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(54) A SHELL HEAT EXCHANGER AND USE OF A SHELL HEAT EXCHANGER

(57) Disclosed is a shell heat exchanger (1) comprising a plate heat exchanging section (2) which comprises a stack of corrugated heat transfer plates (3), and a tube heat exchanging section (4) which comprises a plurality of heat exchanging tubes (5), wherein the plate heat exchanging section (2) and the tube heat exchanging section (4) are arranged separate from each other and wherein the plate heat exchanging section (2) and the tube heat exchanging (4) are enclosed inside the same common heat exchanger shell (6).

Furthermore, use of a shell heat exchanger (1) for exchanging heat between at least two mediums wherein the pressure of at least one of the mediums is different from the pressure surrounding the shell heat exchanger (1).

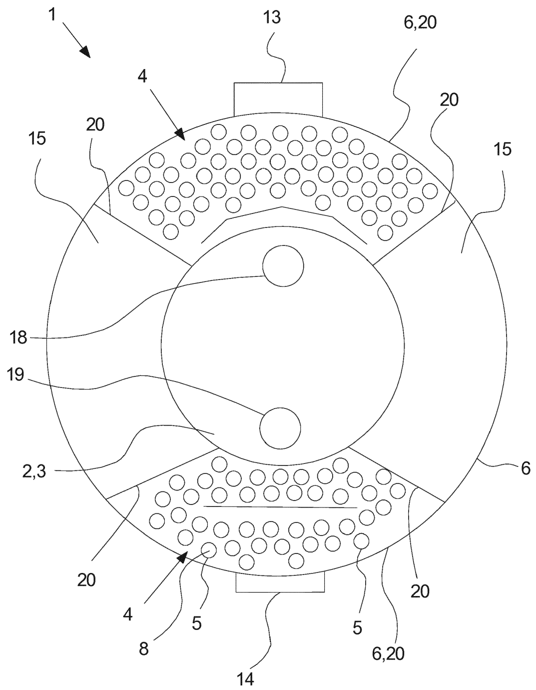

Fig. 2

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Description

Field of the invention

[0001] The invention relates to a shell heat exchanger comprising a plate heat exchanging section which comprises a stack of corrugated heat transfer plates. The invention further relates to use of a shell heat exchanger.

Background of the invention

[0002] Heat exchangers are commonly used for transferring heat between two or more fluids e.g. in cooling or heating processes in connection with refrigeration, air conditioning, chemical plants, power stations or other industrial applications.

[0003] The simplest heat exchanger may be arranged such that a first fluid and a second fluid flow in a parallel flow or in a counter flow and wherein the fluids are separated by a plate. Due to the temperature difference, energy may be transferred across the plate from the first fluid to the second fluid at a rate depending on the temperature difference, fluid velocity, contact area, thermal conductivity of the separating wall etc. Thus, in order to increase the heat transfer rate and thereby the efficiency of the heat exchanger, engineers design heat exchangers wherein these variables are carefully considered. As an example, a plate heat exchanger is designed such that (among others) a large contact area for increasing the heat transfer rate is obtained. This is achieved by pressing a plurality of plates together to form a compact plate stack. wherein the individual plates are usually separated by a sealing gasket. Since some heat exchangers are used for evaporating or condensing a refrigerant in connection with e.g. a refrigeration cycle, the pressure inside the plate heat exchanger may be higher or lower than the surroundings such that the refrigerant is able to evaporate/condense. However, constructing a plate heat exchanger for these circumstances is expensive and if the difference between the inside pressure of the plate heat exchanger and the surrounding pressure is too large, the sealing gaskets may malfunction as a result of the pressure difference and thereby the efficiency of the plate heat exchanger is negatively affected. Thus, it is known to arrange a plate heat exchanger inside an enclosed shell to form a plate-and-shell heat exchanger. The enclosed shell is able to withstand e.g. large pressure difference between the surroundings and the inside of the shell and arranging the plate heat exchanger inside the shell therefore enables use of a plate heat exchanger under large pressure difference. However, in some embodiment's further elements such as coalescers, demisters, pipework, filters, filler elements or other additional elements are also needed inside the shell of the shell heat exchanger e.g. to provide additional functionality to the shell heat exchanger. However, this can be difficult if the plate stack is fully enclosed by shell.

[0004] Thus, from EP 1 479 985 B1 it is known to form the plates so that the plate stack only occupies a part of the space inside the shell. However, manufacturing tools for heat transfer plates are expensive and the plates are therefore typically only formed in a few different sizes making it difficult to efficiently utilize the space inside the shell.

