(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 572 759 A1

(12) # EUROPEAN PATENT APPLICATION

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

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

(21) Application number: **19176275.6**

(22) Date of filing: **23.05.2019**

(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

(30) Priority: **24.05.2018 IT 201800005676**

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

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

(54) # TUBE PLATE FOR A HEAT EXCHANGER AND RELATED TUBE BUNDLE HEAT EXCHANGER

(57) A tube plate for a tube bundle heat exchanger according to the present disclosure comprises:
- a plurality of rear delivery openings arranged in delivery rows and columns, each connectable to a first end of a relative tube of the tube bundle, and a plurality of rear suction apertures organized in suction rows and columns, each connectable to a second end of the relative tube of the tube bundle opposite to the first end,
- delivery channels entirely defined within the thickness of the tube plate, which put in fluid communication among them the rear delivery openings of a same delivery column or of a same delivery row, and suction channels entirely defined within the thickness of the tube plate, which put in fluid communication the rear suction openings of a same suction column or of a same suction row;
with the delivery channels that flow with lateral delivery openings on the side surface of the tube plate and the suction channels that flow with the lateral suction openings on the side surface of the tube plate.

Such a tube plate can be mounted on a shell containing a tube bundle to form a tube bundle heat exchanger of dry expansion type and a relative evaporator.

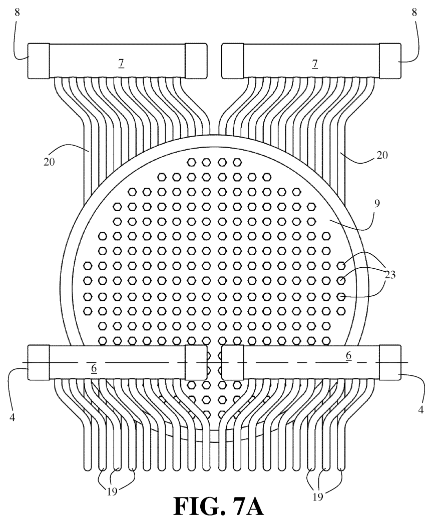


FIG. 7A

EP 3 572 759 A1

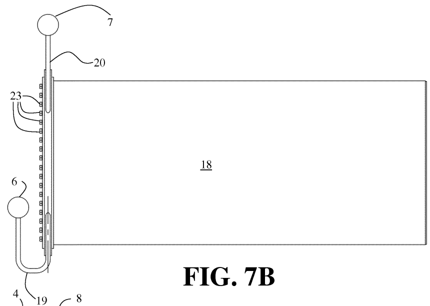


FIG. 7B

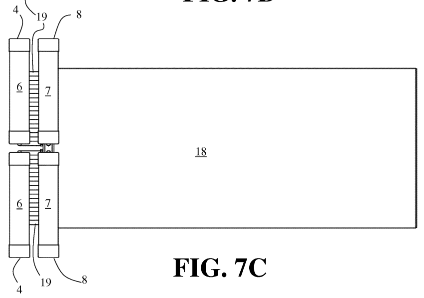


FIG. 7C

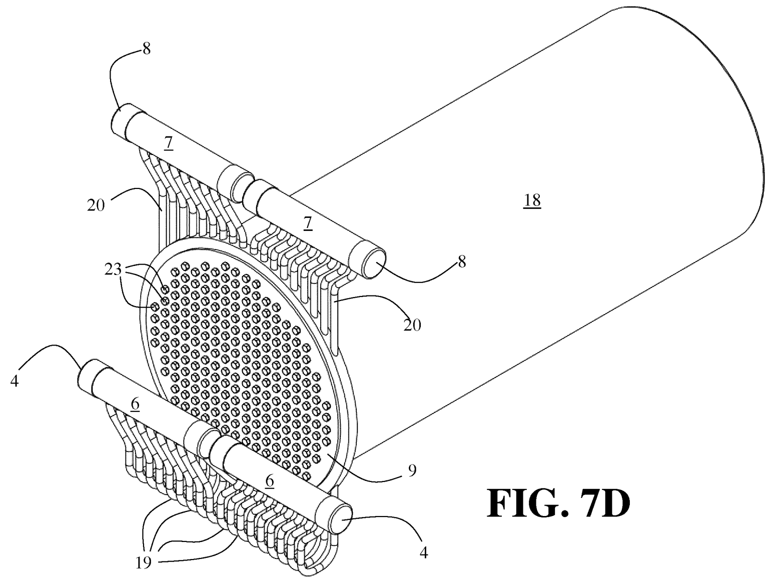


FIG. 7D

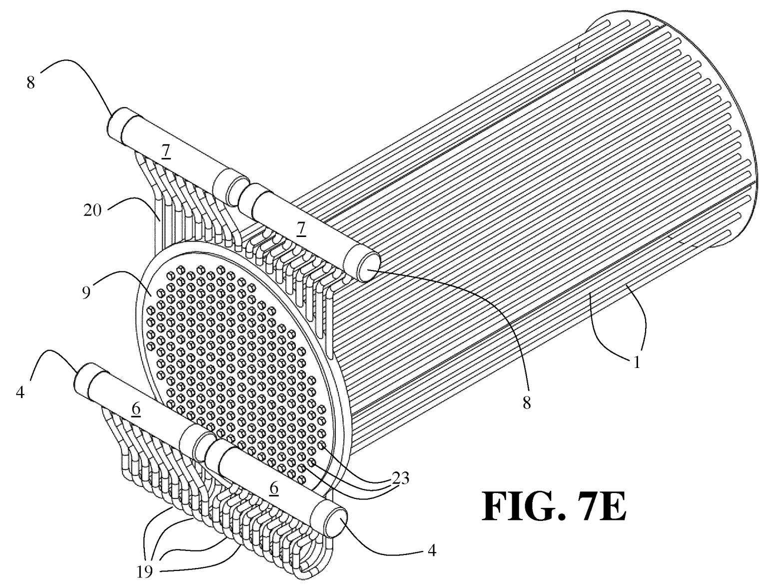


FIG. 7E

Description

TECHNICAL FIELD

[0001] The present disclosure relates to heat exchangers and more in particular to a tube plate for a heat exchanger, as well as a relative tube bundle heat exchanger in which a pressurized fluid is heated/cooled with change of state by means of another fluid in the liquid state contained in the shell.

TECHNOLOGICAL BACKGROUND

[0002] 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] Document FR3046838 discloses (figure 4 of the document) a tube plate according to the preamble of claim 1. It is configured so as to put in fluid communication among them inside the tube plate all the front openings, in which each front opening is connected to a respective tube of a tube bundle. The tubes connected to the tube plate are therefore communicating vessels so that, when the inside of the tube plate is filled with fluid, further injected fluid is distributed among all the tubes.

[0010] A disadvantage of this tube plate is that it does not allow to select the tubes in which to introduce fluid. Furthermore, it cannot be used in heat exchangers with a U-bent tube bundle, as it would put the opposite ends of each tube in direct fluid communication. Finally, it must necessarily be used lying on a horizontal plane, in order to have a correct distribution of the fluid in the tubes by exploiting the principle of communicating vessels.

[0011] EP810414 discloses a heat exchanger for cooling gas by means of cooling pipes installed in an external pipe, in which the cooling pipes are welded at each end to a water chamber which supplies and receives a coolant.

[0012] US5425415 discloses a vertical heat exchanger which comprises a vertical tube bundle connected between a lower inlet opening and an upper outlet opening.

[0013] FR3016958 discloses a heat exchanger, in particular for an air conditioning circuit of a vehicle.

SUMMARY

[0014] The Applicants have found that the so-called dry expansion evaporators are subject to expensive certifications since the delivery chamber, in which the second fluid is collected before being sorted between the various tubes of the tube bundle, is delimited by at least one direct wall contact with the first fluid in the liquid state contained within the shell of the evaporator. In addition, the delivery chamber is defined by bolting the head wall against the tube plate of the shell, so that the removable union of these two parts must be certified as perfectly sealed and as perfectly safe, given that the tube plate has a surface in direct contact with the first fluid in the liquid state.

[0015] To overcome these drawbacks, the Applicants have realized a tube plate for a tube bundle heat exchanger which overcomes the aforementioned limitations. This result is achieved thanks to the tube plate according to the present disclosure, which comprises:

- a plurality of first rear openings arranged in first rows or columns, each connectable to a first end of a relative tube of the tube bundle, and a plurality of second rear apertures organized in second rows or columns, each connectable to a second end of the relative tube of the tube bundle opposite to the first end,
- first channels entirely defined within the thickness of the tube plate, which put in fluid communication among them the first rear openings of a same first column or of a same first row, and second channels entirely defined within the thickness of the tube plate, which put in fluid communication the second rear openings of the same second column or of the same second row;

with the first channels that flow with first lateral openings on the side surface of the tube plate and second channels that flow with the second lateral openings on the side surface of the tube plate. The tube plate is a one-piece plate and the first channels are distinct and separate and are not in fluid communication with each other inside the tube plate, and so also the second channels are distinct and separate and are not in fluid communication with each other inside the tube plate.

[0016] According to one aspect, the first channels are fluid delivery channels and the second channels are fluid suction channels.

[0017] Such a tube plate can be mounted on a shell containing a tube bundle to form a tube bundle heat exchanger of dry expansion type and a relative evaporator.

[0018] An evaporator is made by filling with liquid the containment volume defined by the shell, containing the tube bundle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

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

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

Figures 3A to 3H are respectively views of the outer surface (3A), of the inner surface (3B), of the side surface from above (3C), of the side surface from below (3D), of the profile of the side surface (3E), as well as cross-sections (3F, 3G and 3H) of a circular tube plate according to the present disclosure.

Figures 3I to 3O are similar to figures 3A to 3G and refer to a square tube plate according to the present disclosure.

Figures 4A to 4C are respectively a profile view (4A), a top view (4B) and a detail view (4C) of the tube plate of Figures 3A to 3H mounted on a shell of a heat exchanger.

The figures from 5A to 5E are respectively a top view (5A), a front view (5B), a side view (5C) and perspective views (5D and 5E) of a delivery chamber with walls lapped by air of an environment in which the exchanger is installed.

Figures 6A to 6D are respectively a side view (6A), a front view (6B) and perspective views (6C and 6D) of a suction chamber with walls lapped by the air of a room in which the exchanger is installed.

Figures 7A to 7D are respectively a front view (7A), a side view (7B), a top view (7C) and a perspective view (7D) of a heat exchanger with the circular tube plate of figures from 3A to 3H according to an embodiment of the present disclosure.

Figure 7E shows the heat exchanger of Figure 7D without the shell that defines the containment volume of the coolant.

Figures 8A to 8D are respectively a front view (8A), a side view (8B), top view (8C) and a perspective view (8D) of a heat exchanger with the square tube plate of Figures 3I to 3O according to another embodiment of the present disclosure.

Figure 8E shows the heat exchanger of Figure 8D without the shell that defines the containment volume of the coolant.

DETAILED DESCRIPTION

[0020] A circular tube plate 2 according to the present disclosure is illustrated from different points of view and in section in Figures 3A to 3H. A similar tube plate 2 having a substantially square shape is shown in Figures 3I to 3O which correspond respectively to Figure 3A to 3G. It is made in the form of a monobloc plate of rigid material, with a front surface 9 (Fig. 3B; Fig. 3J) which remains outside the containment volume of the exchanger, a rear surface 10 (Fig. 3A; Fig. 3I) intended to be oriented inside the containment volume of the exchanger, and from a side surface 11 (Figs. 3C, 3D; Figs. 3K, 3L) which defines the thickness of the tube plate 2.

