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(54) **HYBRID TUBE BUNDLE EVAPORATOR**

(57) A tube bundle evaporator longitudinally extending along a horizontal axis, comprising a shell, a tube bundle housed inside said shell, a shell-side refrigerant fluid, a tube-side refrigerated fluid, a lower zone of said evaporator flooded by the refrigerant fluid in the liquid state and containing a first number of tubes of said tube bundle, a process fluid distributor positioned in an upper

zone of said evaporator, a second number of tubes of said tube bundle positioned outside said flooded lower zone, and at least one outlet of refrigerant fluid in the gaseous state from the shell, comprising, inside the shell, a tortuous circuit for the refrigerant fluid which vaporises on contact with said second number of tubes comprising at least one descending portion of circuit.

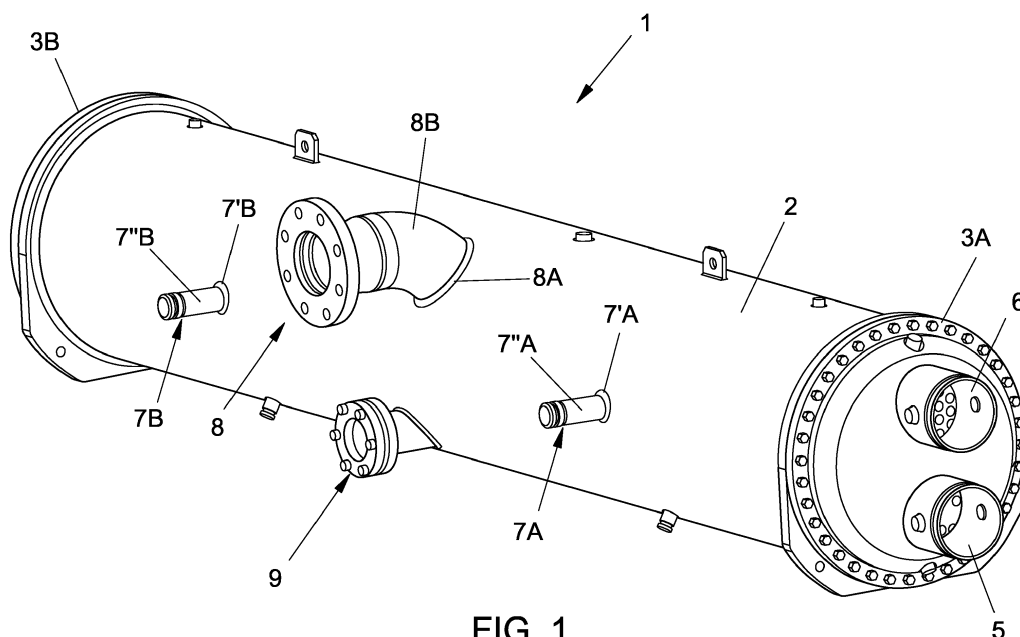


FIG. 1

Description

[0001] The present invention refers to an improved hybrid tube bundle evaporator having a low-load and high performance for vapour compression refrigeration circuits.

[0002] For some time the market has offered tube bundle and shell evaporators for known-type vapour compression refrigerating circuits, constituted substantially by a tube bundle inside a recipient usually having a cylindrical shape with a horizontal axis, usually known as a "shell", and closed at the ends.

[0003] The device is crossed by two fluid currents: a current corresponding to the process fluid, i.e. the fluid that is to be cooled, which flows on the "tube-side", that is, inside the tubes, while the other current corresponds to the service fluid, i.e. the refrigerant fluid used as the vector of the heat exchange and which flows on the "shell-side", i.e. in the space delimited between the inner surface of the shell and the outer surfaces of the tubes; the large outer surfaces of the tubes, generally having a modest diameter and in a large number, enable heat exchange of large quantities of heat.

[0004] The pathway of the tube bundle inside the shell can be straight, with a parallel axis to the longitudinal axis of the evaporator, from an inlet head to the opposite outlet head, or can be straight but with an outward and return pathway over the whole length of the shell, with an inlet and outlet at the same evaporator head; the type depends on the general characteristics of the system and the design choices and expected performances.

[0005] In extreme and simplistic synthesis, the process that takes place inside an evaporator in a refrigeration circuit is a continuous process, through which the flow of the service refrigerant fluid at a lower temperature subtracts heat from the process fluid flow at a higher temperature, and in turn heats up and changes from the liquid phase to the gaseous phase.

[0006] In the literature and on the market at least four types of tube bundle evaporators are well-known: the flooded type, i.e. with the tube bundle completely immersed in the service fluid in the moist phase; the low-load flooded type, in which the service fluid load is reduced coherently with the setting and control of other parameters of the system; the falling film type, in which the tubes are sprinkled by the service refrigerant fluid which falls in cascade; of the spray type, where the service refrigerant fluid is sprayed onto the tubes.

[0007] Another type, known as hybrid, pairs the characteristics of the low-load flooded type with those of the falling film type.

[0008] As is known, each of these types has advantages and drawbacks: it is also known that exchangers at present in use require a considerable load of refrigerant fluid to improve the heat exchange, and adopt mechanical solutions that constrain the arrangement of the inlet and outlet fittings of the refrigerant fluid, which must necessarily be arranged respectively on the bottom and on

the top of the shell. These traditional arrangements of the fittings lead to significant evaporator volumes and constraints with the other components of the system, often relevant.

[0009] It is also known that all tube bundle evaporators have a service flow distribution in the shell that is not uniform, which can lead to a worsening of the evaporator performance.

[0010] To reduce the effect of the non-uniform flow distribution, generally partial partitions are installed, in a perpendicular direction to that of the flow, which switch the direction and make the velocity profile more uniform.

[0011] These configurations are notoriously poorly efficient, as the control and intervention conditions during routine operation of the system are especially delicate. There therefore exists a need to simplify the structure of tube bundle evaporators for known-type vapour-compression refrigerating circuits.

[0012] The technical task of the present invention is, therefore, to provide a tube bundle evaporator which obviates the above-described technical drawbacks of the prior art.

[0013] Within the context of this technical task, an object of the invention is to realise a tube bundle evaporator of a hybrid type, which unites the characteristics of the low-load flooded type and of the falling film type, thus obviating the drawbacks of both.

[0014] A further aim of the invention is to realise a tube bundle evaporator of a hybrid type which optimises the fluid-dynamics of the service fluid and the heat exchange with the process flow.

[0015] A further aim of the invention is to realise a tube bundle evaporator of a hybrid type from which the service fluid in outlet can be returned to the refrigeration circuit prevalently in the gaseous phase.

[0016] A further aim of the invention is to realise a tube bundle evaporator of a hybrid type which improves the distribution system of the service fluid on the tube bundle.

[0017] A further aim of the invention is to realise a tube bundle evaporator of a hybrid type which optimises the positions of the fittings towards the external devices.

[0018] The technical task, together with these and other objects according to the present invention, is attained by a tube bundle evaporator longitudinally extending along a horizontal axis, comprising a shell, a tube bundle housed inside said shell, a shell-side refrigerant fluid, a tube-side refrigerated fluid, a lower zone of said evaporator flooded by the refrigerant fluid in the liquid state and containing a first number of tubes of said tube bundle, a process fluid distributor positioned in an upper zone of said evaporator, a second number of tubes of said tube bundle positioned outside said flooded lower zone, and at least one outlet of refrigerant fluid in the gaseous state from the shell, characterised in that it comprises, inside the shell, a tortuous circuit for the refrigerant fluid which vaporises on contact with said second number of tubes comprising at least one descending portion of circuit.

