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(54) Heat exchanger

(57) A heat exchanger, comprising a circular housing having a first and a second end plate (6,7), where the first end plate is provided with an inlet port (2) and the first or the second end plate is provided with an outlet port (3), and further comprising a plurality of corrugated heat exchanger plates (10,11) having ridges (12) and grooves (13), where the heat exchanger plates are fixedly attached to each other, such that a first flow channel is created between the heat exchanger plates, and where the heat exchanger further comprises a plurality of compensation plates (20) positioned between the heat exchanger plates (6,7) and at least one of the end plates. The advantage of this heat exchanger is that it reduces the stress imposed on the inlet and outlet regions of the heat exchanger due to thermal cycling.

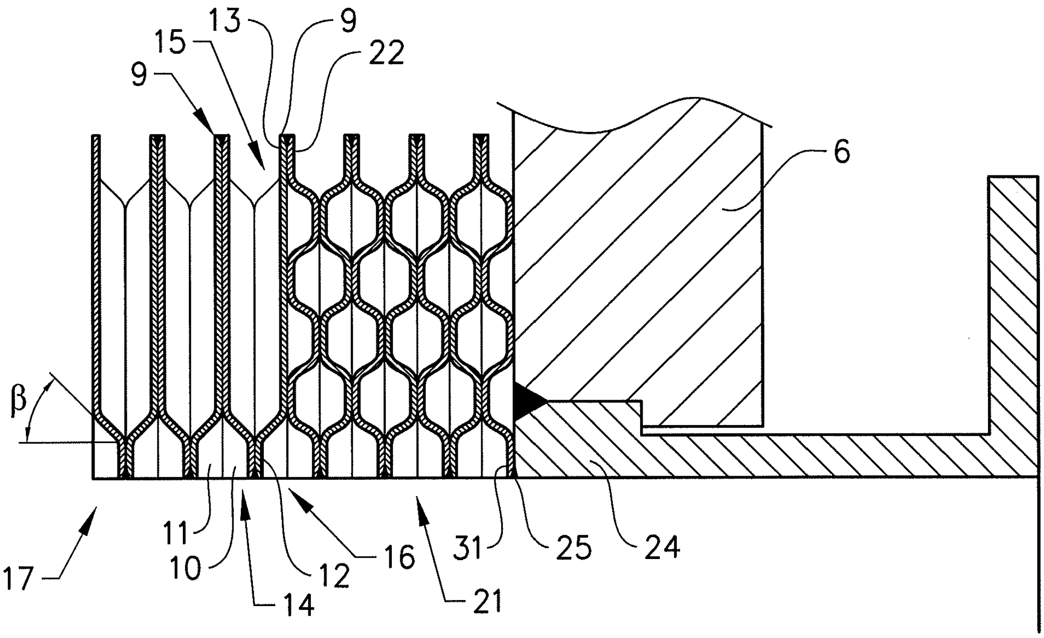

FIG. 6

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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger comprising a plurality of compensation plates that will improve the resistance to thermal fatigue of the heat exchanger.

BACKGROUND ART

[0002] Plate heat exchangers are used throughout industry as standard equipment for efficient heating, cooling, heat recovery, condensation and evaporation. Heat exchangers may be of different types and designs, depending on the type of medium that is to be heated or cooled.

[0003] One type of heat exchanger is the plate-and-shell type. This type is well suited for uses involving high pressures and high temperatures. Such a plate-and-shell heat exchanger comprises a pack of corrugated, circular metal plates housed in a vessel. The heat transfer surface of the heat exchanger is formed by thin corrugated discs stacked and welded on top of each other, which creates a process channel between the plates. The fluid for the process channel is led into the plate pack via ports welded into the discs and to an end plate of the vessel, and is distributed into the process channel between the plates. The corrugated discs are alternately welded at the outer circumference of the discs and at the port holes, thereby creating alternate fluid channels. The inlet and outlet ports for the process channel are positioned in the end plates, either in the same end plate or in both end plates. The inlet and outlet ports for the shell side of the heat exchanger are welded in the side wall of the vessel. The flow through the heat exchanger may be of either a counter-current, a cocurrent or a cross flow type.

[0004] The construction of such a heat transfer core makes the plate-and-shell type plate pack highly resistant to thermal expansion. This in turn makes them ideal for use under high-pressure and high-temperature conditions.

[0005] There is however a problem with fast thermal cycling of such heat exchangers, especially for larger heat exchangers having a large diameter. Since the corrugated discs are thin and in contact with the fluids, they will respond immediately to temperature changes. The vessel on the other side, being of a much thicker material, will respond much slower to temperature changes. This will result in high stresses at the inlet and outlet port regions for the process channel, where the discs are welded to the end plate of the heat exchanger. In one example, a stainless steel disc having a diameter of 1 m will expand almost 2 mm with a temperature rise of 100 degrees centigrade. Fast thermal cycling should thus be avoided for plate-and-shell type heat exchangers.

[0006] US 7004237 B2 describes a plate-and-shell type heat exchanger for fluids, in which a spring device compensates for longitudinal thermal expansion of the heat exchanger core.

[0007] US 6474408 B1 and US 6892797 B2 describe heat exchangers for gas provided with means that allows for thermal expansion in the longitudinal direction of the heat exchanger.

[0008] These known solutions may work well for thermal expansion in the longitudinal direction of the heat exchanger, but will not solve the problem with radial expansion. There is thus room for an improved heat exchanger, in which radial expansion is allowed.

DISCLOSURE OF INVENTION

[0009] An object of the invention is therefore to provide a heat exchanger where stress due to thermal expansion at the inlet and outlet region is minimized.

[0010] The solution to the problem according to the invention is described in the characterizing part of claim 1. Claims 2 to 13 contain advantageous embodiments of the heat exchanger.

[0011] With a heat exchanger, comprising a housing having a first end plate, a second end plate and a shell, where the first end plate is provided with an inlet port and the first or the second end plate is provided with an outlet port, and further comprising a plurality of corrugated heat exchanger plates having ridges and grooves, where the heat exchanger plates are fixedly attached to each other, such that a first flow channel is created between the heat exchanger plates, the object of the invention is achieved in that the heat exchanger further comprises a plurality of compensation plates positioned between the heat exchanger plates and at least one of the end plates.