[0021] On the back surface 10 first rear openings 12 are defined, which can for example be delivery openings 12 of a fluid, and many second rear openings 13, which can for example be suction openings 13, which may be connected to respective ends of the tubes of a tube bundle. The first rear openings 12 and the second rear openings 13 are organized in first rows or columns and, respectively, second rows or columns (or vice versa).

[0022] In the following description, reference will be made to the non-limiting example in which the first openings 12 are delivery openings 12 and the second openings 13 are suction openings, and in which both the delivery openings 12 and the suction openings 13 are organized in delivery and suction columns distinct and separated from each other and not in fluid communication with each other within the thickness of the single-piece tube plate 2. However, according to an aspect not shown in the figures, the first openings 12 can be arranged in columns and the second openings 13 can be arranged in rows, distinct and separated from one another and not in fluid communication within the thickness of the single-piece tube plate 2.

[0023] According to an aspect shown in the figures, the first openings 12 are distinct and separated from the second openings 13 so as to allow the tube plate 2 to be used to pump fluid into the tubes through the first openings 12 and to suck the fluid from the tubes through the second openings 13.

[0024] As shown in the sectional view of Figure 3F (Figure 3N) and of Figure 3H, the rear delivery openings 12 of a same delivery column are connected in fluid communication with each other within the thickness of the tube plate 2 by means of a respective delivery channel 14 which opens onto the side surface 11 with a respective lateral delivery opening 16. Similarly, the rear suction openings 13 of a same suction column are connected in fluid communication with each other by a respective suction channel 15 which opens onto the side surface 11 with a respective lateral suction opening 17. The delivery channels 14 and the suction channels 15 are made in the compact thickness of the tube plate 2, as illustrated by the comparison of Figures 3F and 3G (Figures 3N and 3O). In Figures 3A and 3G (figures 3I and 3O) is also shown the peripheral groove 21 on the rear surface 10 intended to accommodate the profile of the shell so as to close the containment volume of the heat exchanger.

[0025] Preferably, but not necessarily, the delivery channels 14 and the suction channels 15 are arranged so as to lead to first lateral openings 16 diametrically opposed to the lateral suction openings 17. For example, the lateral delivery openings 16 can be oriented downwards (fig. 3D; fig. 3L) and the lateral suction openings 17 can be oriented upwards (fig. 3C; fig. 3K).

[0026] According to the present disclosure, each of the tubes of the tube bundle has an end sealingly secured and in fluid communication to a respective first rear opening 12 and the opposite end sealed and in fluid communication to a respective rear suction opening 13. To fix each tube in a waterproof manner in the respective rear opening, internally threaded holes 22 are made on the front face 9 of the tube plate, substantially coaxial with a corresponding first rear opening 12 or suction opening 13. These internally threaded holes 22 have a sufficiently large diameter for inserting a mandrel through them so as to access inside a tube engaged in the rear delivery opening 12 or suction opening 13, so as to fix the tubes in a waterproof manner in the respective rear openings thanks to an expansion process. Once performed the expansion, the internally threaded holes 22 are sealed by screws 23, which are visible from the outside, as shown in Figures 7A to 8E.

[0027] With this structure, the second pressurized fluid may be distributed with passage of state among all the tubes of the tube bundle which belong to the same delivery channel 14, pumping it through the respective lateral delivery opening 16, and it can be sucked from all the tubes of the tube bundle that belong to the same suction channel 15 simply by pumping it through the respective lateral suction opening 17.

[0028] In other words, the volume of the second fluid to be pumped through the tubes of the beam is divided into as many sub-volumes as there are the delivery channels 14 outside the exchanger, before reaching the tube plate 2. Inside the tube plate, each delivery channel 14 provides for the subdivision of the respective sub-volume only among the tubes that are connected to it. Even if the delivery channels 14 were considered, from a regulatory point of view, as functionally equivalent to the delivery chambers of the known exchanger of figures 1 and 2, however, they are characterized by considerably smaller volumes, which reduces certification costs. Moreover, the delivery channels 14 (as well as the suction channels 15) are made in the single-piece thickness of the tube plate 2 and are not obtained by union of two bolted plates.

[0029] The tube plate 2 shown in the above figures may easily be connected to a shell 18 in the manner shown in Figures 4A to 4C, for example with the lateral delivery openings 16 facing downwards and the lateral suction openings 17 facing upwards (or vice versa), engaging the profile of the shell 18 in the groove 21 of the rear wall 10, as shown in Figure 4C.

[0030] The heat exchanger is completed by mounting one or more delivery chambers 6, for example of the type shown in figures 5A to 5E, and one or more suction chambers 7, for example of the type shown in figures 6A to 6D. Each delivery chamber 6 is delimited by walls separated by the shell 18 and is configured to be at a distance from it, so that the walls of the delivery chamber 6 are lapped by the air of the environment in which the exchanger is installed. Each delivery chamber 6 has outlet openings 19 sealedly connected in fluid communication to a respective lateral delivery opening 16 of the tube plate 2, and has an inlet opening 4 suitable for being placed in fluid communication with a delivery conduit of the second fluid.

[0031] In a dual manner, each suction chamber 7 is also delimited by walls separated by the shell 18 and at a distance from it, so as to be lapped by air of the environment in which the exchanger is installed, and has inlet openings 20 connected in sealing fluid composition to respective lateral suction openings 17 of the tube plate 2, besides having an outlet opening 8 suitable for being placed in fluid communication with a suction conduit of the second fluid.

[0032] Figures 7A to 7D and Figures 8A to 8D show heat exchangers according to alternative embodiments of the present disclosure, in which the various parts are numbered with the same references of the figures from 3A to 6D. Figure 7E (Figure 8E) shows the heat exchanger of Figure 7D (Figure 8D) without the shell 18, so as to uncover the bundle of tubes 1 fixed to the tube plate 2. Thanks to this configuration, it is possible to extract the tube bundle 1 from the shell 18 by removing the bolts (not shown) which fix the tube plate 2 to the shell 18 and then pulling out the tube bundle 1 longitudinally from the shell 18.

[0033] In the configuration shown in Figure 7E (Figure 8E) it can be understood that the tube bundle 1 is bent in a U-shape and is separated by a substantially horizontal separator, fixed to the tube plate 2, which remains inside the shell 18 to define a circulation path of the first fluid in a liquid, from an inlet conduit of the first fluid to an outlet conduit of the first fluid, directed countercurrent with respect to a path for circulation of the second fluid under pressure in the bundle of tubes 1. Clearly, also the cocurrent configuration is possible simply by reversing the flow of one of the two fluids.

[0034] Thanks to the particular characteristics of the tube plate 2, it is possible to realize evaporators which have the same performances as known evaporators in terms of heat exchange efficiency, but which require lower certification costs, and thus lower total costs, because:

- the volume of the second fluid, pumped at a pressure in the pipes and destined to a phase transition, is divided into sub-volumes before being distributed to each tube;
- the subdivision into sub-volumes takes place inside one or more delivery chambers 6 delimited by walls completely detached from the shell 18 and lapped by air of the environment;
- the distribution of each sub-volume of the second fluid is carried out through channels defined in the single-piece body of the tube plate, so that certification obligations are avoided, that are due when the distribution of the second fluid in the tube bundle takes place through a cavity obtained by bolting two distinct parts;
- similarly, suction of the second fluid is carried out by sub-volumes thanks to the suction channels 15 defined in the body of the tube plate 2;
- finally, the different aspirated sub-volumes of the second fluid are conveyed to one or more suction chambers 7 delimited by walls completely detached from the shell 18 and lapped by air of the environment.

Claims

1. A tube plate (2) for a tube bundle heat exchanger, having:

   - a front surface (9), a rear surface (10) opposite to the front surface (9) and a side surface (11) which defines a thickness of the tube plate between the front surface (9) and the rear surface (10),
   - at the rear surface (10), a plurality of first rear openings (12) organized in first rows or first columns, each first rear opening (12) being connectable to a first end of a corresponding tube of the tube bundle (1), and a plurality of second rear openings (13) organized in second rows or second columns, each second rear opening (13) being connectable to a second end of the corresponding tube of the tube bundle (1) opposite to said first end,
   - first channels (14) entirely defined within the thickness of the tube plate (2), which bring into fluid communication among them the first rear openings (12) of a same first row or of a same first column,
   - second channels (15) entirely defined within the thickness of the tube plate (2), which bring into fluid communication the second rear openings (13) of a same first row or of a same first column,

   wherein the first channels (14) terminate with respective first lateral openings (16) on the side surface (11) of the tube plate (2) and the second channels (15) terminate with second lateral openings (17) on the side surface (11) of the tube plate (2),
   wherein said tube plate (2) is a single piece plate, **characterized in that**
   said first channels (14) are distinct and separated among them and are not in fluid communication among them inside the tube plate (2);
   said second channels (15) are distinct and separated and are not in fluid communication among them inside the tube plate (2);
   each first lateral opening of said first lateral openings (16) is in fluid communication inside the tube plate (2) with a single respective channel of said first channels (14);
   each second lateral opening of said second lateral openings (17) is in fluid communication inside the tube plate (2) with a single respective channel of said second channels (15).

2. The tube plate (2) according to claim 1, wherein said

second lateral openings (17) are defined on the side surface (11) of the tube plate (2) preferably in diametrically opposite positions with respect to said first lateral openings (16).

3. The tube plate (2) according to claim 1 or 2, wherein internally threaded holes (22) are drilled on said front surface (9), each threaded hole of said internally threaded holes (22):

- is coaxial with a corresponding rear opening of said first rear openings (12) and of said second rear openings (13),
- has a sufficiently large inner diameter to allow a mandrel to pass through it and to enter into a tube (1) inserted in the corresponding rear opening;

wherein the tube plate (2) also comprises as many threaded screws (23) as said internally threaded holes (22), each of said threaded screws (23) being screwed into a relative threaded hole (22) so as to seal it hermetically.

4. A tube plate (2) according to one of the preceding claims, wherein said first channels (14) are delivery channels (14) of a fluid and said second channels (15) are suction channels (15) of said fluid, and wherein said delivery channels (14) are distinct and separated from said suction channels (15) and are not in fluid communication among them inside the tube plate (2).

5. A tube bundle heat exchanger, comprising:

a shell (18) defining a containment volume, said shell (18) having an inlet conduit and an outlet conduit from the containment volume suitable for a first fluid in a liquid state to be cooled or heated, and at least one tube plate (2),
a tube bundle (1),
a delivery chamber (6) of a second fluid under pressure to be heated or cooled with a state passage, defining an inlet opening (4) suitable for being placed in fluid communication with a delivery conduit of the second fluid, and a plurality of outlet openings (19) each suitable for being placed in fluid communication with a respective tube of the tube bundle (1),
a suction chamber (7) of the second fluid, defining a plurality of inlet openings (20) each suitable for being placed in fluid communication with a respective tube of the tube bundle (1), and an outlet opening (8) suitable for being placed in fluid communication with a suction conduit of the second fluid,
characterized in that
said head wall is as defined in claim 4;
said first ends of the tubes (1) of said tube bundle are sealedly plugged-in in said first rear openings (12) of the tube plate (2) in fluid communication with the corresponding delivery channel (14), and said second ends of the tubes (1) of said tube bundle are sealedly fixed into said second rear openings (13) of the tube plate in fluid communication with the corresponding suction channel (15);
said delivery chamber (6) is delimited by walls separated from said shell (18) and at a distance therefrom, so that said walls of the delivery chamber (6) are lapped by air of an environment in which the heat exchanger is installed, wherein each outlet opening of said outlet openings (19) of the delivery chamber (6) is connected in fluid communication and in a waterproof manner to a respective first lateral opening of said first lateral openings (16) of the tube plate (2);
said suction chamber (7) is delimited by walls separated from said shell (18) and at a distance therefrom, so that said walls of the suction chamber (7) are lapped by air of an environment in which the exchanger is installed, wherein each inlet opening of said inlet openings (20) of the suction chamber (7) is connected in fluid communication in a waterproof manner to a respective second lateral opening of said second lateral openings (17) of the tube plate (2).