[0005] It is therefore an object of the present invention to provide for a more efficient shell heat exchanger.

The invention

[0006] The invention provides for a shell heat exchanger comprising a plate heat exchanging section which comprises a stack of corrugated heat transfer plates and a tube heat exchanging section which comprises a plurality of heat exchanging tubes. The plate heat exchanging section and the tube heat exchanging section are arranged separate from each other. Furthermore, the plate heat exchanging section and the tube heat exchanging are enclosed inside the same common shell.

[0007] Providing a shell heat exchanger with both a plate heat exchanging portion and a tube heat exchanging portion inside the same pressure vessel is advantageous in that a plurality of heat exchanging pipes may be dispersed in the free and unused space surrounding the stack of heat exchanging plates of the plate heat exchanging section, whereby the capacity and the efficiency of the shell heat exchanger is increased.

[0008] Combining heat transfer plates and heat transfer tubes in the same shell is further advantageous in that a plurality of possible setups of heat exchanging functions of the shell heat exchanger may be achieved, such as condenser and/or evaporator applications in one unit and separating the tube heat exchanging section and the plate heat exchanging section from each other is advantageous in that a first refrigerant may flow around the tubes in the tube heat exchanging section and a second refrigerant may flow around the heat transfer plates in the plate heat exchanging section, hereby enabling a shell heat exchanger with multiple heat exchanging functions and high adaptability to operational requirement is obtained.

[0009] In this context, the term "tube heat exchanging section" should be understood as a portion of the space inside the shell heat exchanger, wherein heat is exchanged through the wall of a tube, pipe, cylinder or tubular structural element suited for conducting a fluid, gas, a finely divided solid or other.

[0010] In this context, the term "plate heat exchanging section" should be understood as a portion of the space inside the shell heat exchanger, wherein heat is exchanged through the wall of a heat transfer plate, disc, sheet or other.

[0011] In an aspect of the invention, the shell has a tubular shape and wherein the tubular shell is closed at both ends.

[0012] Constructing the shell in a substantially tubular shape which is closed at both ends is advantageous in that the shell heat exchanger may withstand a large pressure difference between the inside of the shell and the surroundings.

[0013] In an aspect of the invention, the stack of corrugated heat transfer plates is arranged to extend substantially the entire length of the tubular shell.

[0014] Arranging the plate stack such that it extends the entire length of the shell is advantageous in that the full length of the tubular shell is utilized for heat transfer whereby the capacity and efficiency of the heat exchanger is enhanced.

[0015] In an aspect of the invention, the tube heat exchanging section is arranged to extend substantially the entire length of the tubular shell.

[0016] Arranging the tubes so that they extend the entire length of the shell is advantageous in that the full length of the tubular shell is utilized for heat transfer whereby the capacity and efficiency of the heat exchanger is enhanced.

[0017] In an aspect of the invention, the plurality of heat exchanging tubes are substantially running in parallel.

[0018] Forming the pipe to run in parallel is advantageous in that they hereby may be dispersed evenly and compact inside the shell heat exchanger and whereby the space inside the shell heat exchanger is utilized effectively resulting in even heat transfer throughout the length of the shell heat exchanger. Furthermore, arranging the heat exchanging tubes such that they are substantially running in parallel is advantageous in that the flow disturbance through the shell is minimized.

[0019] In an aspect of the invention, the plurality of heat exchanging tubes are arranged to extend in a longitudinal direction of the shell.

[0020] Making the tubes extend in the longitudinal direction of the shell is advantageous in that the tubes can be formed longer and with fewer bends thus reducing pressure loss and cost.

[0021] In an aspect of the invention, the plurality of heat exchanging tubes are arranged to extend transversely in relation to a longitudinal direction of the shell.

[0022] Arranging the plurality of heat exchanging tubes such that they extend transversely in relation to a longitudinal direction of the shell is advantageous in that the heat exchanging tubes are arranged such that the surrounding fluid flows in a cross-flow in relation to the heat exchanging tubes which enhances the heat transfer and thereby the capacity and the efficiency of the shell heat exchanger.

[0023] In an aspect of the invention, the plate heat exchanging section comprises a first flow channel through the shell, wherein the tube heat exchanging section comprises a second flow channel through the shell. Furthermore, the first flow channel is separate from the second flow channel.