[0012] By this first embodiment of the heat exchanger, a heat exchanger is obtained in which the stress on the joints between the inlet and outlet ports and the heat exchanger plates are reduced. This will allow the heat exchanger to be able to withstand a greater temperature gradient than existing heat exchangers. The heat exchanger can be used in areas where fast temperature cycling is present. The heat exchanger can also be used in areas where higher temperature differences are present. The operating range of the heat exchanger is thus increased.

[0013] In an advantageous development of the inventive heat exchanger, the compensation plates are fixedly attached to the heat exchanger plates on one side and to the inlet and outlet ports on the other side. This is advantageous in that a heat exchanger that can withstand high pressures is obtained, compared with heat exchangers having sealing gaskets.

[0014] In an advantageous development of the inventive heat exchanger, the pattern of the compensation plates comprises concentric ridges and grooves. The advantage of this is that the radial stiffness of the compensation plates is reduced compared with existing heat exchanger plate patterns.

[0015] In an advantageous development of the inventive heat exchanger, the flank angle of the compensation plates is smaller than the flank angel of the heat exchanger plates. The advantage of this is that the radial stiffness can be reduced further.

[0016] In an advantageous development of the inventive heat exchanger, the flank angle of the compensation plates is less than 30 degrees. The advantage of this is that the radial stiffness can be reduced further.

[0017] In an advantageous development of the inventive heat exchanger, the compensation plate comprises a circular opening in the centre of the compensation plate. The advantage of this is that the radial stiffness can be reduced further.

[0018] In an advantageous development of the inventive heat exchanger, the compensation plate comprises a pressure plate in the central opening of the compensation plate. The advantage of this is that the heat exchanger plates are supported.

[0019] In an advantageous development of the inventive heat exchanger, the compensation plate and the pressure plate are attached to each other. The advantage of this is that the handling of the compensation plates and the assembly of the heat exchanger is facilitated.

BRIEF DESCRIPTION OF DRAWINGS

[0020] The invention will be described in greater detail in the following, with reference to the embodiments that are shown in the attached drawings, in which

Fig. 1 shows a heat exchanger according to the invention,

Fig. 2 shows a schematic layout of the plate side flow channel for the heat exchanger according to a first embodiment of the invention,

Fig. 3 shows a schematic layout of the plate side flow channel for the heat exchanger according to a second embodiment of the invention,

Fig. 4 shows a first embodiment of a compensation plate according to the invention,

Fig. 5 shows a cross-section of the compensation plate according to the invention,

Fig. 6 shows a cross section of an inlet or outlet region of the heat exchanger according to the invention,

Fig. 7 shows a second embodiment of a compensation plate according to the invention, and

Fig. 8 shows a second embodiment of a compensation plate with a pressure plate according to the invention.

MODES FOR CARRYING OUT THE INVENTION

[0021] The embodiments of the invention with further developments described in the following are to be regarded only as examples and are in no way to limit the scope of the protection provided by the patent claims.

[0022] Fig. 1 shows a heat exchanger of the plate-and-shell type. Such a heat exchanger is suitable for most applications, such as general cooling and heating duties, condensation, evaporation, reboiling and steam heating. It is especially suitable for handling applications with high temperatures and/or high pressures. The shown heat exchanger is circular, having a round housing with two fixedly attached endplates.

[0023] The heat exchanger 1 comprises a housing 30 made up of end plates 6, 7 and a shell 8. The shell 8 is in this example circular, but other shapes, e.g. elliptical, are conceivable. The heat exchanger 1 further comprises four ports 2, 3, 4, 5 that will constitute either inlet ports or outlet ports to the heat exchanger, depending on the use and configuration of the heat exchanger. In the shown heat exchanger 1, port 2 is the inlet port and port 3 is the outlet port for the first flow channel, which in this example is the flow channel on the plate side, i.e. through the heat exchanger plates. Inlet port 2 and outlet port 3 are in a first embodiment both positioned in the first end plate 6, close to the outer edge of end plate 6. Port 4 is the inlet port for the flow channel of the shell side of the heat exchanger and port 5 is the outlet port for the shell side flow channel. Ports 4 and 5 are positioned in the shell 8 of the heat exchanger. A second end plate 7 closes the heat exchanger. The end plates 6 and 7 are fixed to the shell in a rigid way, allowing for a high pressure in the heat exchanger. The end plates 6, 7 may either be welded to the housing, or fixed to the housing with bolts and a flange. The heat exchanger may be provided with more than one plate side flow channel. The heat exchanger may in this case be divided into different flow channels, and the end plates will have more than one inlet and outlet ports.

[0024] Fig. 2 shows schematically the plate side flow channel for the first embodiment of the heat exchanger. Such a flow channel can be referred to as a U-type flow pattern. A fluid enters the heat exchanger through the inlet port 2 and flows through the inlet flow duct 32. The fluid is distributed from the inlet flow duct 32 through the heat exchanger plate stack 17, where the heat exchange takes place. Since the pressure drop in the inlet flow duct is much lower than the pressure drop through the heat exchanger plate stack, the fluid is distributed in a substantially even way over the heat transfer surface of the heat exchanger. The fluid leaves the heat exchanger through the outlet flow duct 33 and the outlet port 3. The flow path is illustrated with arrows in the figure. The heat exchanger further comprises a compensation plate stack 21 positioned between the first end plate 6 and the heat exchanger plate stack 17. The compensation plate will be described below.

[0025] Fig. 3 shows schematically the plate side flow channel for a second embodiment of the heat exchanger, in which the inlet port 2 is positioned in the first end plate 6 and the outlet port 3 is positioned in the second end plate 7. Such a flow channel can be referred to as a Z-type flow pattern. A fluid enters the heat exchanger through the inlet port 2 and flows through the inlet flow duct 32. The fluid is distributed from the inlet flow duct 32 through the heat exchanger plate stack 17, where the heat exchange takes place in the same way as described above. The fluid leaves the heat exchanger through the outlet flow duct 33 and the outlet port 3. The flow path is illustrated with arrows in the figure. In this embodiment, a compensation plate stack 21 is positioned between the first end plate 6 and the heat exchanger plate stack 17 and another compensation plate stack 21 is positioned between the second end plate 7 and the heat exchanger plate stack 17. Depending on the size of the heat exchanger and the number of compensation plates used, it may suffice to use only one compensation plate stack in this embodiment.

[0026] In both shown embodiments, the inlet port 2 is arranged along an inlet axis 34 and the outlet port 3 is arranged along an outlet axis 35. The inlet axis 34 and the outlet axis 35 are arranged on opposite sides of the centre axis 36 in a symmetric way.