6. The heat exchanger according to the preceding claim, comprising at least two identical delivery chambers (6), in which each delivery chamber (6) is delimited by walls separated from said shell (18) and at a distance therefrom, so that said walls of the delivery chamber (6) are lapped by air of an environment in which the exchanger is installed, in which each outlet opening of said outlet openings (19) is connected in fluid communication in a waterproof manner to a respective lateral delivery opening of said lateral delivery openings (16) of the tube plate (2).

7. The heat exchanger according to one of claims 5 and 6, comprising at least two identical suction chambers (7), in which each suction chamber (7) is delimited by walls separated from said shell (18) and at a distance therefrom, so that said walls of the suction chamber (7) are lapped by air of an environment in which the exchanger is installed, in which each inlet opening of said inlet openings (20) is connected in fluid communication in a waterproof manner to a respective second lateral opening of said second lateral openings (16) of the tube plate (2).

8. The heat exchanger according to one of claims from 5 to 7, wherein said tubes (1) of the tube bundle are U-bent inside the containment volume.

9. The heat exchanger according to claim 8, comprising a separating partition installed inside the shell (18) to define a circulation path for the first fluid in the liquid state, from an inlet conduit of the first fluid to an outlet conduit of the first fluid, directed counter-current with respect to a circulation path of the second fluid under pressure in the tube bundle (1).

10. The heat exchanger according to one of claims 5 to 9, wherein said tube plate (2) is integral with the tubes (1) of the tube bundle, and is removably fixed to the shell (18) so as to allow to extract the tube bundle (1) from the shell (18).

11. An evaporator, comprising a heat exchanger according to one of claims 5 to 10, wherein said containment volume is filled with the first fluid in the liquid state.