[0024] Arranging plate stack and tubes with separate flow channels is advantageous in that a first fluid may flow through the first flow channel and a second fluid may flow through the second flow channel without intermixing with each other and/or the fluid flowing around the heat exchanging tubes and the heat transfer plates. Furthermore, the first fluid may be led to an installation and used for one purpose and the second fluid may be led to another installation and used for another purpose. This is advantageous in that a shell heat exchanger with a plurality of heat exchanging functions and high adaptability to different operating requirements is obtained.

[0025] In an aspect of the invention, the tube heat exchanging section comprises a support structure arranged to mutually fixate the plurality of heat exchanging tubes, wherein the support structure is arranged to be a flow director in relation to the plate heat exchanging section.

[0026] Providing the tube heat exchanging section with a support structure which is arranged to fixate the tubes is advantageous in that the tubes are fixated such that e.g. flow-induced vibrations of the heat exchanging tubes arising from the flow inside the tubes are reduced. Furthermore, arranging the support structure as a flow director allows obstructing the fluid flow such that multiple passes through the plate heat exchanging section inside the shell can be achieved whereby the fluid flowing around the tube heat exchanging section and plate heat exchanging section flows substantially concurrent in some parts of the heat exchanger and substantially crossflow in other parts of the heat exchanger whereby the heat transfer and thereby the capacity and efficiency of the heat exchanger is enhanced. And forming the support structure as a flow director is advantageous in that it saves space and material and simplifies manufacturing.

[0027] Furthermore, the support structure may induce adequate turbulence in the fluid flowing around the tubes and plates such that the heat transfer and thereby the capacity and efficiency of the heat exchanger is enhanced.

[0028] In an aspect of the invention, the shell heat exchanger further comprises a separator arranged inside the shell to at least partially separate a medium flowing through the shell heat exchanger.

[0029] Placing a separator inside the shell is advantageous in that the separator thereby does not have to be arranged in its own shell and in that piping and costs are reduced. Also, arranging a separator inside the shell is advantageous in that impurities which affect the heat transfer rate and/or functionality of the shell heat exchanger are separated from the flow. Hereby the efficiency of shell heat exchanger is enhanced.

[0030] In an aspect of the invention, the separator is a liquid separator

[0031] Providing the shell heat exchanger with a liquid separator is advantageous in that liquids, which may not effectively contribute to the transfer of heat, is separated from the fluid flow whereby the heat transfer and efficiency of the shell heat exchanger is enhanced. The separated liquid, which could be oil originating from a lubrication system of for example a compressor, may be redirected back to the lubrication system such a substantially fixed amount of oil is circulated in the system. This is advantageous in that refilling of oil in the lubrication circuit and oil leak to the surroundings is minimized.

[0032] Furthermore, it is advantageous to separate liquids from the fluid flow in order to avoid damage in the compressor due to the incompressibility of the liquids which may therefore damage the blades, impellers, pistons, screws or other parts of the compressor.

[0033] In this context, the term "liquid" should be understood as oil, water, refrigerant or any other fluid in liquid state which may be separated from the fluid flow inside the plate and shell heat exchanger.

[0034] In an aspect of the invention, the centre of the plate heat exchanging section and/or the centre of the tube heat exchanging section are offset to the centre of the shell.

[0035] Providing the centre of the plate heat exchanging section and/or the centre of the tube heat exchanging section offset to the centre of the shell is advantageous in that the plate heat exchanging section or tube heat exchanging section may be arranged at different positions inside the shell heat exchanger for utilizing the entire space efficiently such that the heat transfer and thereby the capacity and the efficiency of the shell heat exchanger is enhanced.

[0036] In this context, the term "centre" should be understood as the centroid of the area of the cross-sectional shape. For example, the centre of a plate heat exchanging section of circular cross-section should be understood as the point in the circular area at which the distance to the boundary of the circular area is constant. However, determining the centre for a cross-section of complex geometry may not be straight-forward. Thus, the term "centre" should be understood as the centroid of an area which may be determined from the first moment of area. Accordingly, if the mass in the area is not evenly distributed, the centre of gravity/mass is not coincident with the centroid.

[0037] In an aspect of the invention, the cross-sectional shape of the stack of corrugated heat transfer plates is arranged to follow a part of the inside circumference of the shell.

[0038] Arranged the cross-sectional shape of the stack of corrugated heat transfer plates such that they follow a part of the inside circumference of the shell - e.g. by shaping the plates substantially concentric with a part of the shell - is advantageous in that the space inside the shell thereby is utilized more efficiently such that heat transfer is enhanced.