[0027] The inlet port 2 and the outlet port 3 comprise an outer flange to which the heat exchanger is connected to the system in which the heat exchanger is used. Each port further comprises a short pipe that is welded to the end plate and that extends through the end plate so that it can, in this case, abut the compensation plates. The pipe is fixedly attached to the compensation plate closest to the port, e.g. by welding, thereby creating a joint between the port pipe and the compensation plates. An example of this can be seen in Fig. 6.

[0028] The heat exchanger comprises a number of corrugated heat exchanger plates 10, 11 having a corrugated pattern comprising ridges 12 and grooves 13. The ridges and grooves enlarge the heat transfer surface of the heat exchanger and create a suitable pressure drop through the flow channel. The pattern may have different shapes, depending on the use of the heat exchanger. The heat exchanger plates are stacked on each other in such a way that a flow channel is created between the plates, referred to as the plate side flow channel or the first flow channel. Between two adjacent plates 10, 11, the first flow channel 14 is created. In this case, the two plates are welded at the outer periphery 9 of the heat exchanger plates, making up a heat exchanger cassette. An enclosed volume is thus created, which is part of the plate side flow channel. The cassettes are welded to each other at the port openings 16 of the heat exchanger plates. In this way, a second flow channel 15, also referred to as the shell side flow channel, is created on the shell side between the cassettes. The number and size of the cassettes comprised in the heat exchanger is selected depending on the required heating/cooling capacity of the heat exchanger. The welded heat exchanger plates make up the heat exchanger core. Such a heat exchanger core is well known in the art and is not described further. The flow channels in the heat exchanger may be configured in different ways, known to the skilled person.

[0029] In known heat exchangers, the inlet port pipe and the outlet port pipe is welded directly to the heat exchanger plate pack, i.e. to the heat exchanger plate closest to the inlet and outlet ports in order to obtain a pressure tight plate side flow channel. The inlet port pipe and the outlet port pipe are also welded to the end plate of the heat exchanger in order to obtain a pressure tight flow channel on the shell side of the heat exchanger. In this way, the ports opening of the heat exchanger plate will be fixedly attached to the end plate. Since the heat exchanger plate will react to thermal changes much faster than the end plate, there will be stress imposed on the joint between the inlet and outlet pipe and the heat exchanger plate. If the connection is exposed to thermal cycling, the connection will, depending e.g. on the distance between the inlet and outlet pipe, deteriorate and may eventually break.

[0030] The inventive heat exchanger is thus provided with a number of compensation plates 20 disposed between the first end plate 6 and the heat exchanger plate stack 17. The purpose of the compensation plates is to allow the heat exchanger plates to expand or shrink due to a fast temperature change without imposing thermal fatigue to the joints between the heat exchanger plate pack and the end plate. Fig. 4 shows a side view of a compensation plate 20, Fig. 5 shows a cross-section of a compensation plate and Fig. 6 shows a cross-section of the inlet region of a heat exchanger.

[0031] The compensation plate 20 is provided with a concentric corrugated pattern comprising ridges 18 and grooves 19. The pattern is pressed such that the height distance between the ridges and the grooves corresponds to the pressing depth of the plate. The compensation plate has a reference level denoted a, with the pressing depth corresponding to the height h. In the shown example, the grooves are at the reference level a. The outer periphery 22 of the compensation plate is also at the reference level a. The circumference 31 of each port opening 23 in the compensation plate will have the same height as the ridges, i.e. the height h. When the compensation plates are assembled into a compensation plate stack 21, every other compensation plate is turned so that the outer periphery of two adjacent compensation plates bear on each other, and so that the circumference of the port openings of two other adjacent compensation plates bear on each other. At the same time, the ridges of two adjacent compensation plates bear on each other, and the grooves of two other adjacent compensation plates bear on each other.

[0032] The compensation plates in a compensation plate stack 21 are fixedly attached to each other, e.g. by welding or brazing, only at the outer periphery 22 and at the circumference 31 of the port openings 23. The ridges or grooves of respective adjacent compensation plates will also bear on each other, but will not be fixedly attached to each other.

[0033] The flank angle α of the compensation plate may be smaller than the flank angle β of the heat exchanger plates. Normally, the flank angle β of a heat exchanger plate is around 45 degrees in order to provide a large heat transfer surface and at the same time a relatively stiff plate. By choosing a concentric pattern for the compensation plates, a relatively low radial stiffness is obtained. With a small flank angle α, the radial stiffness is further decreased. A flank angle α of between 10 and 30 degrees is preferred. A low radial stiffness of the compensation plate is of advantage.

[0034] In Fig. 6, the inlet port region of a heat exchanger is shown. In this example, seven compensation plates are used in the compensation plate stack 21. The first compensation plate is fixedly attached, e.g. by welding or brazing, to the inlet pipe 24, which in turn is welded to the end plate 6. The consecutive compensation plates are fixedly attached to each other at either the outer periphery 22 or the circumference 31 of the port openings 23. The last compensation plate is fixedly attached to the heat exchanger plate stack 17 at the outer periphery 22 of the compensation plate 20 and the outer periphery 9 of a heat exchanger plate. There will be a very limited flow between the compensation plates, both in the plate side flow channel and in the shell side flow channel, since the corrugated pattern is symmetric and is not laid out for heat transfer. The ridges of one plate bears on the ridges of an adjacent plate, and for every other plate, the grooves of one plate bear on the grooves of another adjacent plate. There are no cross-corrugations in the compensation plate stack due to the concentric pattern of the compensation plates. The outlet port region will resemble the inlet port region.

[0035] The compensation plate stack 21 functions in the following way. When a quick and high temperature rise occurs in the heat exchanger, the heat exchanger plates in the heat exchanger plate stack 17 will immediately expand. The end plate 6 will expand much slower, partly because the end plate is much thicker than the heat exchanger plates and partly because the end plate is in very little contact with the media flowing through the heat exchanger. The compensation plates will expand somewhat slower than the heat exchanger plates, since most of the compensation plates are not in great contact with the flow through the heat exchanger.

[0036] When the heat exchanger plates expand, the compensation plate stack can not expand in the same way, since a compensation plate is fixed to the end plate. The compensation plates can, due to the concentric pattern, expand in a different way than the heat exchanger plates and will expand in a somewhat elliptical shape. Since the compensation plate stack is attached to the heat exchanger plate stack on one side and to the end plate on the other side, each compensation plate will expand somewhat differently. Each plate will thus help to minimize the stress imposed on the joint 25 between the inlet pipe 24 and the port opening circumference 31 of the compensation plate closest to the end plate. Since the compensation plates have a relatively low radial stiffness, the stress imposed on the plates due to the thermal expansion is divided over the complete plate stack, and the stress imposed on each plate is divided over each plate.