[0019] In a preferred embodiment of the invention said

descending portion of circuit is delimited by at least one separating primary vertical partition, longitudinally extended along said horizontal axis, said primary vertical partition separating a first upper chamber of said evaporator where the second number of tubes is positioned from a second upper lateral chamber of said evaporator where said outlet from the shell is positioned.

[0020] In a preferred embodiment of the invention said second number of tubes is greater than said first number of tubes.

[0021] In a preferred embodiment of the invention said separating primary vertical partition superiorly separates said first upper chamber and said second upper lateral chamber and extends downwards up to a distance from the free surface of said flooded lower zone for collecting the refrigerant fluid in the liquid state.

[0022] In a preferred embodiment of the invention said separating primary vertical partition, in cooperation with the free surface of said lower zone, inferiorly delimits a connecting passage between said first upper chamber where said descending portion of circuit extends and said second upper lateral chamber where a rising portion of circuit extends in succession to said descending portion of circuit.

[0023] In a preferred embodiment of the invention said second upper lateral chamber contains a third number of tubes of said tube bundle arranged outside said lower zone.

[0024] In a preferred embodiment of the invention said outlet is positioned in said second upper lateral chamber above said third number of tubes.

[0025] Other characteristics of the present invention are further defined in the following claims.

[0026] Further characteristics and advantages of the invention will more fully emerge from the description of a preferred but not exclusive embodiment of the hybrid tube bundle evaporator according to the invention, illustrated by way of nonlimiting example in the appended drawings, wherein:

figure 1 shows an external view of the evaporator;
figure 2 shows a perspective exploded view of the evaporator;
figure 3 shows a cross-section of the evaporator perpendicular to the longitudinal axis;
figure 4 shows a perspective upper view of the refrigerant fluid distributor;
figure 5 shows a partial lower view of a detail of the refrigerant fluid distributor;
figure 6 shows a partial perspective view of the assembly of internal components of the evaporator;
figure 7 shows a partial perspective view of internal components of the evaporator;
figure 8 shows a sectioned partial perspective view of the head with the inlet and outlet of the process fluid.

[0027] With reference to the figures mentioned, a hor-

izontal axis hybrid tube bundle evaporator is denoted in its entirety by reference number 1, essentially constituted by a cylindrical shell 2, by two closing heads 3A and 3B, a tube bundle 4 thus identified in its entirety and contained inside the shell 2 where the tubes individually perform an outward and return pathway parallel to the longitudinal horizontal axis and over the whole length of the shell 2, an inlet 5 in a closing head 3A of the process fluid to be cooled and an outlet 6 in a closing head 3A of the cooled process fluid; the evaporator 1 further has two inlets 7A and 7B of the service refrigerant fluid in the liquid state in a lower lateral zone of the shell 2, symmetrically arranged in the direction of the longitudinal axis with respect to an outlet 8 of the service refrigerant fluid in the gaseous state positioned in an upper lateral zone of the shell 2, and an optical viewer 9 for controlling the level of the service refrigerant fluid on the lower lateral wall of the shell 2.

[0028] A first number of tubes 41 of the tube bundle 4 is positioned in a lower zone 21 of the evaporator 1 flooded by the service fluid, a second number of tubes 42 is positioned in an upper zone 22 of the evaporator 1 above the first number of tubes 41.

[0029] A distributor 70 of the service refrigerant fluid is positioned in an upper zone 22 of the evaporator 1 above the second number of tubes 42 of the tube bundle 4, and is constituted by two opposite collectors 71A and 71B respectively connected to the inlets 7A and 7B of the refrigerant fluid in the evaporator 1, and mounted with a perpendicular axis to the longitudinal axis of the evaporator 1 and of the tube bundle 4.

[0030] A plurality of straight distribution tubes 72i is perpendicularly connected to both collectors 71A and 71B, by means of respective fittings 73i at the ends thereof, with a longitudinal axis parallel to the axis of the evaporator 1 and the tube bundle 4.

[0031] The distribution tubes 72i inferiorly have a plurality of longitudinal dispensing openings 74i made using laser cutting in the wall of the tube, through which the refrigerated fluid in the liquid state sprinkles the second number of tubes 42 by force of gravity.

[0032] The tube bundle 4 is supported inside the shell 2 by a plurality of transversal support plates 80i perpendicular to the longitudinal axis of the tubes and the evaporator 1, appropriately perforated for guided and continuous passage of the single tubes and appropriately configured for mounting inside the evaporator 1. Perpendicularly to the plurality of the transversal support plates 80i, and therefore parallel to the longitudinal axis of the evaporator 1, a further plurality of vertical longitudinal secondary partitions 81i advantageously joint-fixed to the transversal support plates 80i longitudinally divides, into a plurality of sectors, the second number of tubes 42 of the tube bundle 4 in the zone 22 of the evaporator 1.

[0033] The transversal support plates 80i further divide the longitudinal sectors into sub-units.

[0034] The transversal support plates 80i and the longitudinal partitions 81i have appropriate pluralities of sav-

ings and through openings, respectively 82i and 83i which have the function of equalising the pressure of the refrigerant fluid between these sectors and sub-units inside the evaporator 1.

[0035] A plurality of longitudinal deflecting fins 85ni is further fixed on the longitudinal partitions 81i, again with the aim of equalising the flow distribution of the refrigerant fluid by force of gravity on the tubes of the second number of tubes 42. Laterally of the tube bundle of the second number of tubes 42 is located a special primary vertical partition 88, longitudinally extended, conjoined at the top thereof to the internal lateral surface of the shell 2 and inferiorly extending downwards up to a suitable distance from the free surface of the flooded lower zone 21 for collecting the refrigerant fluid in the liquid state.

[0036] The primary vertical partition 88 divides the upper zone 22 of the evaporator in which it defines a first upper chamber 23 in which the second number of tubes 42 and the distributor 70 of the service refrigerant fluid are housed, and a second upper lateral chamber 24 of the evaporator 1, towards the side of the shell 2 where the inlets 7A and 7B are located, to which the distributor 70 and the outlet 8 of the refrigerant fluid in the gaseous state are connected.

[0037] A third number of tubes 43 connected via a collector 51 in the head 3A is housed inside the second upper lateral chamber 24 of the evaporator 1.

[0038] The head 3A has the inlet collector 51 connected to the inlet 5 of the process fluid in the evaporator 1, and an outlet collector 61 connected to the outlet 6 of the cooled process fluid; the inlet collector 51 supplies the first number of tubes 41, the third number of tubes 43 and the lower group of tubes of said second number of tubes 42; and an outlet collector 61 is supplied by an upper group of tubes of said second number of tubes 42.

[0039] Above the lower zone 21 of the evaporator 1 flooded by service fluid, but in proximity thereof vertically at the second upper lateral chamber 24, there is an upper horizontal row of tubes 44 of said first number of tubes 41, positioned at a higher level than the upper horizontal row of the tubes facing and vertically at said first upper chamber 23.

[0040] The operation of the evaporator 1 according to the invention appears clear from the description and illustration and, in particular, is substantially as follows.

[0041] The process fluid to be cooled is introduced into the evaporator 1 through the inlet 5 in the head 3A, and thus in the inlet collector 51 from which it is distributed into the first number of tubes 41, the third number of tubes 43 and the lower group of tubes of the second number of tubes 42.

[0042] The process fluid to be cooled, coming from the system circulation and appropriately moved by movement means outside the evaporator, travels through the tubes in a horizontal-axis outward and return pathway inside the evaporator 1 over the whole length of the shell 2.

[0043] The upper group of tubes of the second number

of tubes 42 thus returns to the outlet collector 61 in the head 3A, from which the appropriately-cooled process fluid is collected and connected to the outlet 6 from the evaporator 1 and reinjected into the cooling system circulation of which the evaporator is a part.