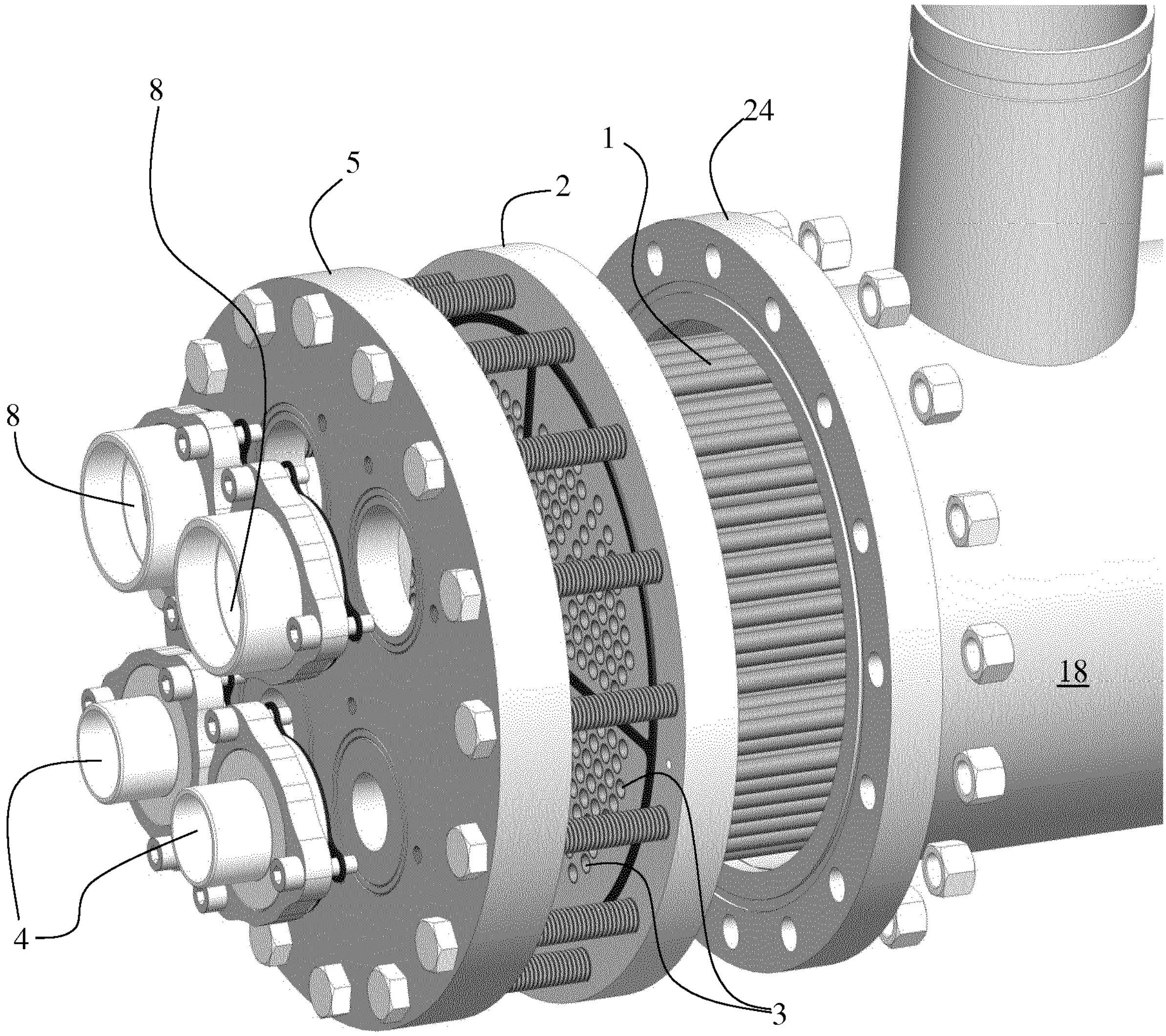


FIG. 1

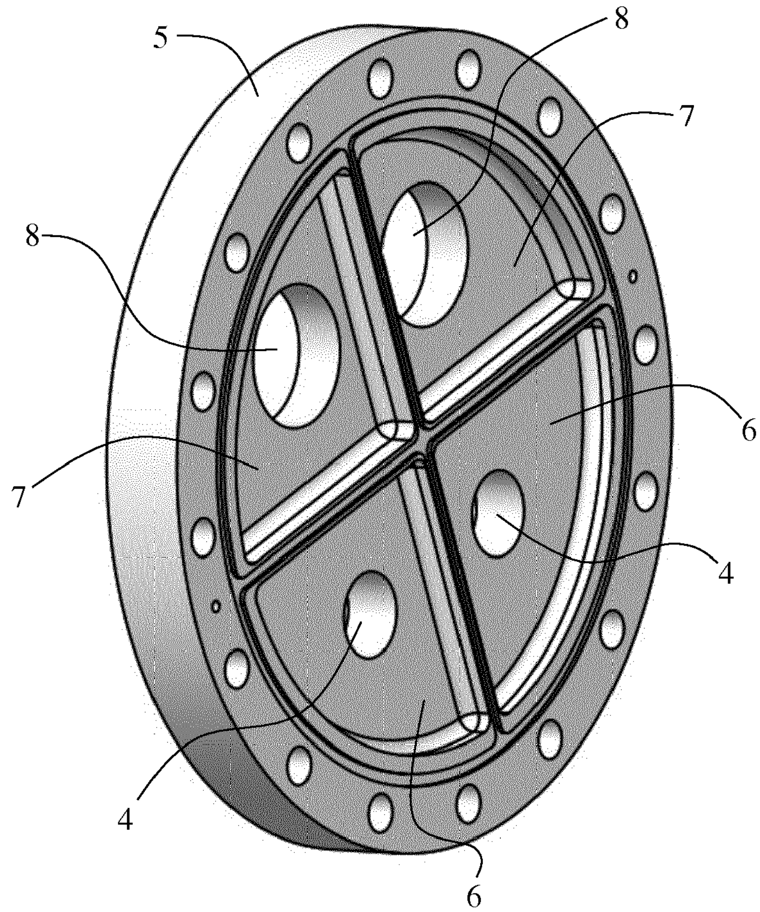


FIG. 2

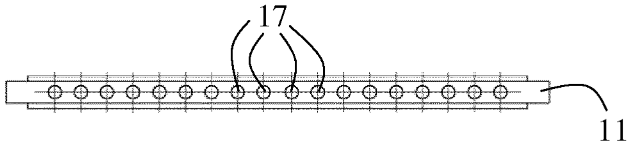


FIG. 3C

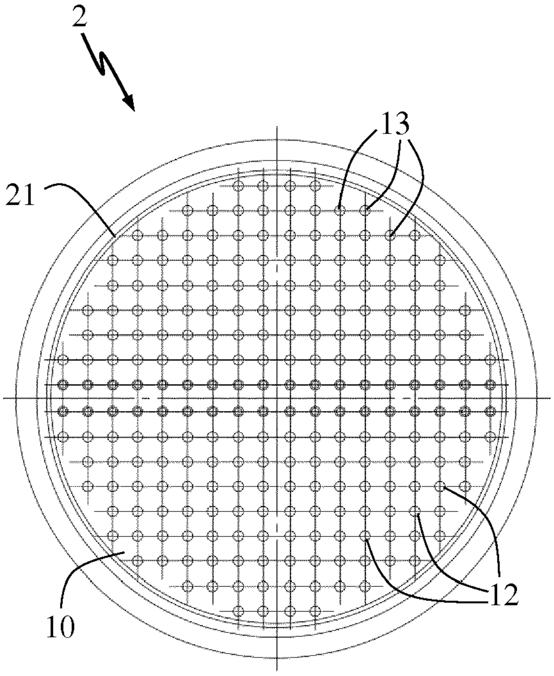


FIG. 3A

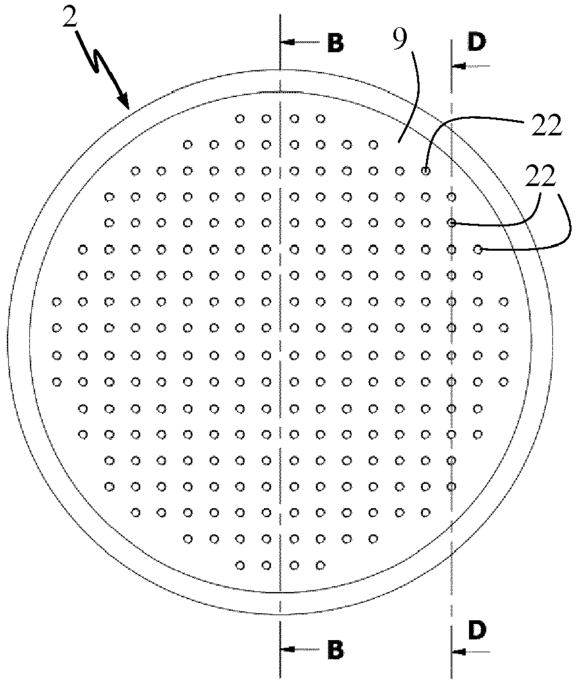


FIG. 3B

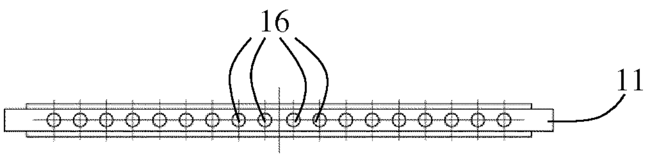


FIG. 3D

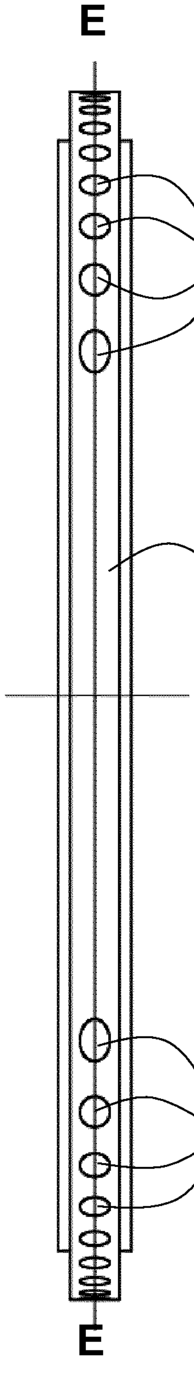


FIG. 3E

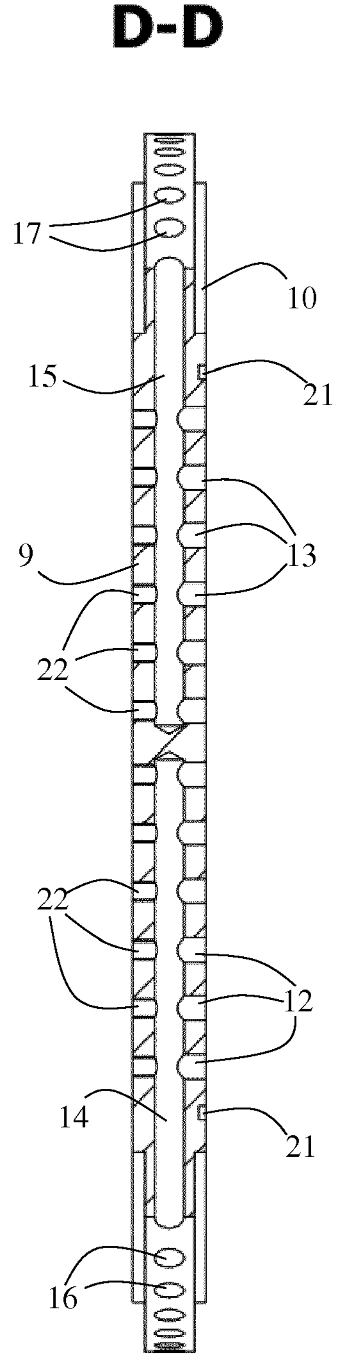


FIG. 3F

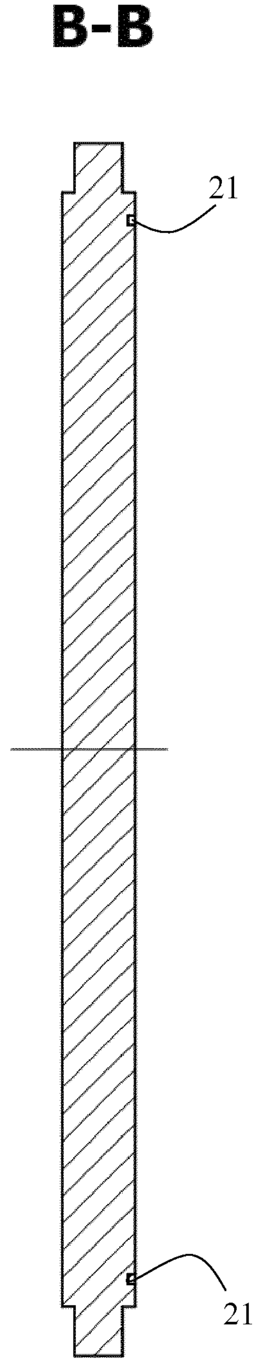


FIG. 3G

E-E

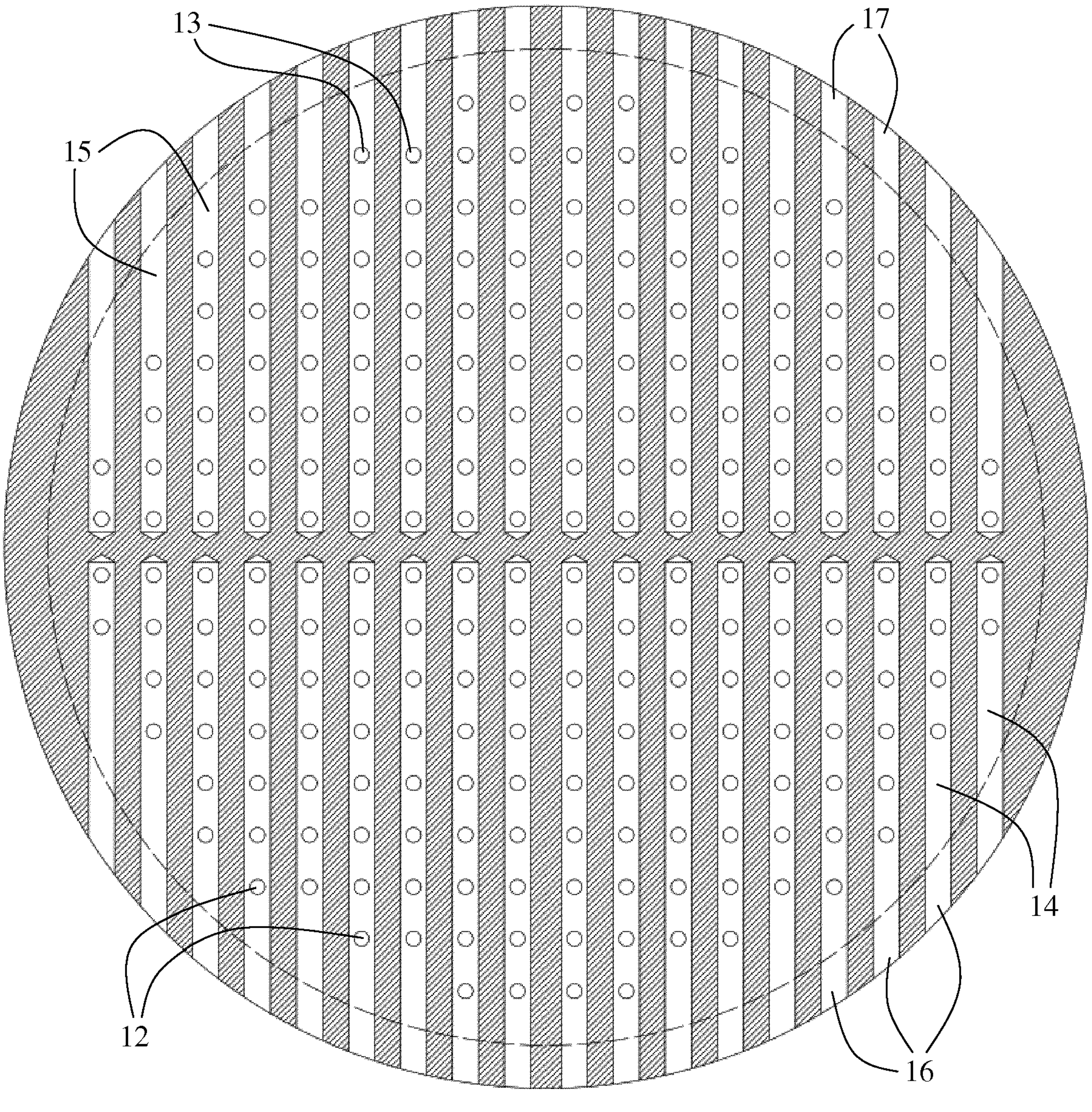


FIG. 3H

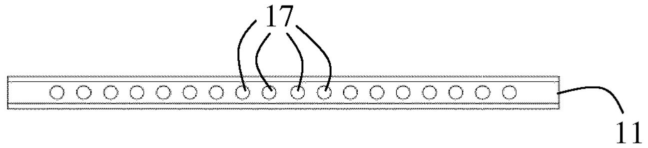
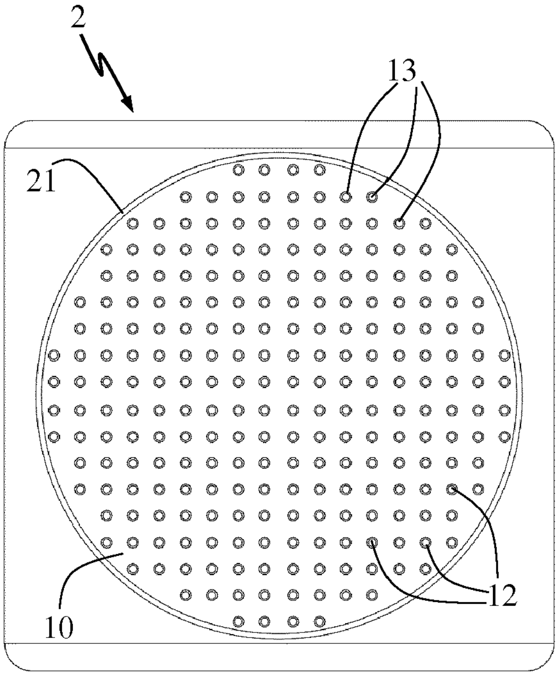