[0037] The complete core of the heat exchanger, comprising the heat exchanger plate stack 17 and one or two compensation plate stacks 21, is held in position by the end plates. Since all plates are welded together, the core is stiff and can only expand in the radial direction, towards the shell. Other forms of deformation are not possible when the core is mounted in the heat exchanger housing. If the core was not mounted in a heat exchanger, the distance between the inlet axis 34 and the outlet axis 35 would increase with higher temperature. Because that the core is fixedly attached to the end plates, the distance between the inlet axis 34 and the outlet axis 35 can not change when the temperature changes. Instead, stress will be imposed on the joint between the core and the end plates.

[0038] The stress imposed on the joints between the core and the end plates will be the same for the two shown embodiments. Since the heat exchanger core is pressed between the end plates, the stress will be the same regardless of on which side of the inlet or outlet flow duct the inlet or outlet port is located.

[0039] In a second embodiment of the compensation plate, shown in fig. 5 and 6, the compensation plate 20 is provided with an opening 28 in the centre of the compensation plate. The opening may be cut out during the pressing of the compensation plate or in a later process step. With the opening in the centre of the compensation plate, every other compensation plate must be welded to an adjacent compensation plate also at the inner periphery 27 in order to obtain a closed channel for the plate side flow channel. The advantage of having an opening in the centre of the compensation plate is that the radial stiffness of the compensation plate is decreased further.

[0040] In order to support the heat exchanger plates, the central opening 28 must be provided with some kind of support means for the support of the centre of the heat exchanger plates. For this purpose, a pressure plate 29 is provided in the centre of each compensation plate. It is advantageous to use the cut-out for the central opening as a pressure plate 29. In order to facilitate the handling of the compensation plates and the assembly of the heat exchanger, the pressure plate is preferably attached to the compensation plate. One way of attaching the pressure plate to the compensation plate is by welding. The outer and inner peripheries of the compensation plate are seal welded in order to obtain a pressure tight weld. The pressure plate is preferably tack welded to the compensation plate in a few positions, in order to obtain a flexible attachment of the pressure plate. The pressure plate should not be rigidly attached to the compensation plate.

[0041] It is also possible to leave a few plate bridges 26 between the pressure plate and the compensation plate during the pressing of the compensation plate. The plate bridges 26 will thus connect the compensation plate to the pressure plate. In this way, the pressure plate and the compensation plate will not be completely separated. This will facilitate the handling of the compensation plate, but may interfere with the attachment of the inner peripheries to each other. It is also possible to attach all pressure plates into one pressure plate unit that is assembled to the heat exchanger separately. Other types of support means are also conceivable.

[0042] The number of compensation plates used in a compensation plate stack may vary depending e.g. on the diameter of the heat exchanger, the temperatures that the heat exchanger is designed for and the thickness and pressing depth of the compensation plates. A suitable number of compensation plates for a heat exchanger having a diameter of 1 meter is between 3 and 9. In the shown example, 7 compensation plates are used. By using too few compensation plates, the stress imposed on the joint between the inlet pipe and the compensation plate will be too high. By using too many compensation plates, an unnecessary large volume is wasted in the heat exchanger, since the compensation plate stack is not part of the heat transfer surface of the heat exchanger.

[0043] The invention is not to be regarded as being limited to the embodiments described above, a number of additional variants and modifications are possible within the scope of the subsequent patent claims.

REFERENCE SIGNS

[0044]

1: Heat exchanger
2: Inlet port
3: Outlet port
4: Inlet port
5: Outlet hole
6: First end plate
7: Second end plate
8: Shell
9: Heat exchanger plate outer periphery
10: Heat exchanger plate
11: Heat exchanger plate
12: Ridge
13: Groove
14: First flow channel
15: Second flow channel
16: Heat exchanger plate port opening
17: Heat exchanger plate stack
18: Compensation plate ridge
19: Compensation plate groove
20: Compensation plate
21: Compensation plate stack
22: Compensation plate outer periphery
23: Compensation plate port opening
24: Inlet pipe
25: Joint
26: Plate bridge
27: Compensation plate inner periphery
28: Central opening
29: Pressure plate
30: Housing
31: Port opening circumference
32: Inlet flow duct
33: Outlet flow duct
34: Inlet axis
34: Outlet axis
35: Centre axis

Claims

1. Heat exchanger (1), comprising a housing (30) having a first end plate (6); a second end plate (7) and a shell (8), where the first end plate (6) is provided with an inlet port (2) and the first or the second end plate (6, 7) is provided with an outlet port (3), and further comprising a plurality of corrugated heat exchanger plates (10, 11) having ridges (12) and grooves (13), where the heat exchanger plates are fixedly attached to each other, such that a first flow channel (14) is created between the heat exchanger plates (10, 11), **characterized in that** the heat exchanger further comprises a plurality of compensation plates (20) positioned between the heat exchanger plates (10, 11) and at least one of the end plates (6, 7).

2. Heat exchanger according to claim 1, **characterized in that** the shell (8) is circular.

3. Heat exchanger according to claim 1 or 2, **characterized in that** the plurality of compensation plates (20) are fixedly attached to each other to form a compensation plate stack (21).

4. Heat exchanger according to claim 3, **characterized in that** the first end plate (6) is provided with an inlet port (2) and an outlet port (3), and that a compensation plate stack (21) is fixedly attached to the heat exchanger plates (10, 11) on one side and to the inlet and outlet ports (2, 3) of the first end plate (6) on the other side.

5. Heat exchanger according to claim 3, **characterized in that** the first end plate (6) is provided with an inlet port (2) and the second end plate (7) is provided with an outlet port (3), and that a first compensation plate stack (21) is fixedly attached to the heat exchanger plates (10, 11) on one side and to the inlet port (2)

of the first end plate (6) on the other side, and that a second compensation plate stack (21) is fixedly attached to the heat exchanger plates (10, 11) on one side and to the outlet port (3) of the second end plate (7) on the other side.

6. Heat exchanger according to any of claims 1 to 5, **characterized in that** the pattern of a compensation plate (20) comprises concentric ridges (18) and grooves (19).