[0044] The service refrigerant fluid in the liquid state, coming from other lines of the cooling system and appropriately moved by movement means outside the evaporator, is injected into the evaporator 1 symmetrically, given equal conditions of temperature and pressure, through the two inlets 7A and 7B positioned in the lower lateral zone of the shell 2 the inside of which corresponds to the second upper lateral chamber 24 of the evaporator 1.

[0045] The two opposite collectors 71A and 71B are respectively connected to the inlets 7A and 7B of the fluid distributor 70 of the service refrigerant fluid, via which collectors and via the successive plurality of fittings 73i derived therefrom, the refrigerant fluid reaches the plurality of distribution tubes 72i from opposite ends. The supply of the refrigerant fluid from the collectors 71A and 71B to the opposite ends of the plurality of distribution tubes 72i advantageously guarantees the homogeneity of the temperature and pressure conditions of the refrigerant fluid in each tube and inside each of the tubes of the plurality of distribution tubes 72i.

[0046] The refrigerant fluid locates, in the plurality of distribution tubes 72i, the plurality of lower longitudinal dispensing openings 74i, through which the refrigerated fluid in the liquid state sprinkles the second number of tubes 42 by force of gravity.

[0047] The heat exchange by convection, between the refrigerant flow and the outer walls of the second number of tubes 42 inside which the process fluid flows at a higher temperature, causes, among other things, the raising of the temperature of the refrigerant fluid, and a partial passage thereof from the liquid phase to the mixed-gaseous phase ("mist") and to the gaseous phase.

[0048] The refrigerant fluid, in its fall by force of gravity from the plurality of lower longitudinal dispensing openings 74i in the plurality of distribution tubes 72i on the second number of tubes 42, is compartmentalised into a plurality of sub-units of a plurality of sectors defined by the plurality of transversal support plates 80i and of vertical longitudinal partitions 81i.

[0049] The plurality of longitudinal deflecting fins 85i fixed on the longitudinal partitions 81i advantageously facilitates the detachment of the refrigerant fluid that might have accumulated on the longitudinal partitions 81i during the liquid phase and a better and progressive redistribution on the rows of the second number of tubes 42 positioned inferiorly of the longitudinal deflecting fins 85i.

[0050] The pluralities of savings and through openings, respectively 82i and 83i in the transversal support plates 80i and in the longitudinal partitions 81i which are compartmentalised into a plurality of sub-units of a plurality of sectors inside the evaporator 1, advantageously facil-

itate the uniformity of the distribution of the refrigerant fluid during the progressively gaseous and mixed-gaseous phase in the progressive fall thereof on the rows of the second number of tubes 42.

[0051] The portion of refrigerant fluid still in the liquid phase, after having sprayed the second number of tubes 42 by force of gravity, precipitates and is collected (floods) in the lower zone 21 of the evaporator 1, where the first number of tubes 41 of the tube bundle 4 is positioned and where the heat exchange is actuated in a static form by conduction between the refrigerant fluid in the liquid phase and the outer walls of the first number of tubes 41 of the tube bundle 4 which remains completely immersed (flooded) in the fluid.

[0052] Using the optical viewer 9 positioned on the lateral lower wall of the shell 2, the level of the service refrigerant fluid in the flooded lower zone 21 is controlled, which level must be maintained, by an appropriate control and balancing of the functions of the system outside the evaporator 1, at a higher level than the upper horizontal row of the first number of tubes 41 of the tube bundle 4.

[0053] The portion of refrigerant fluid in the gaseous and mixed-gaseous phase, created for the heat exchange realised with interaction of the refrigerant fluid and the second number of tubes 42 in the first upper chamber 23 of the evaporator 1, physically and naturally tending to vertically rise towards the top of the first upper chamber 23, is advantageously aspirated by means of an appropriate depression created by aspirating means outside the evaporator 1 at the outlet 8 from the shell 2, positioned at the upper lateral chamber 24 of the evaporator 1.

[0054] The presence of the longitudinally-extended primary vertical partition 88 that defines the first upper chamber 23 and the second upper lateral chamber 24 of the evaporator 1, advantageously attributes to the portion of refrigerant fluid in the gaseous phase and mixed-gaseous phase a tortuous pathway from the first upper chamber 23 to the second upper lateral chamber 24 comprising at least a portion of a descending circuit.

[0055] The primary partition 88, in cooperation with the free surface of the collecting flooded lower zone 21, inferiorly delimits a connecting passage between the first upper chamber 23 where a descending portion of circuit extends, and the second upper lateral chamber 24 where a rising portion of circuit extends in succession to a descending portion of circuit of the tortuous pathway of the refrigerant fluid in the gaseous and mixed-gaseous phase.

[0056] In proximity of the connecting passage of the tortuous pathway, and superiorly of the flooded lower zone 21 of collection of a service fluid, but in proximity thereof and vertically at the second upper lateral chamber 24, there is the upper horizontal row of tubes 44 of the first number of tubes 41, positioned at a higher level than the upper horizontal row of the tubes facing and vertically at said first upper chamber 23.

[0057] The tortuous pathway of the refrigerant fluid in

gaseous and mixed-gaseous phase advantageously strikes, in the inversion from the descending portion of circuit to the rising portion of circuit, the upper horizontal row 44 of tubes of the first number of tubes 41 and thus actuates a heat exchange which tends to reduce the moisture of the mixed-gaseous phase which is still residual.

[0058] The third number of tubes 43 is also housed in the second upper lateral chamber 24 and is arranged at a greater height than the horizontal row of tubes 44, which is further struck by the refrigerant fluid in the gaseous and mixed-gaseous phase in a rising portion of circuit of the tortuous pathway, actuating a further heat exchange which tends to eliminate the moisture still residual in the mixed-gaseous phase (mist).

[0059] The refrigerated service fluid is advantageously thus distanced by the evaporator 1 from the outlet 8 and injected into the circuit of the refrigeration system in prevalently gaseous phase.

[0060] Modifications and variants to the hybrid tube bundle evaporator described in the foregoing are, naturally, possible.

[0061] It has been observed that a hybrid tube bundle evaporator according to the invention is particularly advantageous for optimisation of the fluid-dynamics of the service fluid and the heat exchange with the process flow.

[0062] A hybrid tube bundle evaporator thus-conceived is susceptible to numerous modifications and variants, all falling within the scope of the inventive concept; moreover, all the details are replaceable by technically equivalent elements.

[0063] In practice, the materials used, as well as the dimensions, can be any according to the needs and the state of the art.