FIG. 3K



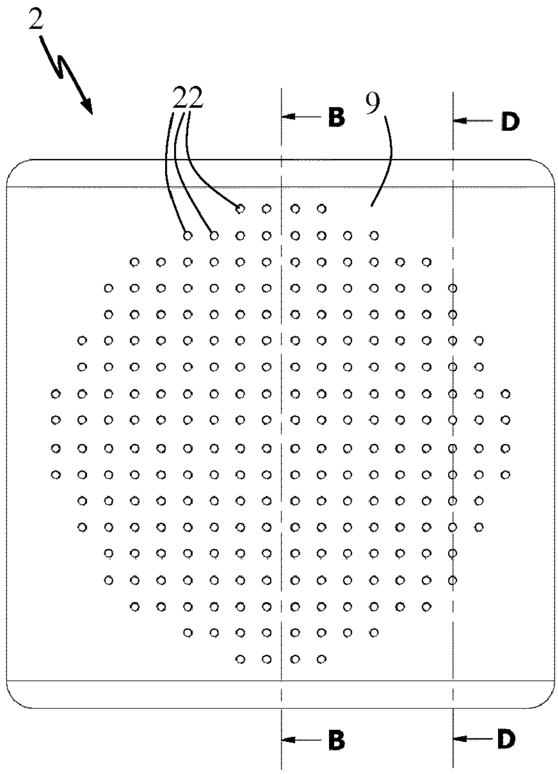


FIG. 3I

FIG. 3J

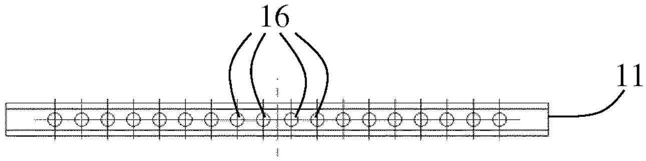


FIG. 3L

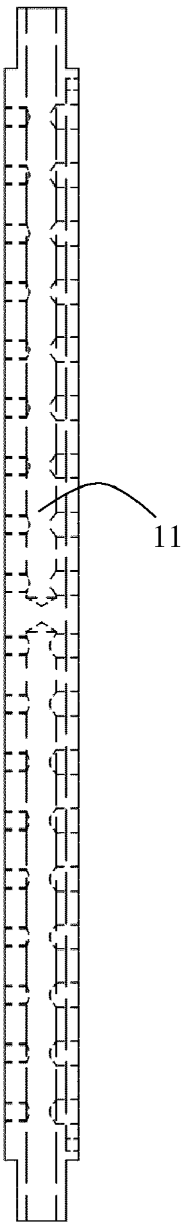


FIG. 3M

D-D

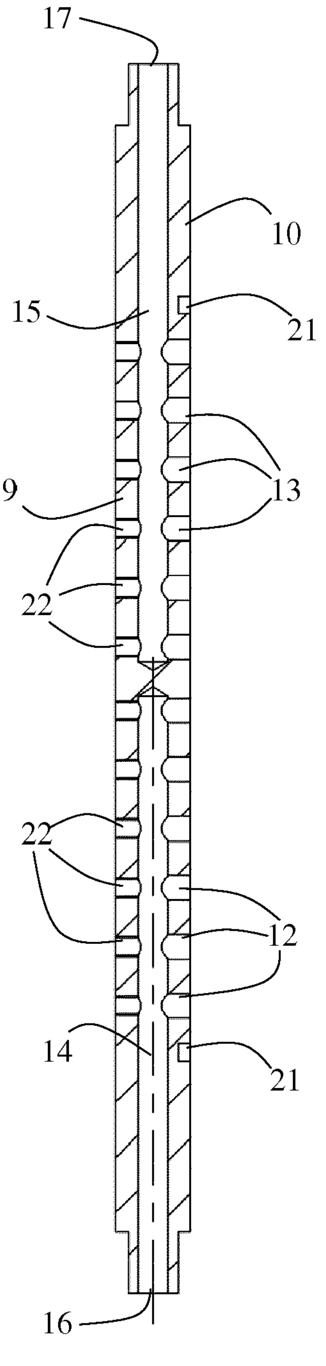


FIG. 3N

B-B

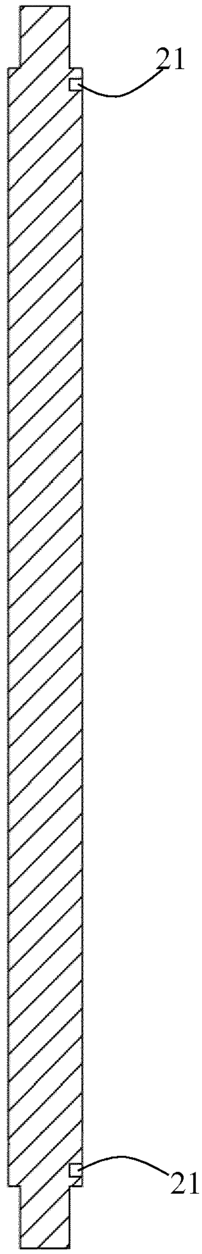


FIG. 3O

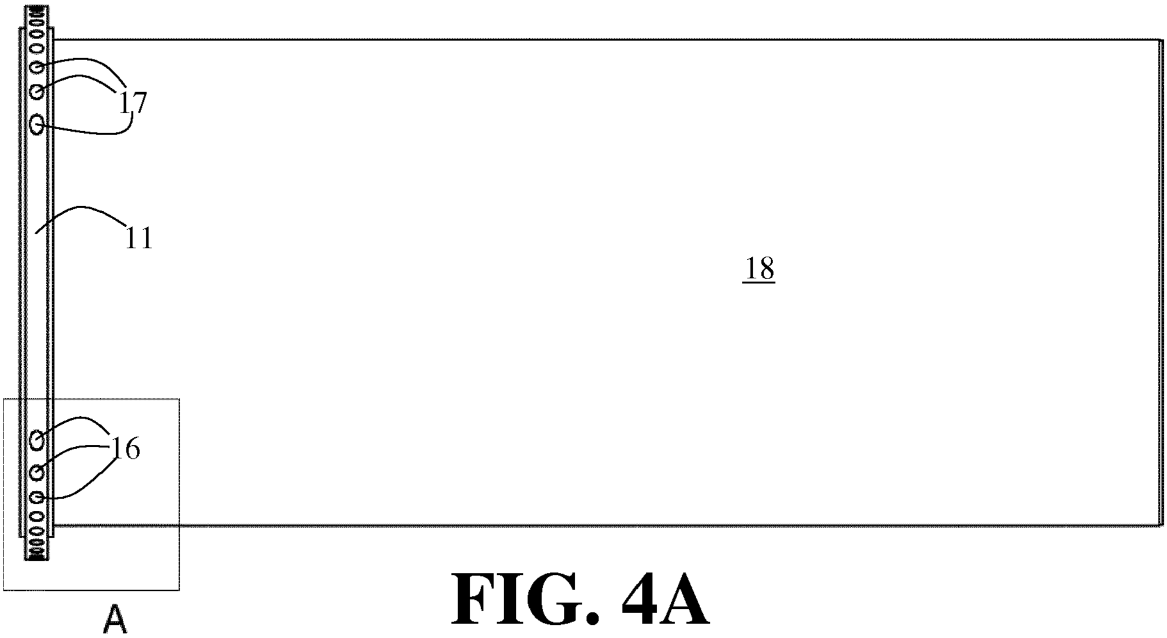


FIG. 4A

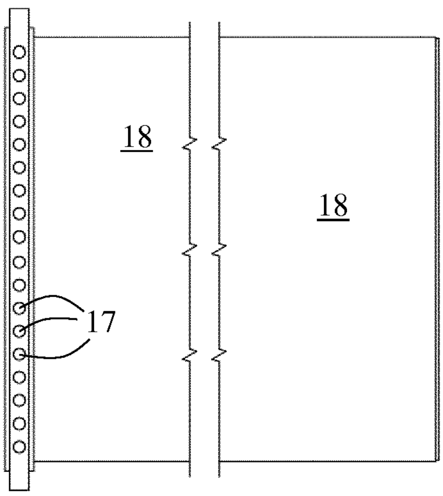


FIG. 4B

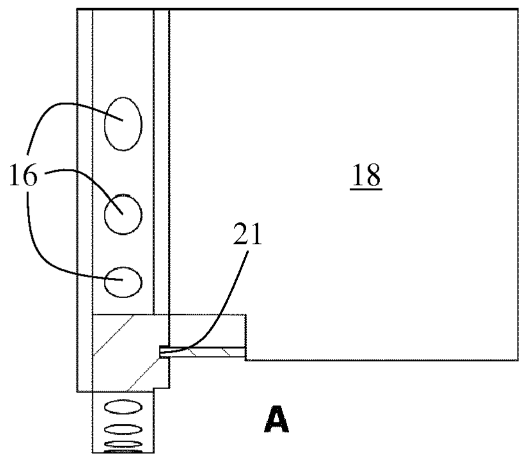


FIG. 4C

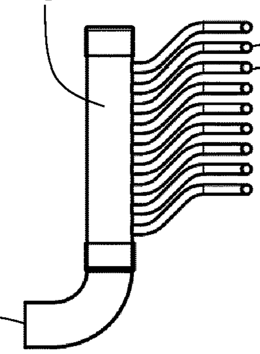


FIG. 5A

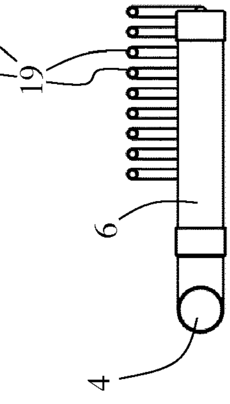


FIG. 5B

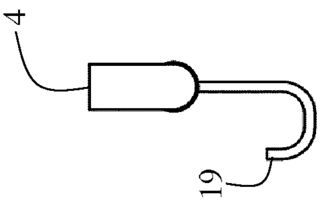


FIG. 5C

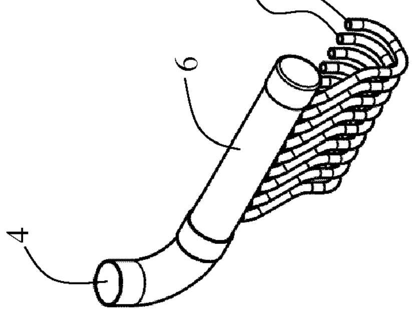


FIG. 5D

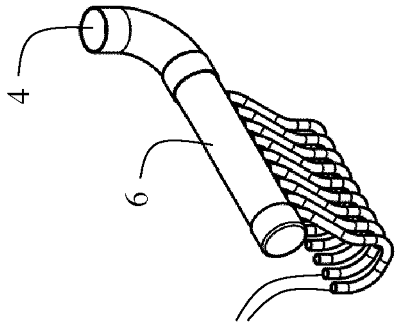


FIG. 5E

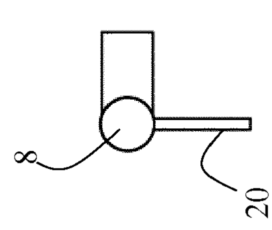


FIG. 6A

