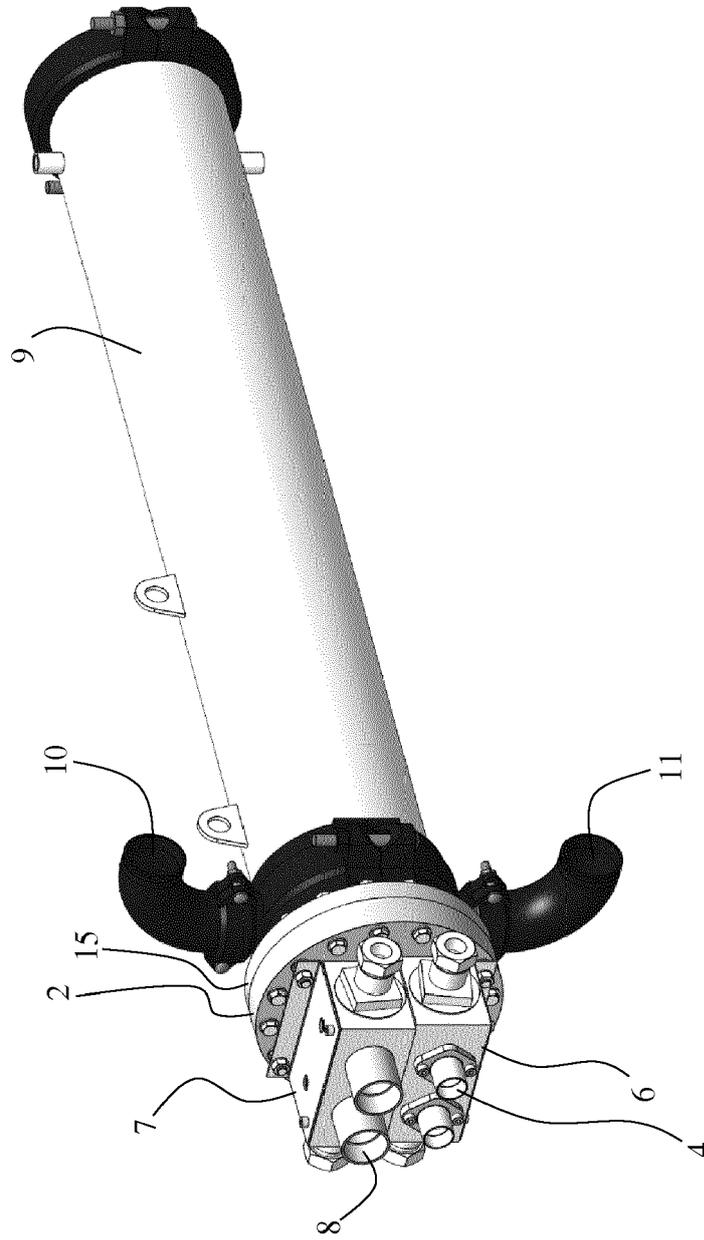
**FIG. 6b**



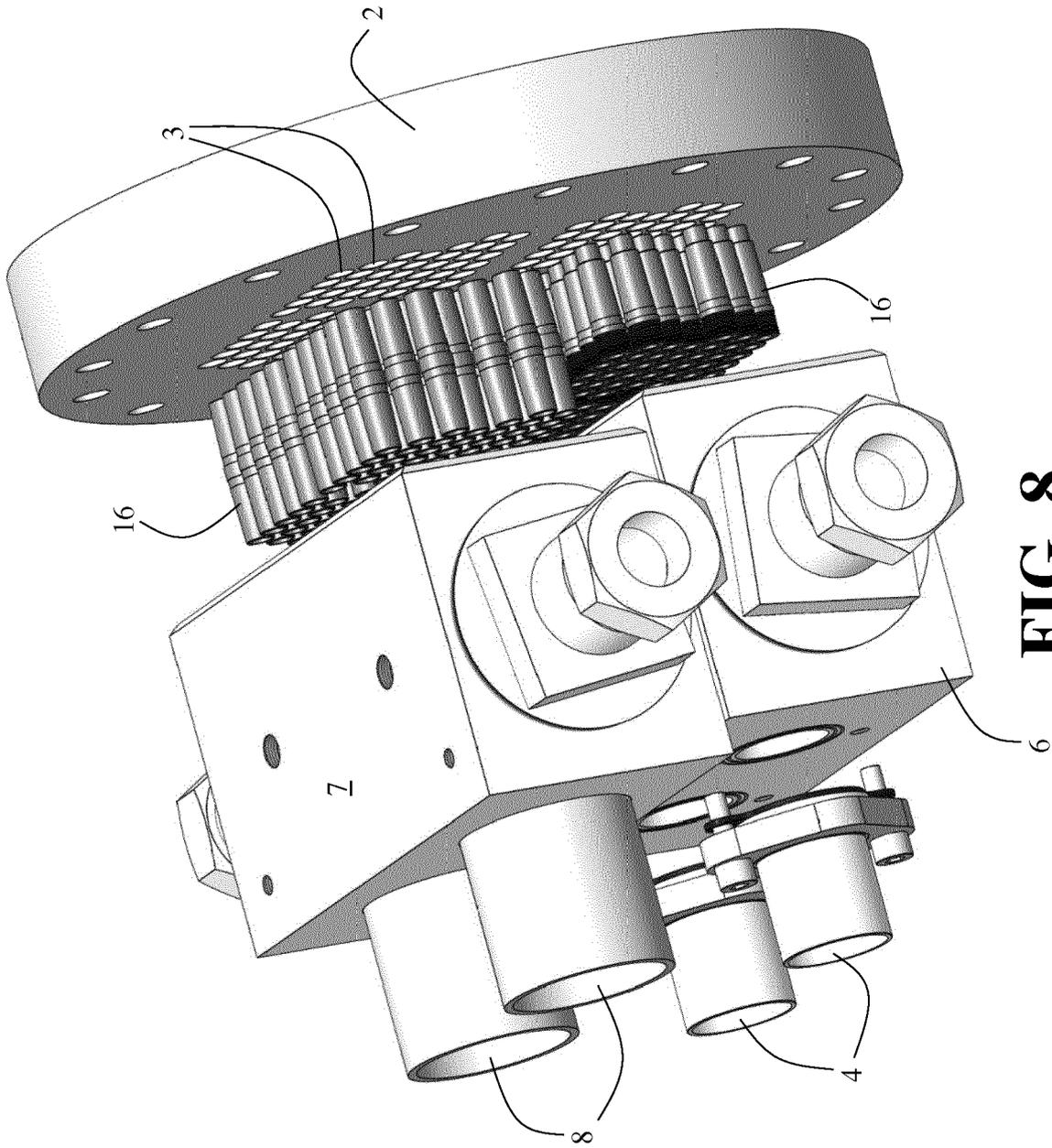
**FIG. 5c**



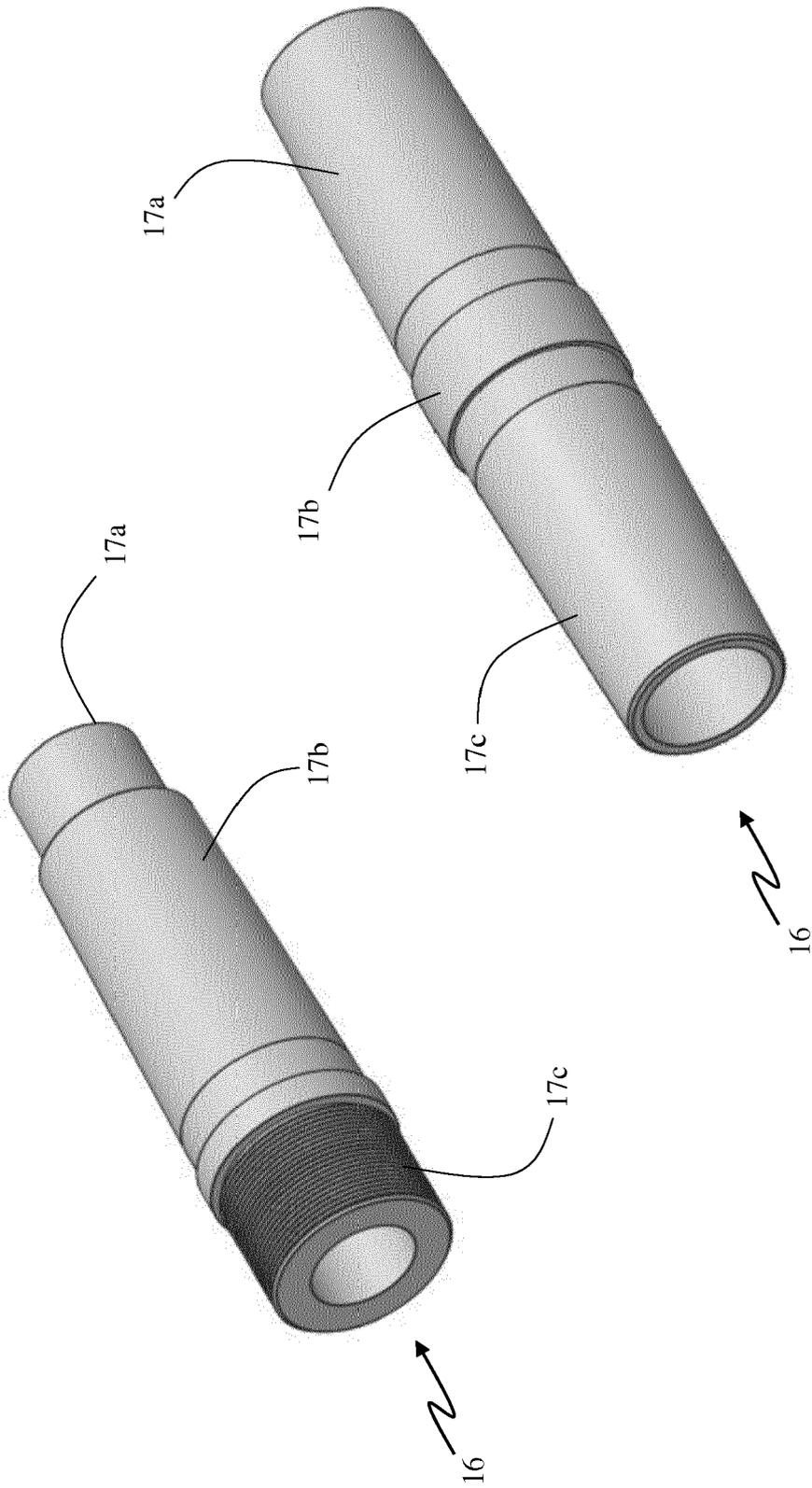
**FIG. 6c**



**FIG. 7**



**FIG. 8**



**FIG. 9**



EUROPEAN SEARCH REPORT

Application Number  
EP 19 17 5870

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	FR 1 335 130 A (È.M.R. CORBINEAU) 16 August 1963 (1963-08-16) * page 2 *	1-11	INV. F28D7/16 F28F9/02
A	US 2006/266504 A1 (ROHRBAUGH DARYL E [US] ET AL) 30 November 2006 (2006-11-30) * figures 2, 3, 4B *	1-11	
A	US 2005/061025 A1 (AYUB ZAHID HUSSAIN [US]) 24 March 2005 (2005-03-24) * the whole document *	1-11	
A	US 3 800 867 A (MAC KENZIE P) 2 April 1974 (1974-04-02) * the whole document *	1-11	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>15 October 2019</b>	Examiner <b>Axters, Michael</b>
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	

1  
EPO FORM 1503 03/02 (P04C01)

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

EP 19 17 5870

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-10-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 1335130 A	16-08-1963	NONE	
US 2006266504 A1	30-11-2006	US 2006266504 A1	30-11-2006
		US 2008010829 A1	17-01-2008
US 2005061025 A1	24-03-2005	NONE	
US 3800867 A	02-04-1974	DE 2127834 A1	09-12-1971
		US 3800867 A	02-04-1974

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- FR 1335130 [0009]
- US 2006266504 A [0010]
- US 2005061025 A [0011]
- US 3800867 A [0012]