Claims

1. A tube bundle evaporator 1 longitudinally extending along a horizontal axis, comprising a shell 2, a tube bundle 4 housed inside said shell 2, a shell-side refrigerant fluid, a tube-side refrigerated fluid, a lower zone 21 of said evaporator 1 flooded by the refrigerant fluid in the liquid state and containing a first number of tubes 41 of said tube bundle 4, a process fluid distributor 70 positioned in an upper zone 22 of said evaporator 1, a second number of tubes 42 of said tube bundle 4 positioned outside said flooded lower zone 21, and at least one outlet 8 of refrigerant fluid in the gaseous state from the shell 2, **characterised in that** it comprises, inside the shell 2, a tortuous circuit for the refrigerant fluid which vaporises on contact with said second number 42 of tubes comprising at least one descending portion of circuit.
2. The horizontal tube bundle evaporator 1 according to claim 1, **characterised in that** said descending portion of circuit is delimited by at least one separat-

- ing primary vertical partition 88, longitudinally extended along said horizontal axis, said primary vertical partition 88 separating a first upper chamber 23 of said evaporator where the second number of tubes 42 is positioned from a second upper lateral chamber 24 of said evaporator 1 where said outlet 8 from the shell is positioned.
3. The horizontal tube bundle evaporator 1 according to any one of the preceding claims, **characterised in that** said second number of tubes 42 is greater than said first number of tubes 41.
 4. The horizontal tube bundle evaporator 1 according to any one of claims 2 and 3, **characterised in that** said separating primary vertical partition 88 superiorly separates said first upper chamber 23 and said second upper lateral chamber 24 and extends downwards up to a distance from the free surface of said flooded lower zone 21 for collecting the refrigerant fluid in the liquid state.
 5. The horizontal tube bundle evaporator 1 according to the preceding claim, **characterised in that** said separating primary vertical partition 88, in cooperation with the free surface of said lower zone 21, inferiorly delimits a connecting passage between said first upper chamber 23 where said descending portion of circuit extends and said second upper lateral chamber 24 where a rising portion of circuit extends in succession to said descending portion of circuit.
 6. The horizontal tube bundle evaporator 1 according to the preceding claim, **characterised in that** said second upper lateral chamber 24 contains a third number of tubes 43 of said tube bundle 4 arranged outside said lower zone 21.
 7. The horizontal tube bundle evaporator 1 according to the preceding claim, **characterised in that** said outlet 8 is positioned in said second upper lateral chamber 24 above said third number of tubes 43.
 8. The horizontal tube bundle evaporator 1 according to any one of claims 2 to 7, **characterised in that** it comprises a plurality of secondary vertical partitions 81i which divide said first upper chamber 23 into a plurality of sectors where said tubes of said second number 42 of tubes are distributed.
 9. The horizontal tube bundle evaporator 1 according to the preceding claim, **characterised in that** said secondary vertical partitions 81i are provided with a plurality of deflecting fins 85i of the refrigerant fluid.
 10. The horizontal tube bundle evaporator 1 according to any one of claims 8 and 9, **characterised in that** said secondary vertical partitions 81i are provided with a plurality of through-openings 83i for equalisation of the pressure of the refrigerant fluid among said sectors.
 11. The horizontal tube bundle evaporator 1 according to any one of claims 8 to 10, **characterised in that** a plurality of transversal support plates 80i of said tube bundle 4 is positioned inside said shell 2, to which plurality of transversal support plates 80i said secondary vertical partitions 81i are fixed.
 12. The horizontal tube bundle evaporator 1 according to the preceding claim, **characterised in that** said transversal support plates 80i divide said sectors into sub-units and are provided with through-openings 82i for the equalisation of the pressure of the refrigerant fluid among said sub-units.
 13. The horizontal tube bundle evaporator 1 according to any one of claims 2 to 12, **characterised in that** above said flooded lower zone 21 for collecting a service fluid, and vertically at the position of said second upper lateral chamber 24, there is an upper horizontal row of tubes 44 of said first number of tubes 41, positioned at a higher level than the upper horizontal row of the tubes facing and vertically at said first upper chamber 23.
 14. The horizontal tube bundle evaporator 1 according to any one of claims 6 to 13, **characterised in that** said shell 2 has a head 3A provided with an inlet collector 51 which supplies said first number of tubes 41, said third number of tubes 43 and a lower group of tubes of said second number of tubes 42, and an outlet collector 61 supplied by an upper group of tubes of said second number of tubes 42.
 15. A vapour compression refrigeration circuit **characterised in that** it comprises a tube bundle evaporator according to any one preceding claim.