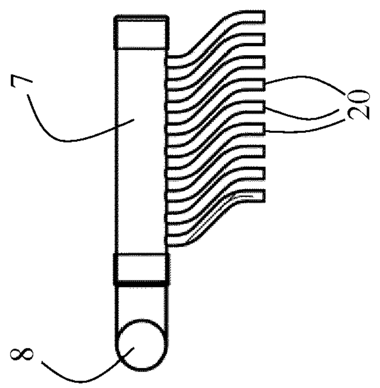


FIG. 6B

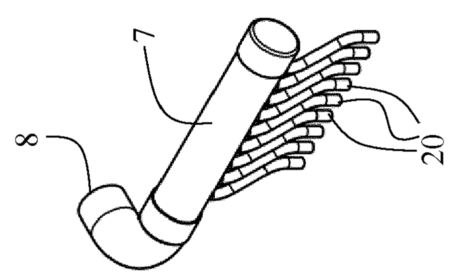


FIG. 6C

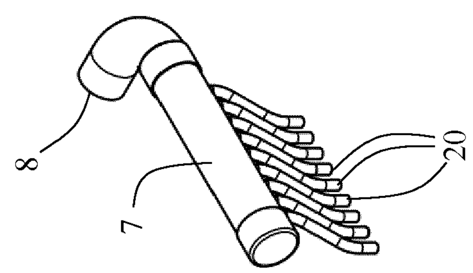


FIG. 6D

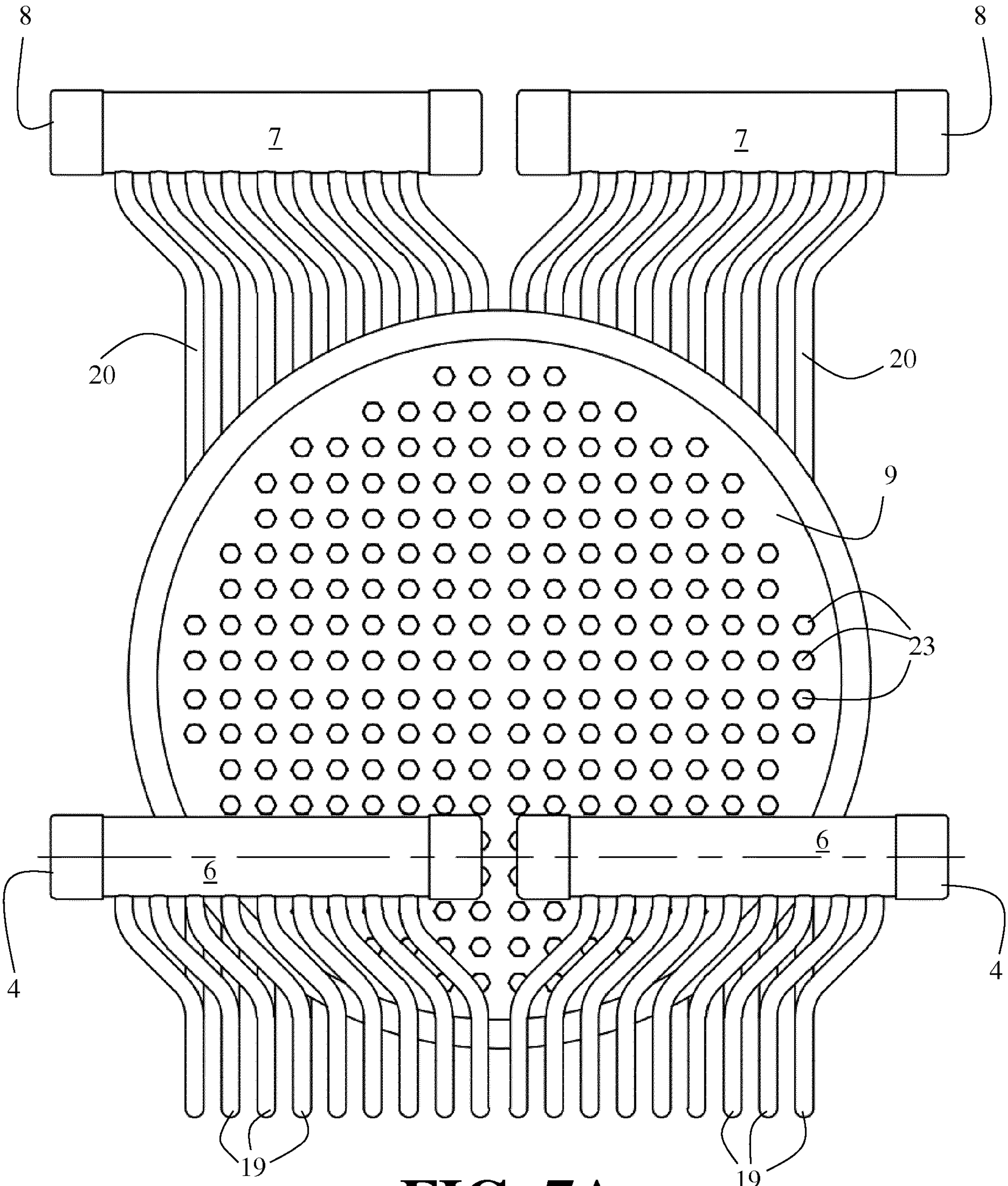


FIG. 7A

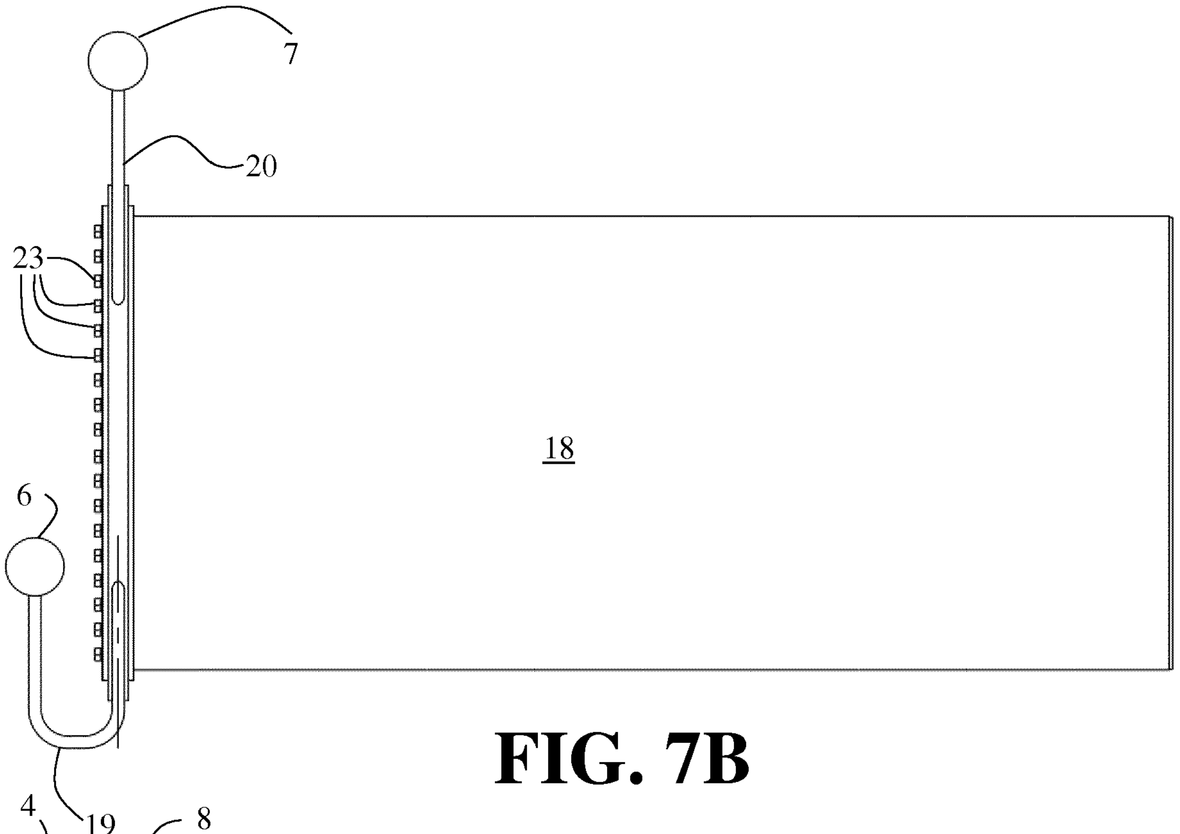


FIG. 7B

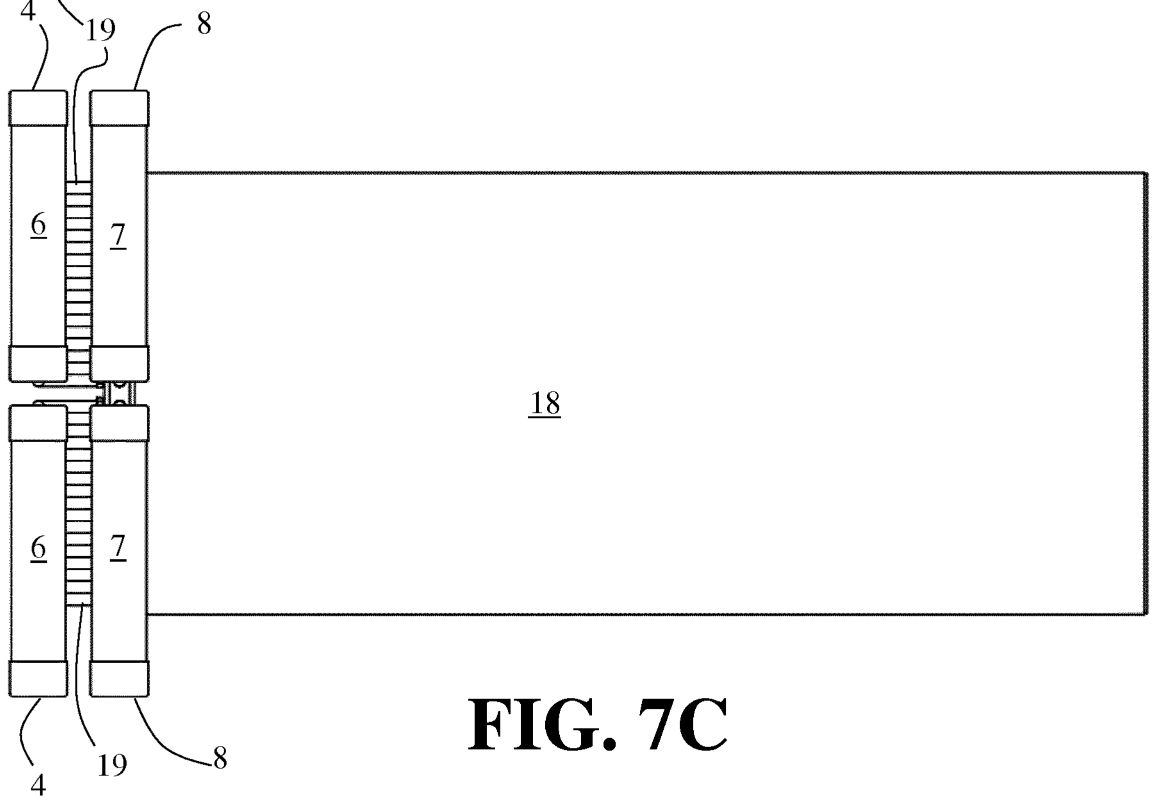


FIG. 7C

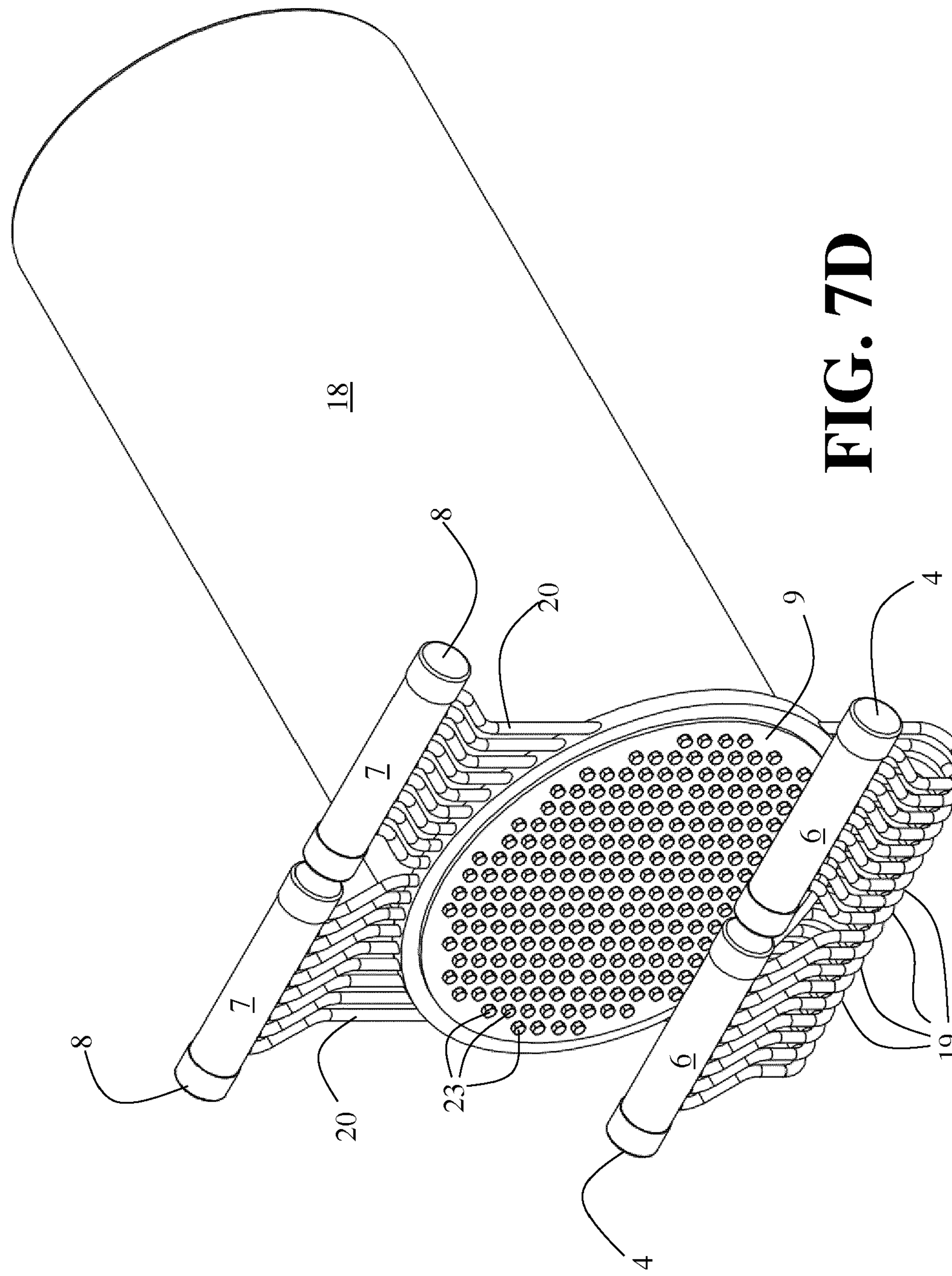


FIG. 7D

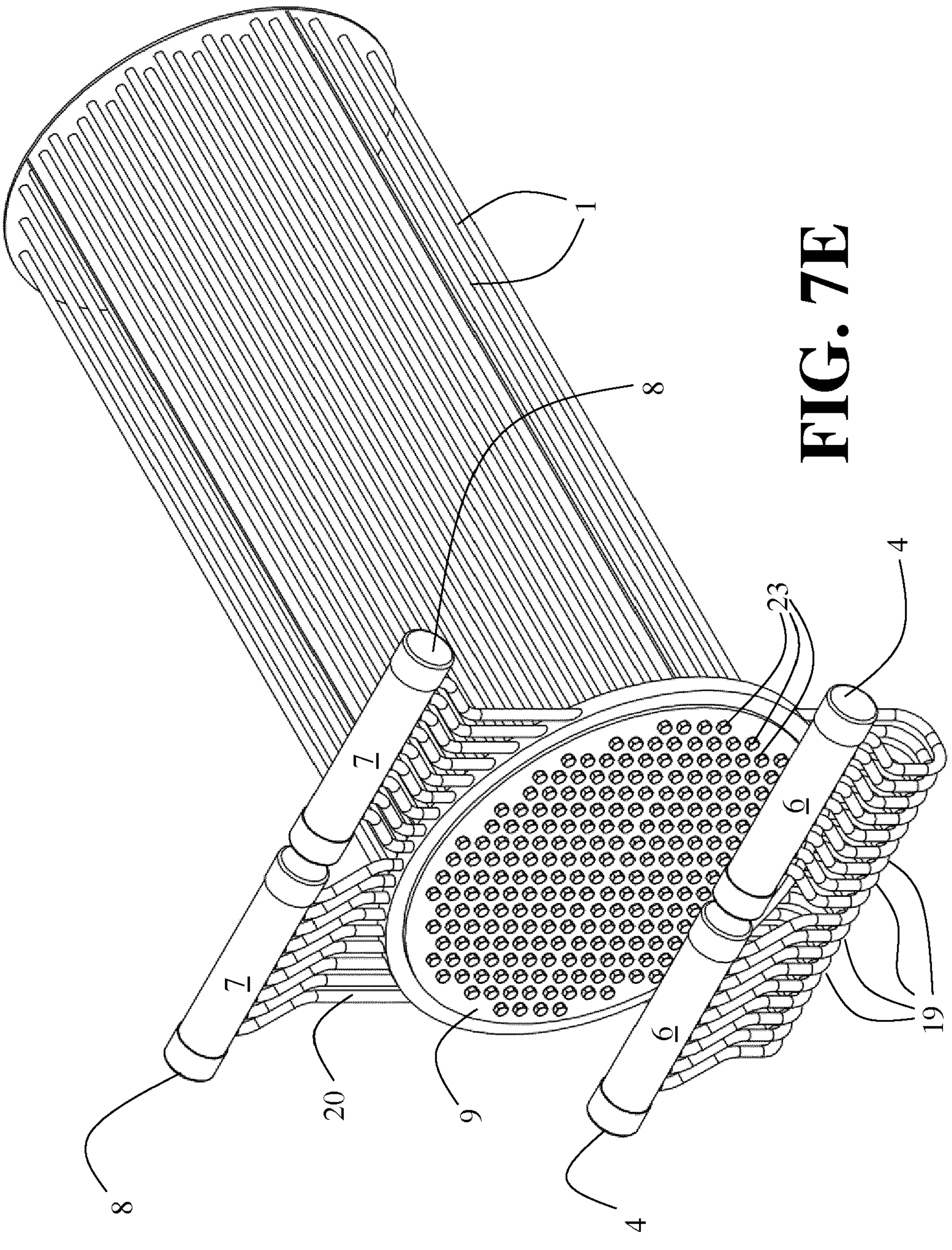


FIG. 7E

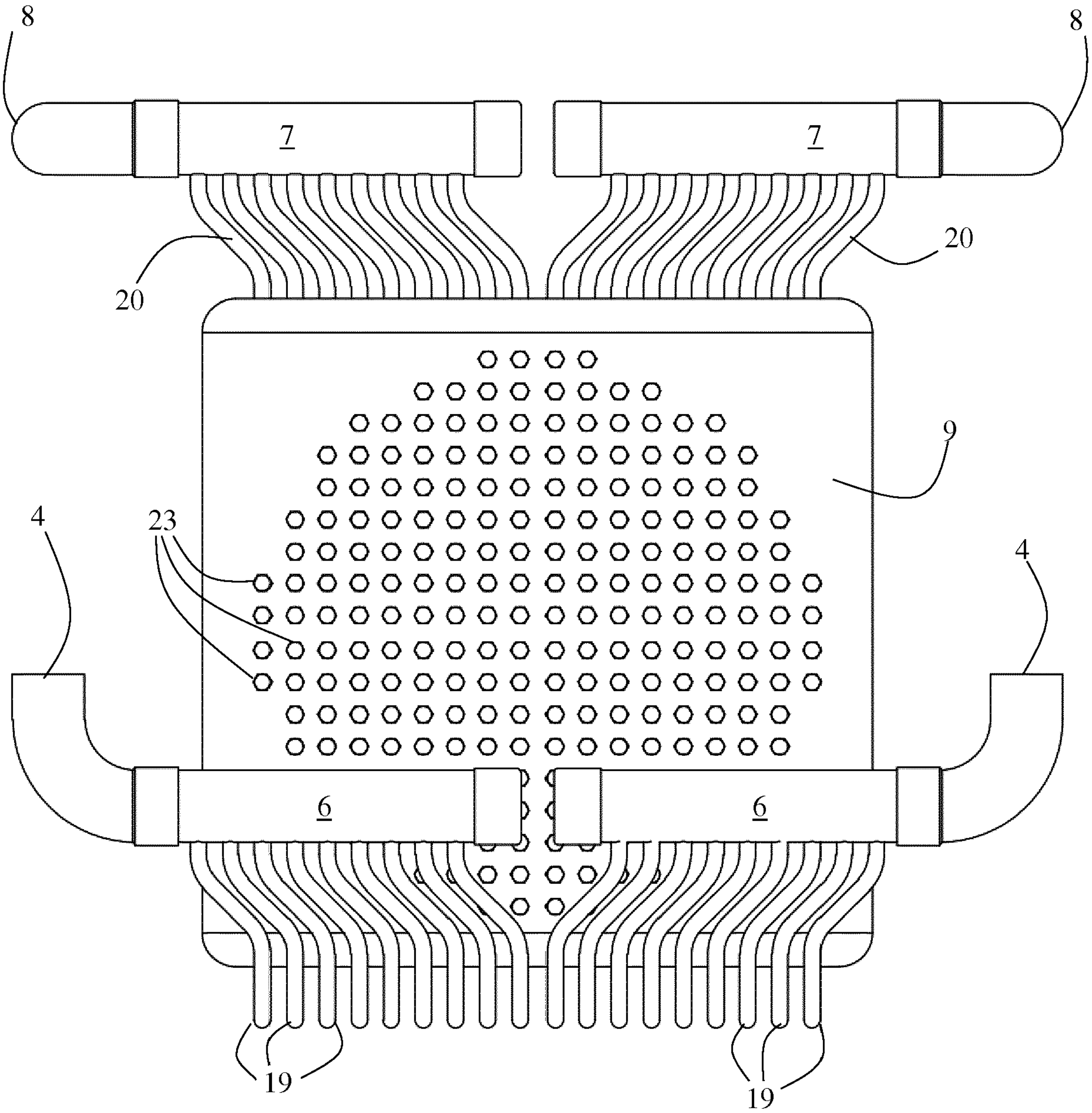


FIG. 8A

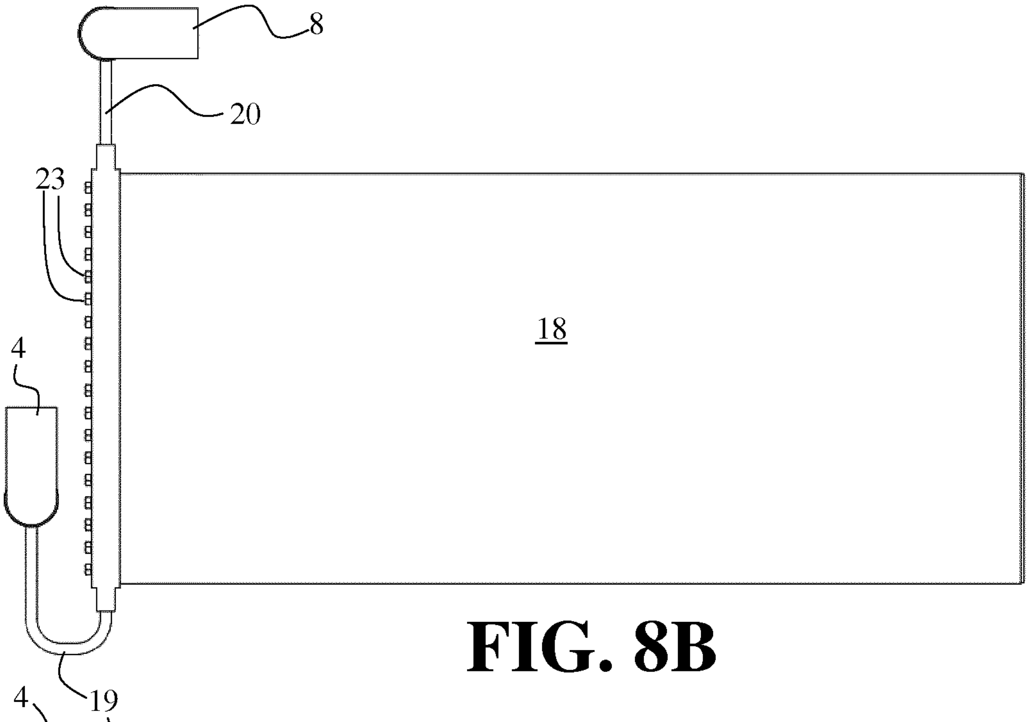


FIG. 8B

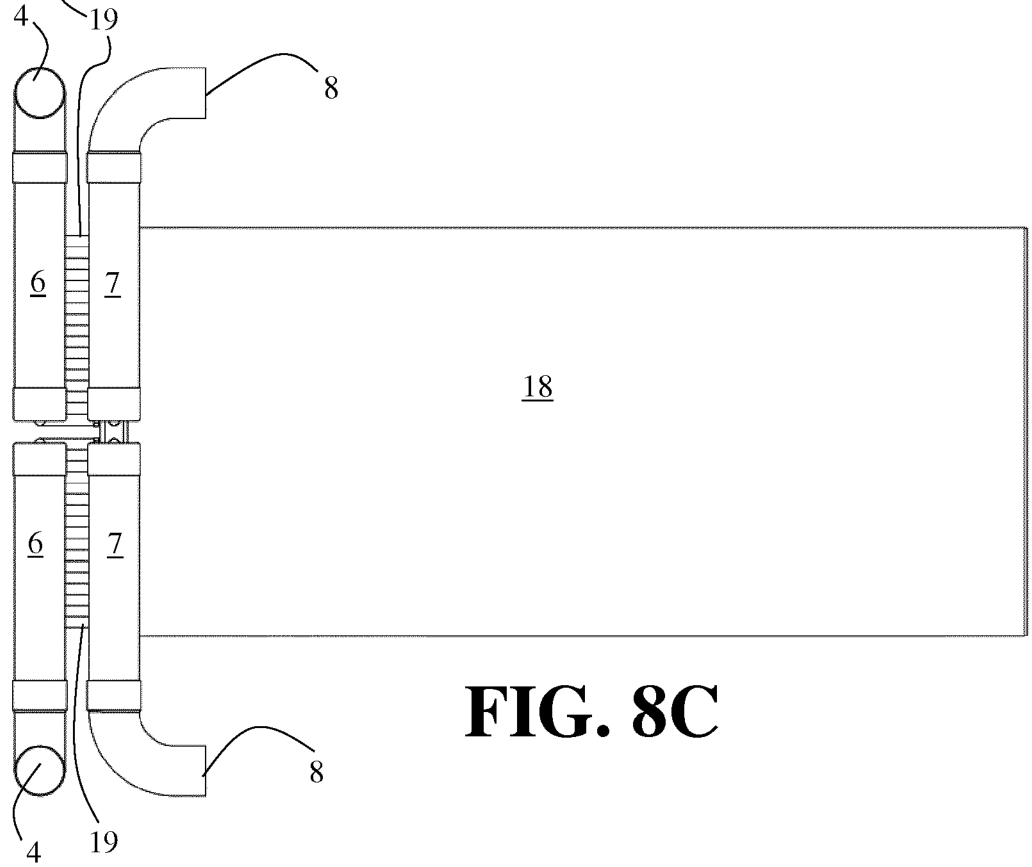


FIG. 8C

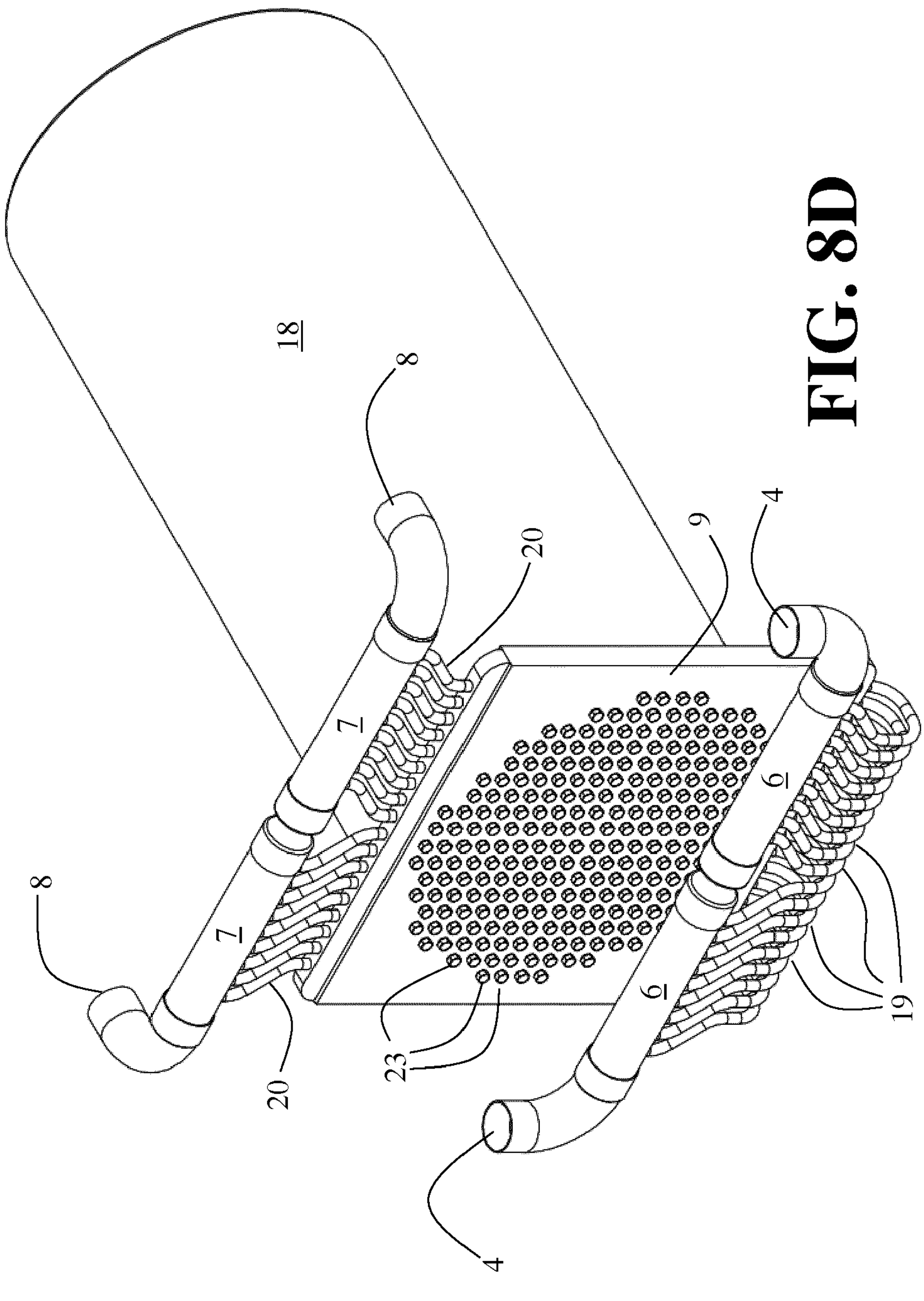


FIG. 8D

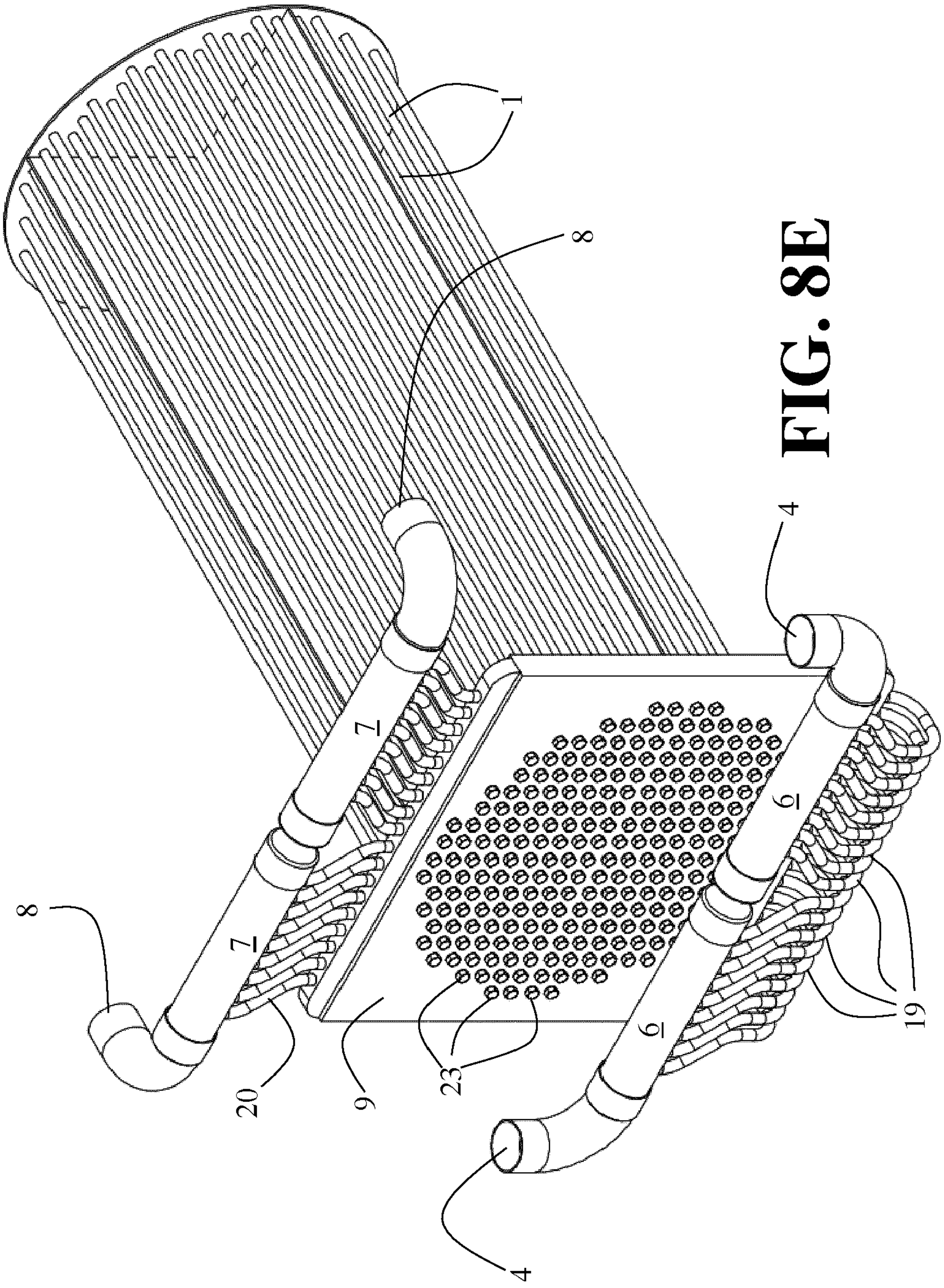


FIG. 8E

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 17 6275