7. Heat exchanger according to any of claims 1 to 6, **characterized in that** flank angle (α) of the compensation plates (20) is smaller than the flank angel (β) of the heat exchanger plates (10, 11).

8. Heat exchanger according to any of claims 1 to 7, **characterized in that** the flank angle (α) of the compensation plates (20) is less than 30 degrees.

9. Heat exchanger according to any of claims 1 to 8, **characterized in that** the compensation plate (20) comprises a circular opening (28) in the centre of the compensation plate.

10. Heat exchanger according to claim 9, **characterized in that** two adjacent compensation plates (20) are fixedly attached to each other at the outer periphery (22) and the inner periphery (27) of the compensation plate.

11. Heat exchanger according to claim 9 or 10, **characterized in that** the compensation plate (20) comprises a pressure plate (29) in the central opening (28) of the compensation plate.

12. Heat exchanger according to claim 11, **characterized in that** the compensation plate (20) and the pressure plate (29) are attached to each other.

13. Heat exchanger according to any of claims 1 to 12, **characterized in that** the heat exchanger plates and/or the compensation plates are welded to each other.

14. Heat exchanger according to any of claims 1 to 12, **characterized in that** the heat exchanger plates and/or the compensation plates are brazed to each other.

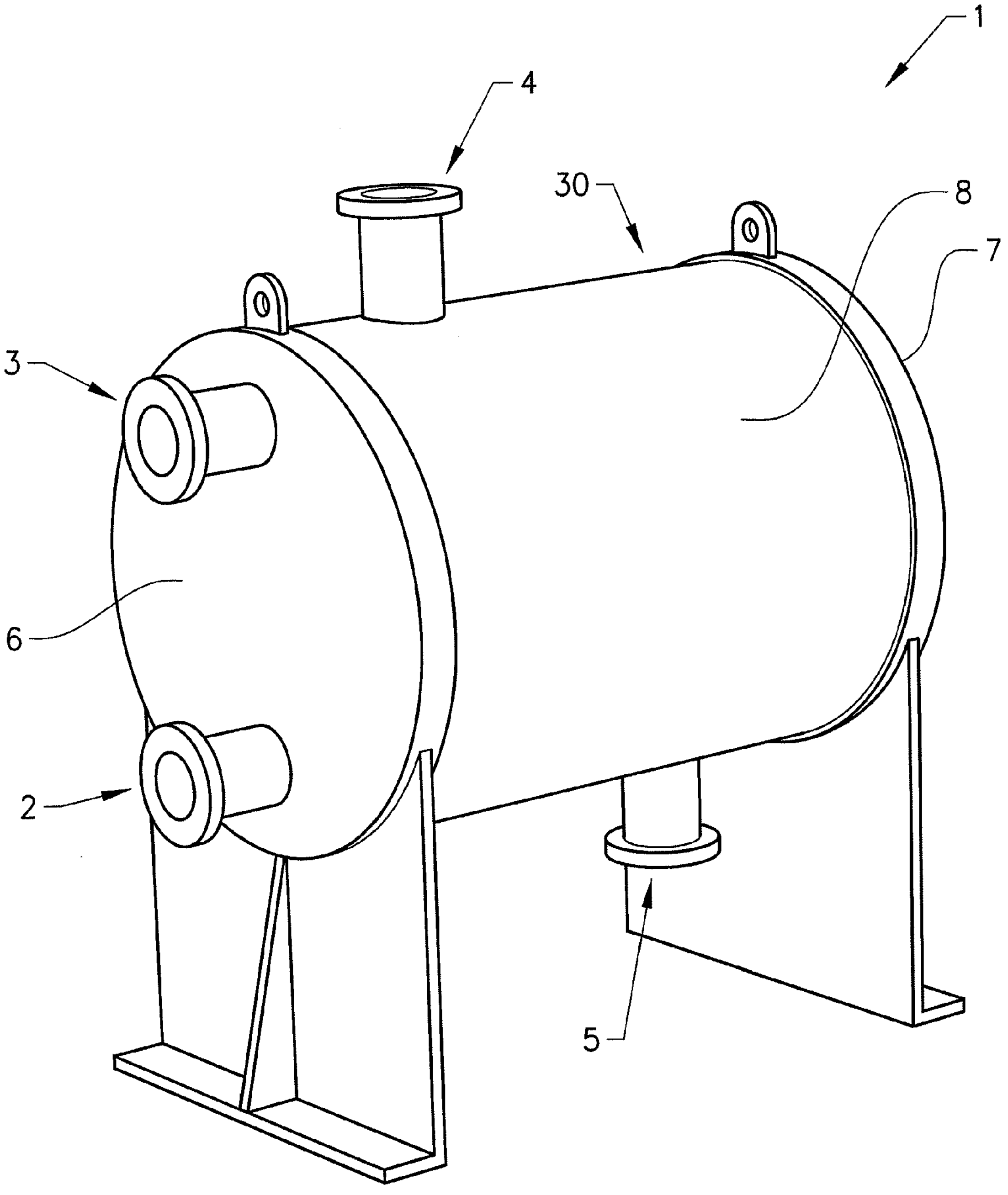

FIG. 1

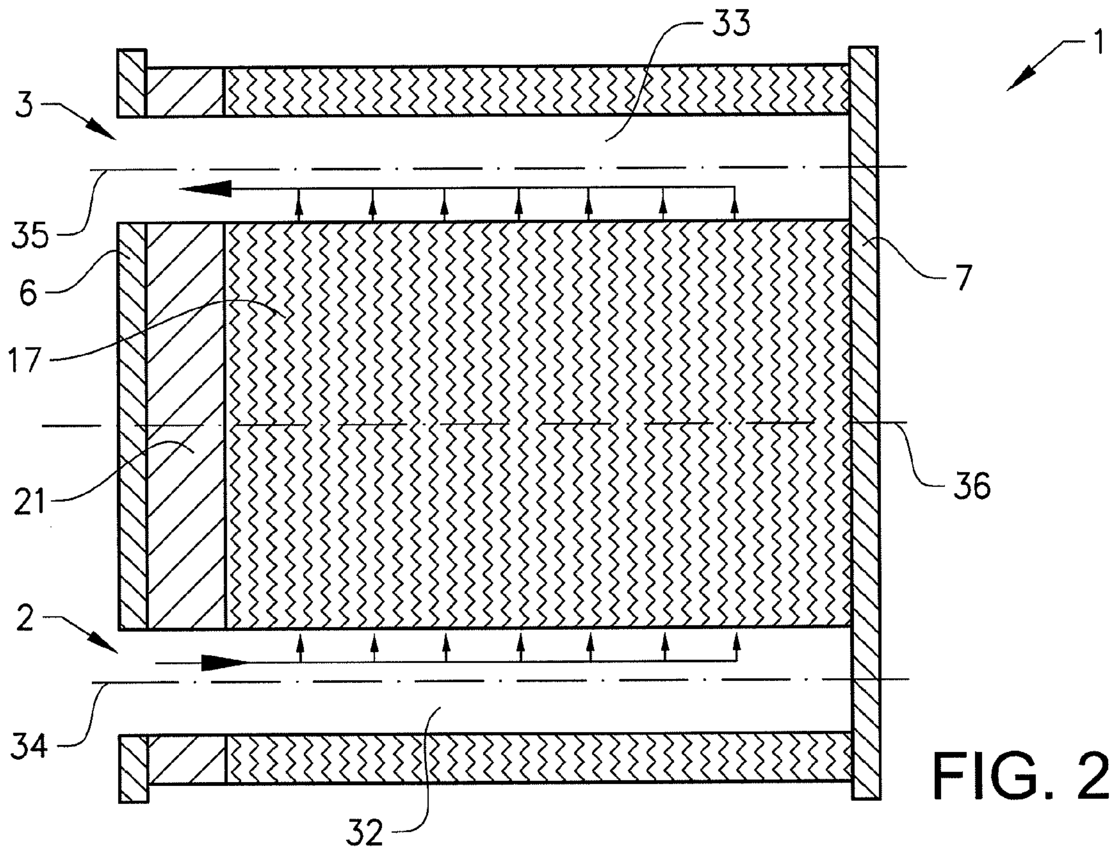

FIG. 2

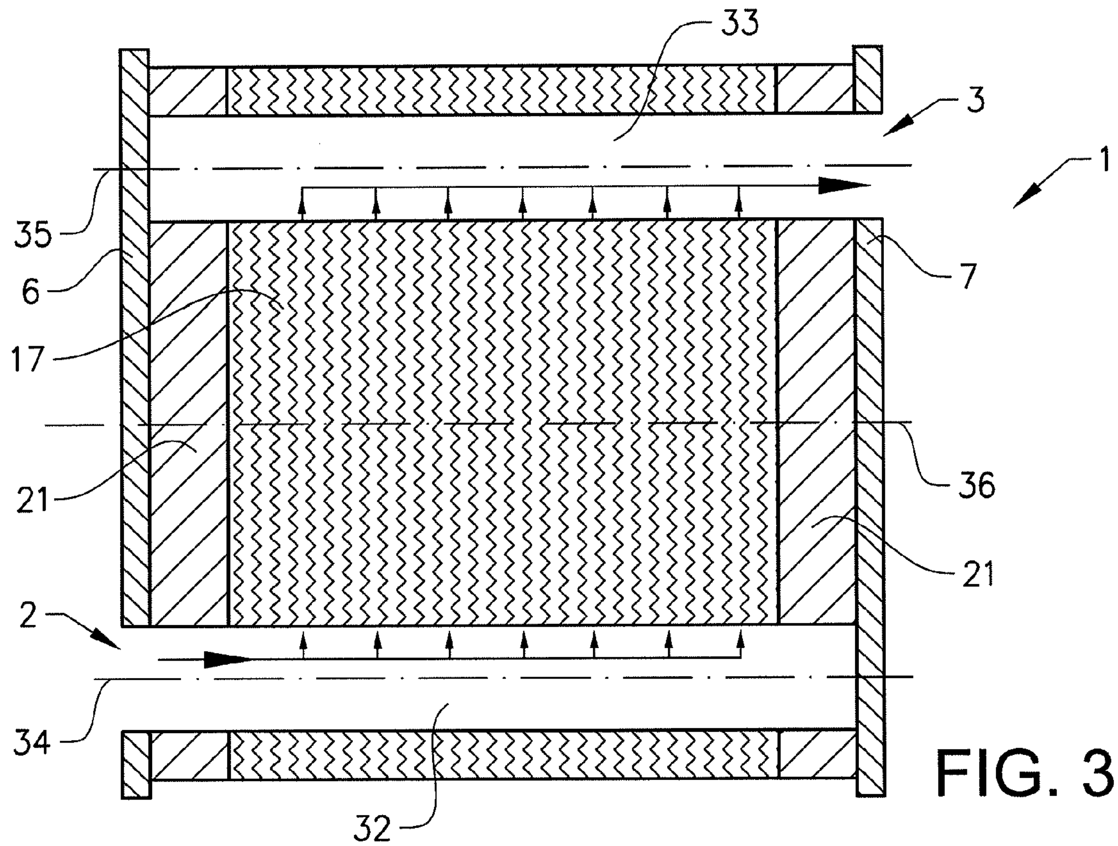

FIG. 3

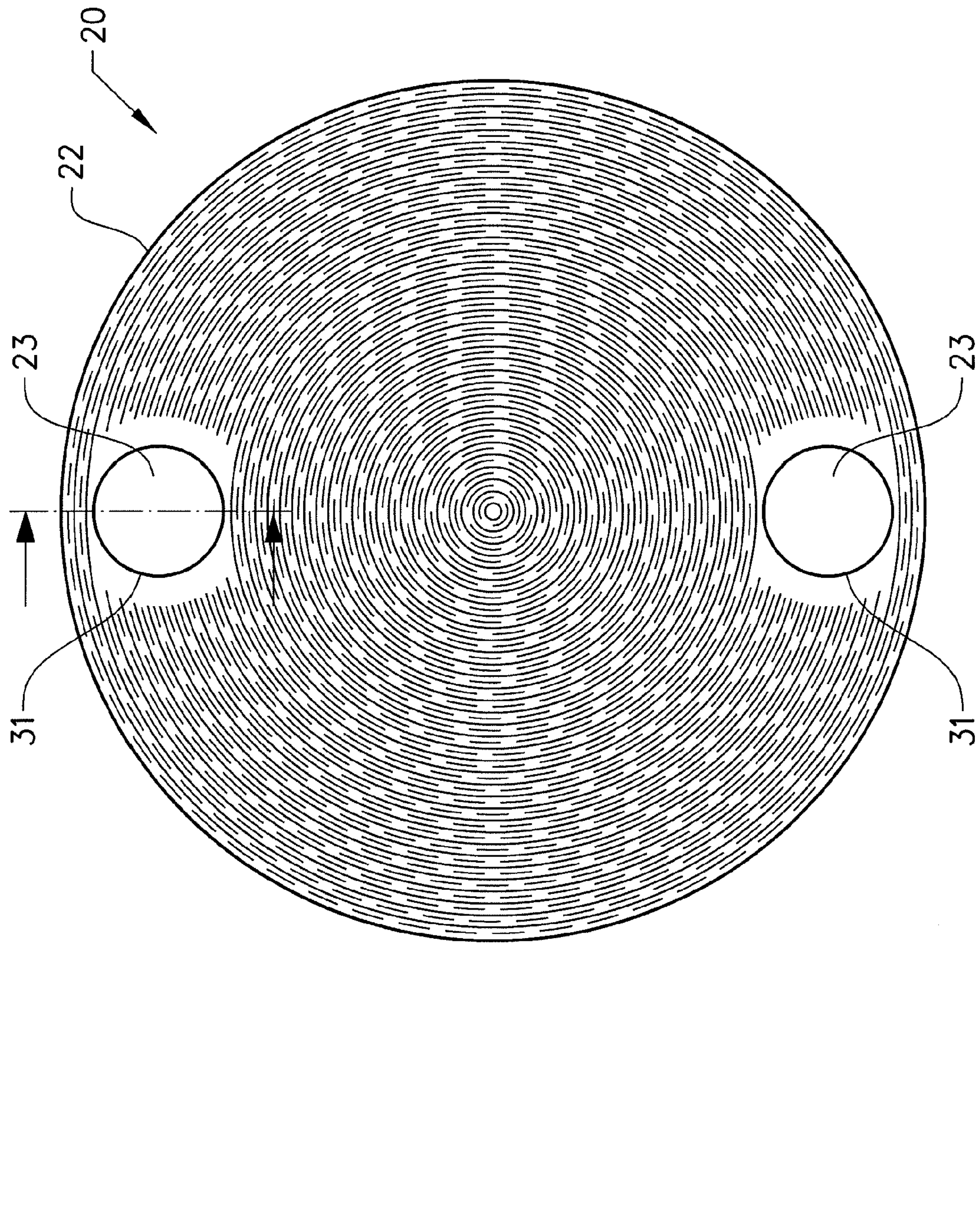

FIG. 4

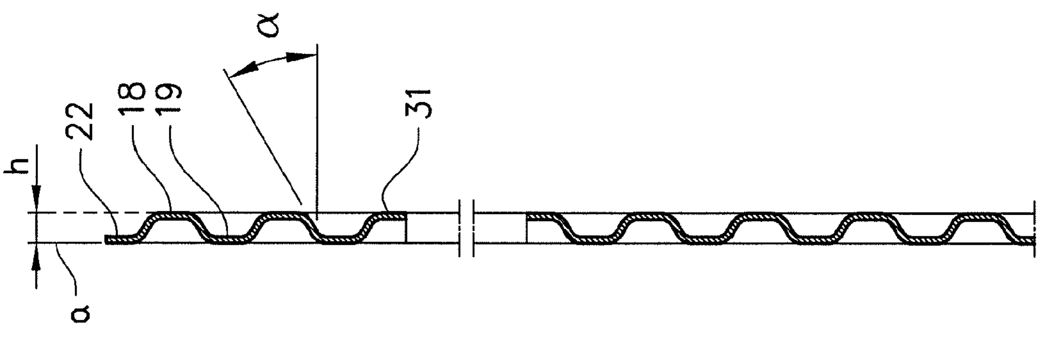

FIG. 5

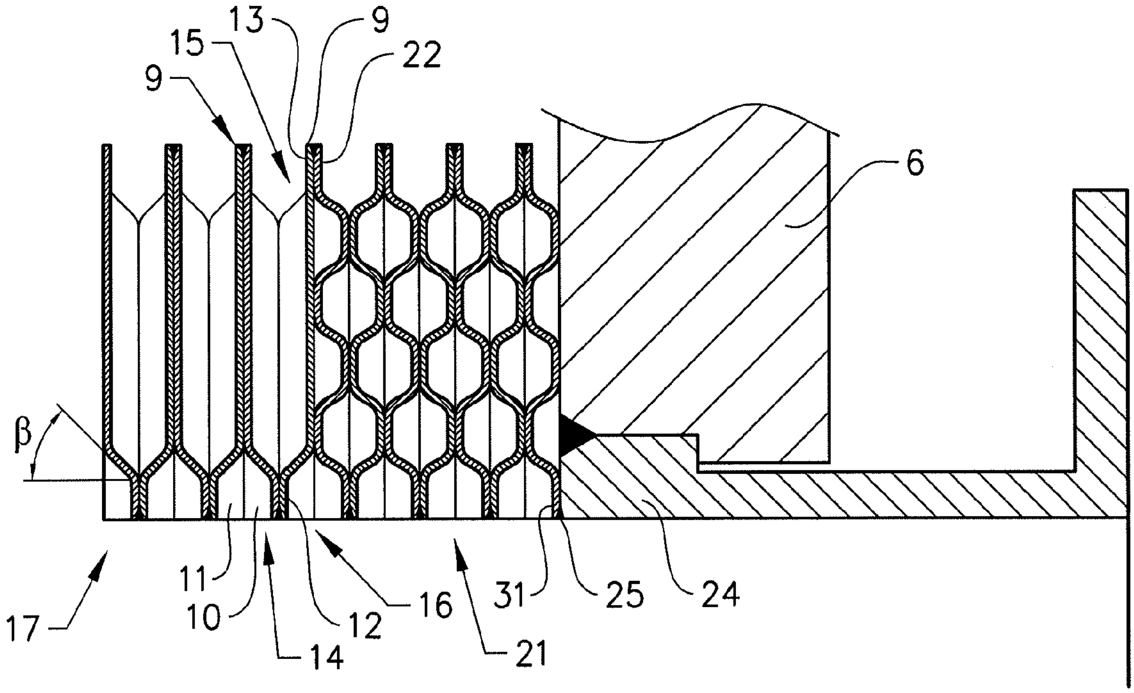

FIG. 6

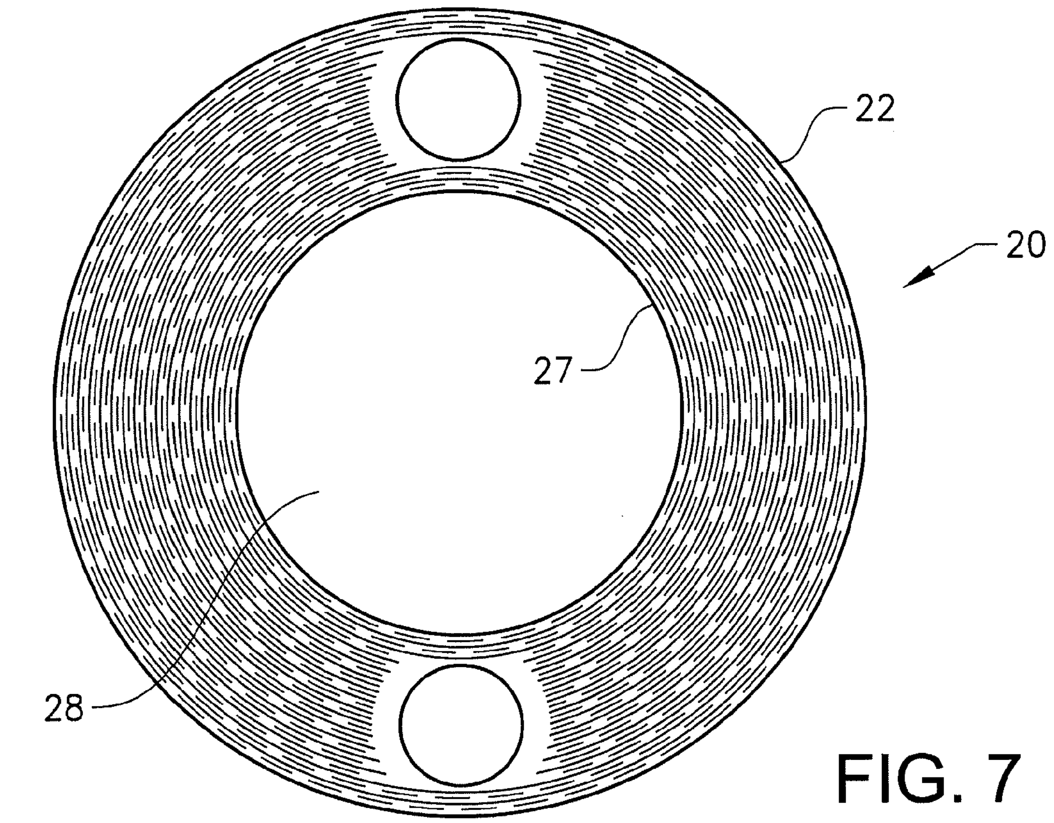

FIG. 7

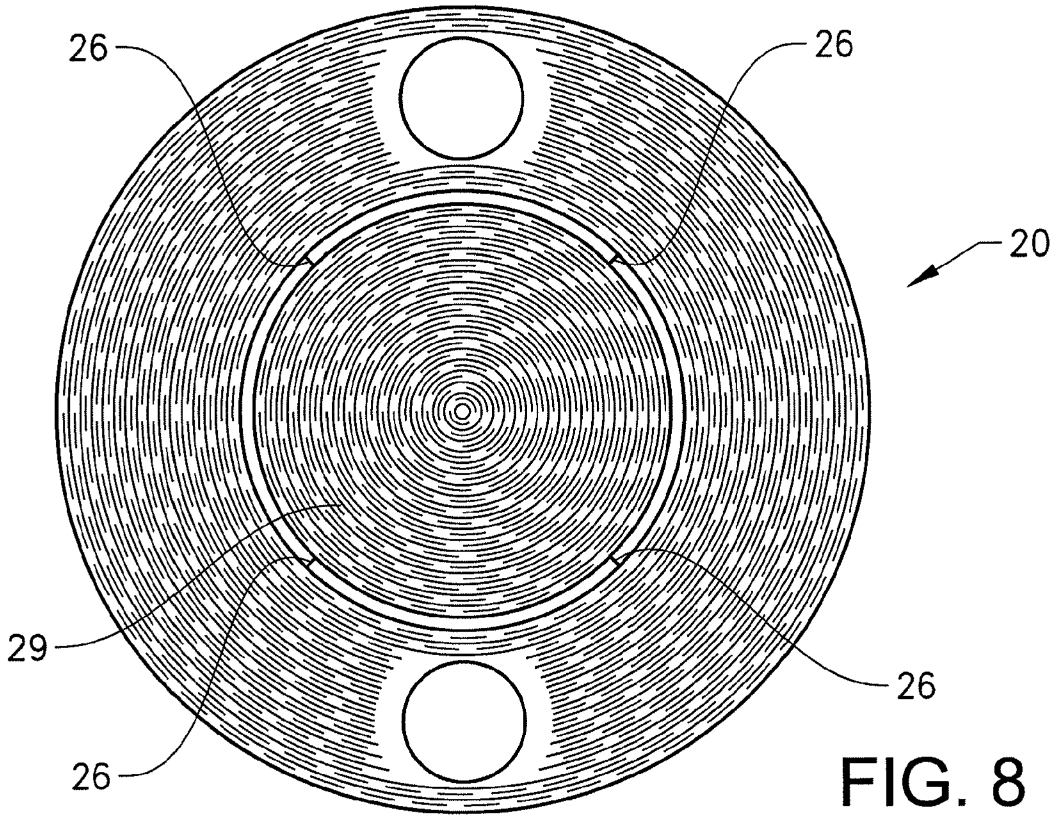

FIG. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 08 17 1770

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,D Y	US 2003/000688 A1 (MATHUR ACHINT P [US] ET AL) 2 January 2003 (2003-01-02) * paragraph [0029]; figures 13,15 *	1,2,6 3,4,9,10,12	INV. F28D9/00 F28F9/00
A	DATABASE WPI Section Ch, Thomson Scientific, London, GB; Class J08, AN 1983-63334K XP002527541 & SU 951 062 A1 (YAROSL MOTOR WKS) 15 August 1982 (1982-08-15) * abstract; figures 1,2 *	1-14	
Y	US 2003/116305 A1 (BEDDOME DAVID W [US] ET AL) 26 June 2003 (2003-06-26) abstract* figures 1-7 *	3,4,9,10,12	
A,D	US 5 368 095 A (KADAMBI VEDANTH [US] ET AL) 29 November 1994 (1994-11-29) * the whole document *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

F28D
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 May 2009	Martínez Rico, Celia

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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