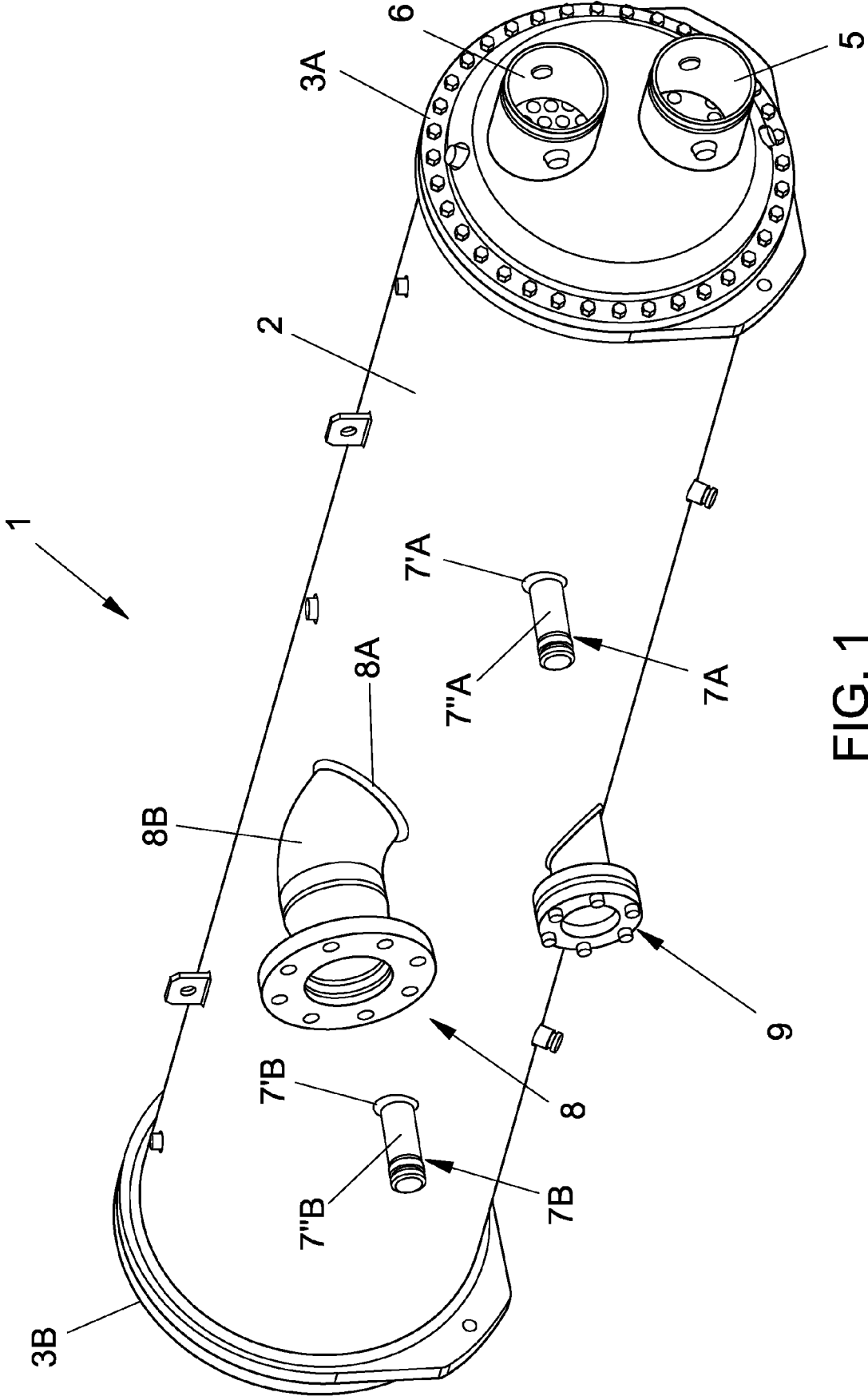


FIG. 1

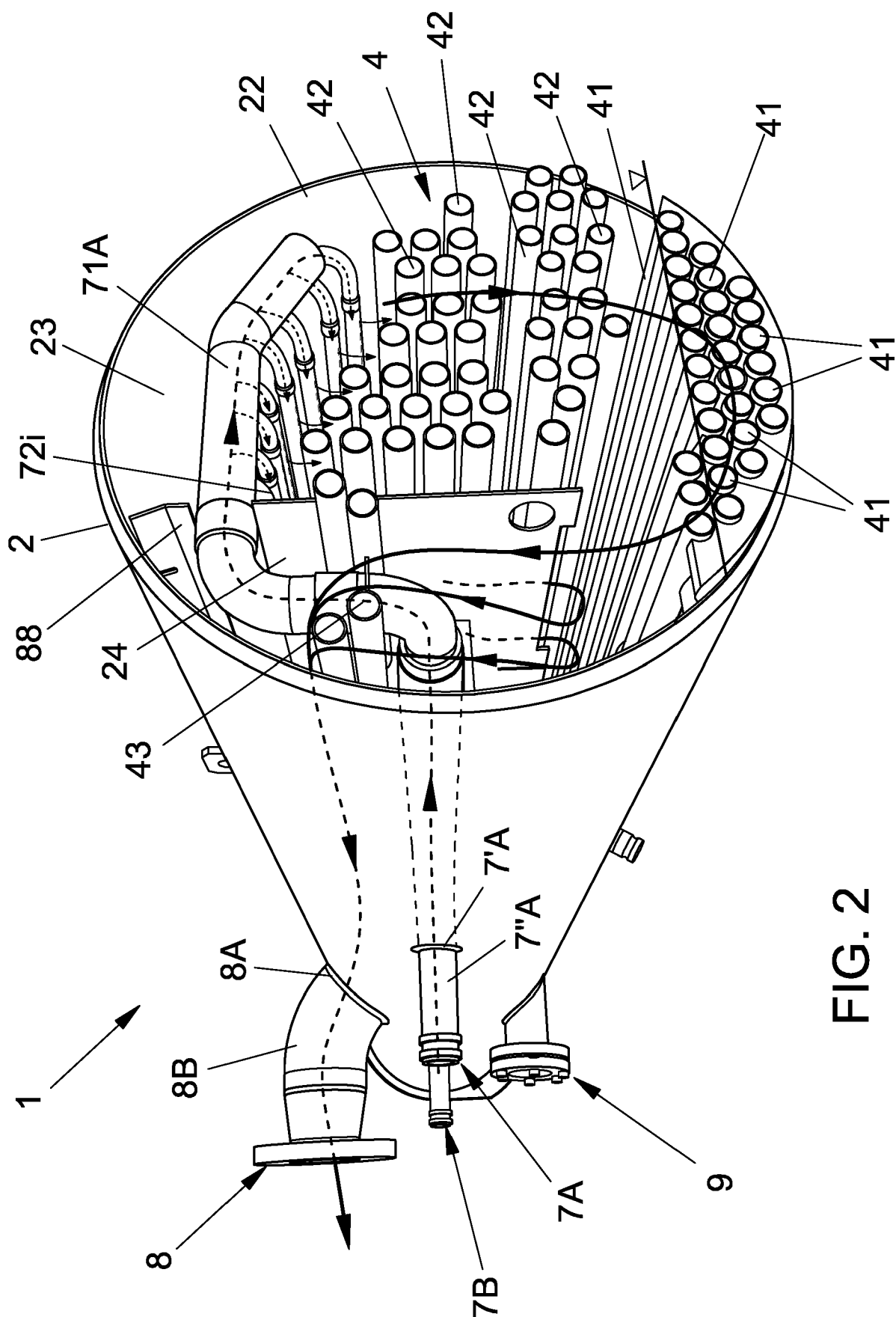


FIG. 2

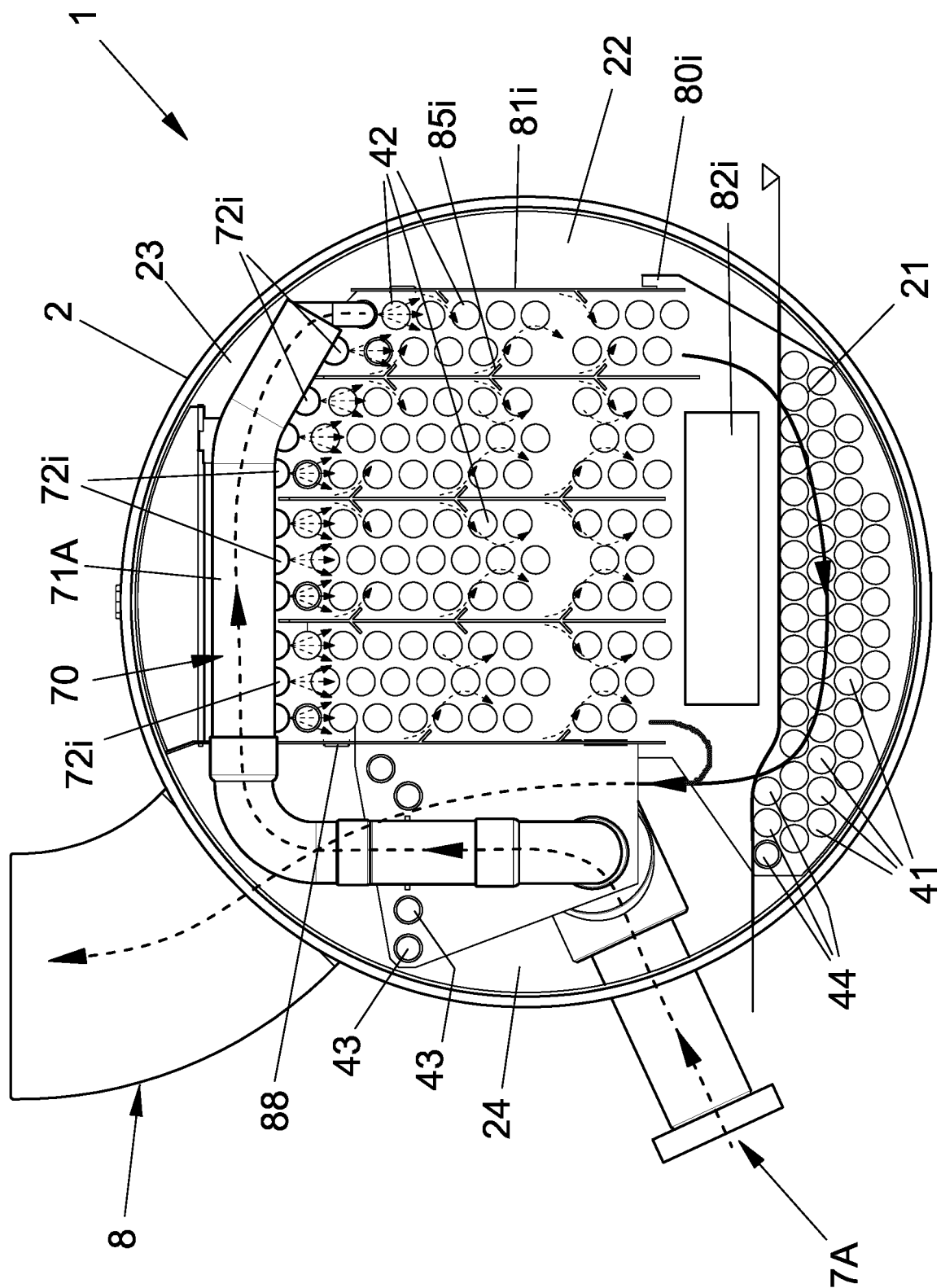


FIG. 3

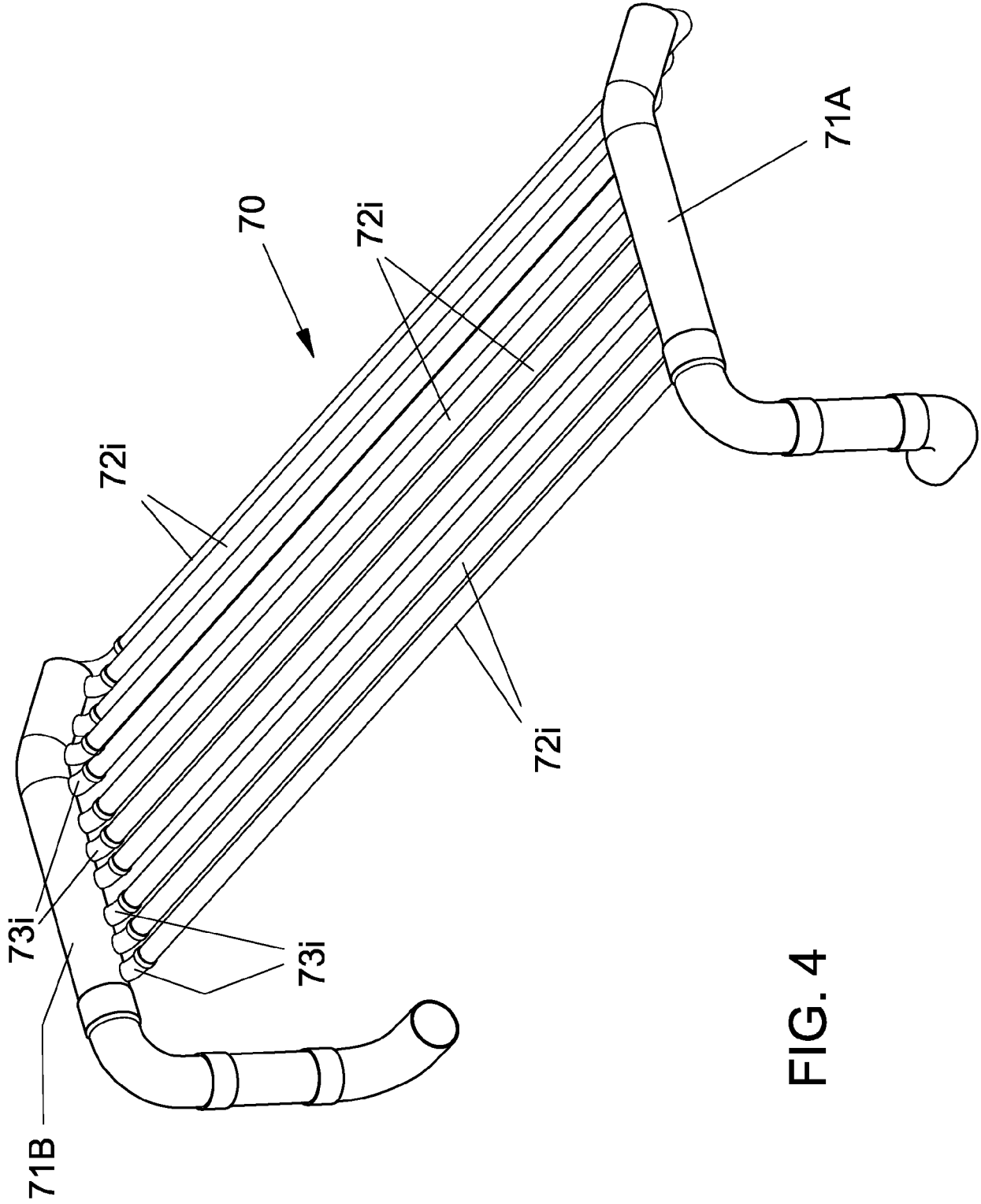


FIG. 4

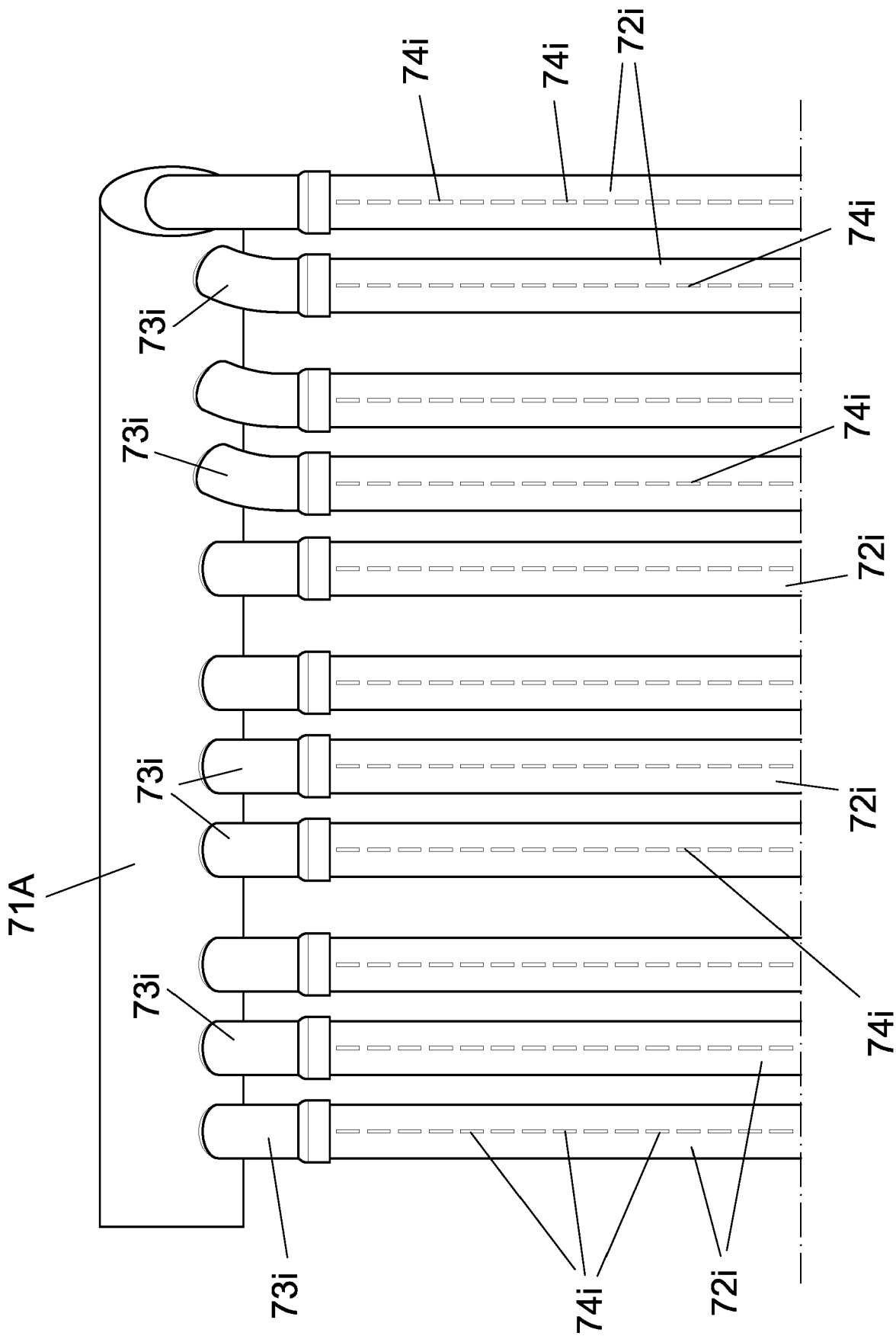


FIG. 5

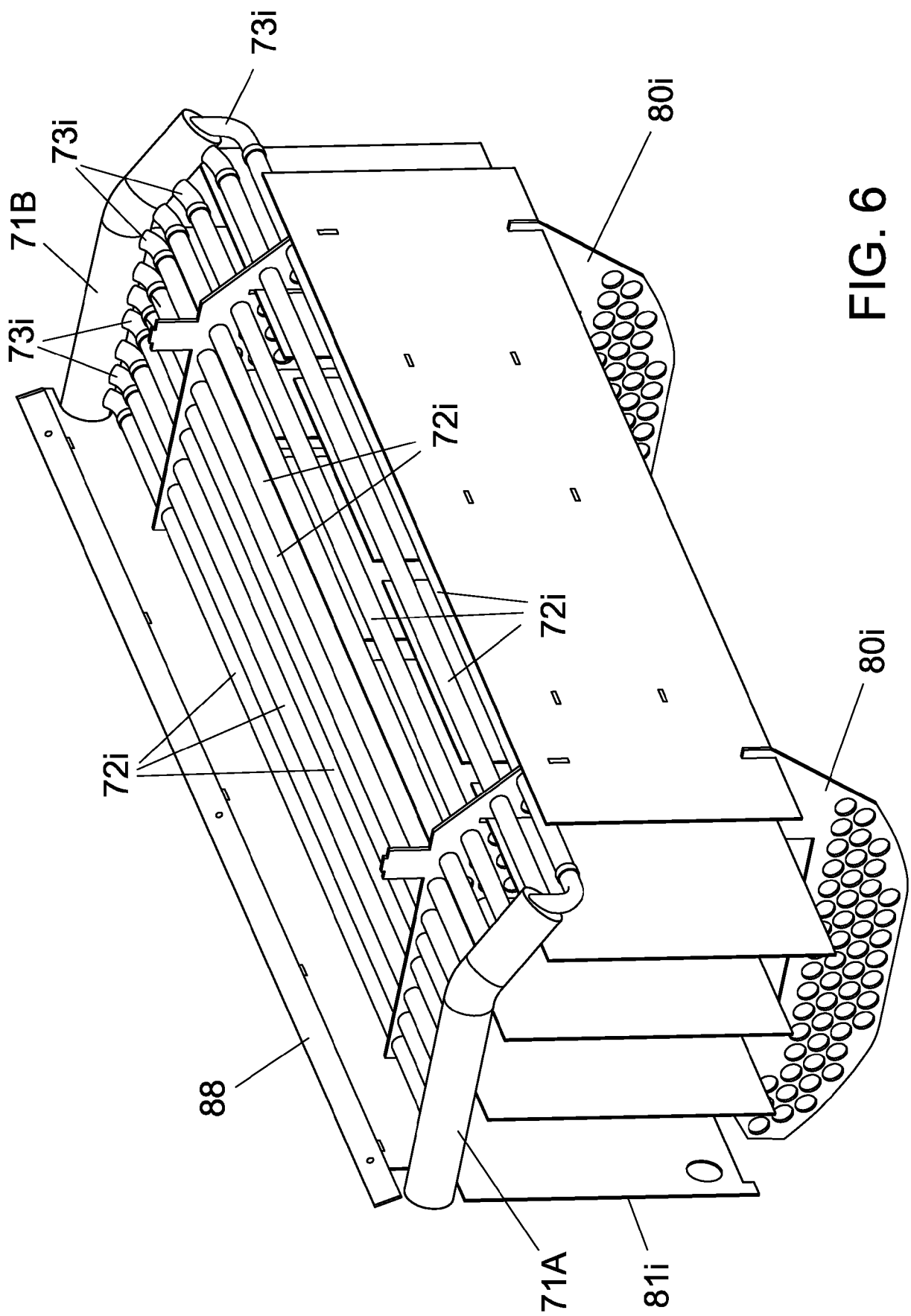


FIG. 6

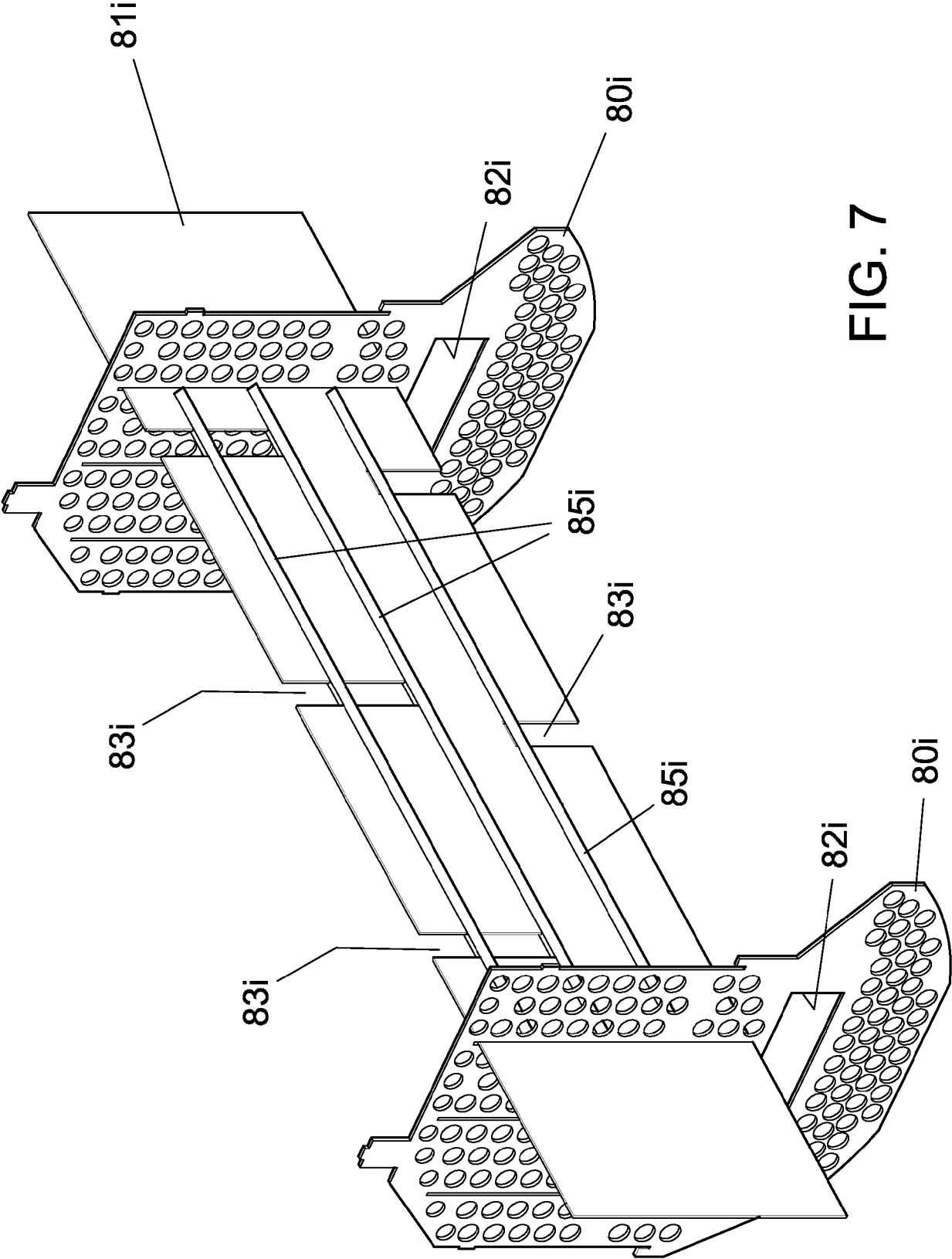


FIG. 7

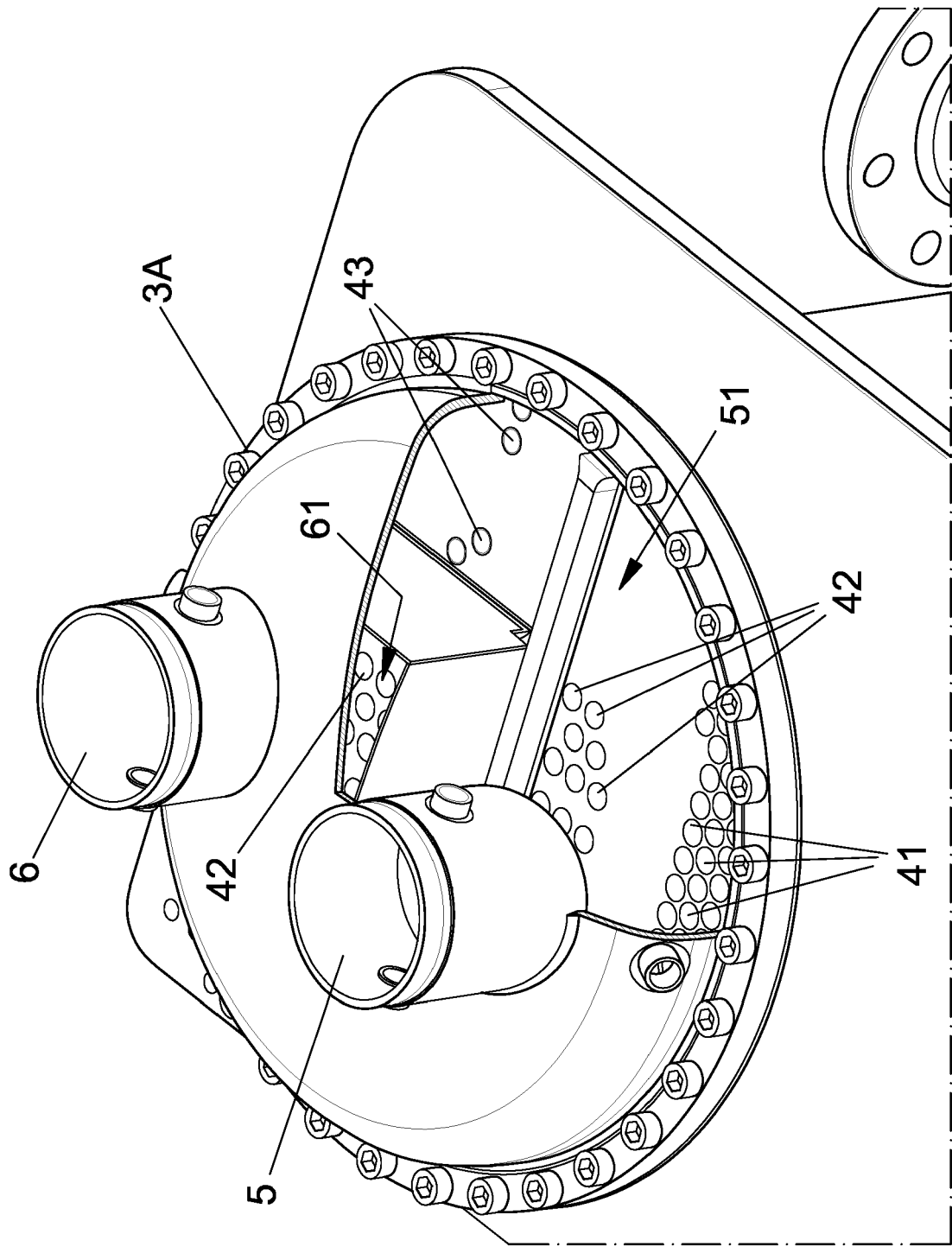


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 20 17 5886

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/276130 A1 (DE LARMINAT PAUL [FR] ET AL) 4 November 2010 (2010-11-04) * paragraph [0020] - paragraph [0049]; figures 5A,5B,5C,12 *	1-5,8,9,11,12,14,15	INV. F28D7/16 F25B39/02 F28D3/04 F28F9/22
X	WO 2011/011421 A2 (JOHNSON CONTROLS TECH CO [US]; KULANKARA SATHEESH [US] ET AL.) 27 January 2011 (2011-01-27) * abstract; figure 6 *	1-5,8,14,15	