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 3 046 838 A1 (COMMISSARIAT ENERGIE ATOMIQUE [FR]) 21 July 2017 (2017-07-21) * figures 2,4 * -----	1-11	INV. F28F9/02 F28D7/16
A	EP 0 810 414 A2 (BORSIG BABCOCK AG [DE]) 3 December 1997 (1997-12-03) * figure 1 * -----	1-11	
A	US 5 425 415 A (MASTER BASHIR I [US] ET AL) 20 June 1995 (1995-06-20) * the whole document * -----	1-11	
A	FR 3 016 958 A1 (VALEO SYSTEMES THERMIQUES [FR]) 31 July 2015 (2015-07-31) * the whole document * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28F F28D

2

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 October 2019	Mellado Ramirez, 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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 17 6275

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.

09-10-2019

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
FR 3046838	A1	21-07-2017	EP	3405736	A2	28-11-2018
			FR	3046838	A1	21-07-2017
			WO	2017125513	A2	27-07-2017
EP 0810414	A2	03-12-1997	AT	216060	T	15-04-2002
			EP	0810414	A2	03-12-1997
			ES	2175214	T3	16-11-2002
			JP	4140068	B2	27-08-2008
			JP	H1062078	A	06-03-1998
			US	5813453	A	29-09-1998
US 5425415	A	20-06-1995	NONE			
FR 3016958	A1	31-07-2015	EP	3099994	A1	07-12-2016
			FR	3016958	A1	31-07-2015
			PL	3099994	T3	28-09-2018
			US	2017010054	A1	12-01-2017
			WO	2015114101	A1	06-08-2015

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

Patent documents cited in the description

- FR 3046838 **[0009]**
- EP 810414 A **[0011]**
- US 5425415 A **[0012]**
- FR 3016958 **[0013]**