X	US 2006/080998 A1 (DE LARMINAT PAUL [FR] ET AL) 20 April 2006 (2006-04-20) * paragraphs [0032], [0033], [0038] - paragraph [0042]; figure 5 *	1-5,14,15	
X	US 2011/120181 A1 (DE LARMINAT PAUL [FR] ET AL) 26 May 2011 (2011-05-26) * paragraph [0038] - paragraph [0060]; figure 13 *	1-5,14,15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D F25B F28F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 28 September 2020	Examiner Jessen, Flemming
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010276130 A1	04-11-2010	AT 554355 T	15-05-2012
		CN 101855502 A	06-10-2010
		CN 101903714 A	01-12-2010
		CN 101907375 A	08-12-2010
		CN 101932893 A	29-12-2010
		CN 102788451 A	21-11-2012
		EP 2232166 A2	29-09-2010
		EP 2232167 A1	29-09-2010
		EP 2232168 A2	29-09-2010
		EP 2341302 A1	06-07-2011
		EP 2450645 A2	09-05-2012
		EP 2482006 A1	01-08-2012
		EP 2482007 A1	01-08-2012
		EP 2482008 A1	01-08-2012
		JP 5226807 B2	03-07-2013
		JP 5616986 B2	29-10-2014
		JP 5719411 B2	20-05-2015
		JP 2011080756 A	21-04-2011
		JP 2011510248 A	31-03-2011
		JP 2011510249 A	31-03-2011
		JP 2011510250 A	31-03-2011
		JP 2013092365 A	16-05-2013
		JP 2013242140 A	05-12-2013
		KR 20100113108 A	20-10-2010
		US 2009178790 A1	16-07-2009
		US 2010242533 A1	30-09-2010
		US 2010276130 A1	04-11-2010
		US 2010319395 A1	23-12-2010
		US 2010326108 A1	30-12-2010
		US 2016238291 A1	18-08-2016
		WO 2009089446 A2	16-07-2009
		WO 2009089488 A1	16-07-2009
		WO 2009089503 A2	16-07-2009
		WO 2009089514 A2	16-07-2009
WO 2011011421 A2	27-01-2011	CN 102472589 A	23-05-2012
		EP 2457051 A2	30-05-2012
		US 2011017432 A1	27-01-2011
		WO 2011011421 A2	27-01-2011
US 2006080998 A1	20-04-2006	CA 2580888 A1	27-04-2006
		CN 101052854 A	10-10-2007
		EP 1809966 A2	25-07-2007
		JP 2008516187 A	15-05-2008
		KR 20070065894 A	25-06-2007
		TW 1279508 B	21-04-2007

EPO FORM P0459

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

55

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

EP 20 17 5886

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
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28-09-2020

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2006080998 A1	20-04-2006
		WO 2006044448 A2	27-04-2006

US 2011120181 A1	26-05-2011	EP 2097687 A2	09-09-2009
		JP 2010515006 A	06-05-2010
		KR 20090114367 A	03-11-2009
		TW 200837316 A	16-09-2008
		US 2008148767 A1	26-06-2008
		US 2011120181 A1	26-05-2011
		WO 2008080085 A2	03-07-2008

15

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25

30

35

40

45

50

EPO FORM P0459

55

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