[0039] In an aspect of the invention, the shell heat exchanger is arranged to operate at an inside pressure different from the outside pressure of the shell.

[0040] This is advantageous in that this facilitates evaporation or condensing of fluids which do not evaporate or condense at the outside pressure. Hereby a vapor-compression cycle, vapor absorption cycle, gas cycle or other thermodynamic cycle may be sustained.

[0041] Furthermore, the invention provides for use of a shell heat exchanger according to the above-mentioned shell heat exchangers is provided for exchanging heat between at least two mediums wherein the pressure of at least one of the mediums is different from the pressure surrounding the shell heat exchanger.

[0042] Using a shell heat exchanger according to the present invention in relation to a pressurised fluid or a fluid at a negative pressure is advantageous in that the shell of the present invention is particularly suited for handling a pressure difference.

Figures

[0043] The invention will be described in the following with reference to the figures in which

- fig. 1. illustrates a cross sectional view of the shell heat exchanger configured as a condenser, as seen from the front,
- fig. 2 illustrates a cross sectional view of the shell heat exchanger configured as a condenser with heat exchanging tubes above and below the plate stack, as seen from the front,
- fig. 3 illustrates a cross sectional view of the shell heat exchanger configured as an evaporator, as seen from the front,
- fig. 4 illustrates a cross sectional view of the shell heat exchanger configured as an evaporator without heat exchanging tubes at the top portion, as seen from the front,
- fig. 5 illustrates a cross sectional view of the shell heat exchanger configured as an evaporator and with heat exchanging tubes arranged above the separator, as seen from the front, and
- fig. 6 illustrates a shell heat exchanger as seen from the side.

Detailed description

[0044] Fig. 1-2 illustrates embodiments of the shell heat exchanger configured as a condenser.

[0045] A condenser is typically a part of a refrigeration cycle which transfers energy from a first fluid, e.g. a refrigerant, to a second fluid of lower temperature, e.g. water for the purpose of providing hot water to e.g. an industrial or domestic installation. Due to the temperature difference between the water and the refrigerant, heat will transfer from the refrigerant to the water in accordance with the second law of thermodynamics. In this example, the temperature of the water rises as a result of the heat transfer from the refrigerant to the water and consequently the temperature of the refrigerant will be lowered and/or it may condense, hence the term "condenser".

[0046] Thus, in this embodiment, the shell heat exchanger 1 is configured as a condenser, wherein the water to be heated may be fed through the plate heat exchanging section inlet 18 and/or one or more of the plurality of the heat exchanging tubes 5 in the tube heat exchanging section 4. A refrigerant is fed through the shell inlet 13 which is of higher temperature than the water. Due to the heat transfer mechanism as mentioned above, the water, now hotter or in a different state, flows out of the shell heat exchanger 1 through the plate heat exchanging section outlet 19 and the refrigerant, now colder or in a different state, flows out through the shell outlet 14. The refrigerant may also be further subcooled by the tubes 5 in the tube heat exchanging section 4 before it flows out through the shell outlet 14.

[0047] In this embodiment, the shell heat exchanger 1 is configured as a condenser in connection with a refrigeration cycle. However, it should be emphasized, that in another embodiment the shell heat exchanger 1 may also be configured to operate in connection with other industrial applications such as air conditioning, chemical plants, power stations, heat pumps or other industrial areas.

[0048] In this embodiment, water is fed through the plate heat exchanging section 2 and the tube heat exchanging section 4. However, in another embodiment, different fluid mediums such as marmalade, milk, brine, a refrigerant, steam or any other kind of fluid may be fed through the flow channel 7 in the plate heat exchanging section 2 and/or flow channel 8 of the tube heat exchanging section 4 and/or the shell inlet 13 and outlet 14.

[0049] Furthermore, in other embodiments, different mediums may be fed through each tube heat exchanging section 4 and plate heat exchanging section 5 and each medium may be of different temperature and/or pressure. For example, a first medium of a first temperature and first pressure may flow through a tube heat exchanging section 4 which is arranged at the top of the shell heat exchanger 1 (for example as illustrated in fig. 2) and a second medium of a second temperature and second pressure may flow through the tube heat exchanging section 4 arranged at a bottom part of the shell heat exchanger 1. A third medium of a third temperature and third pressure may flow through the plate heat exchanging section 2. The fluid mediums may flow to different installations depending on the requirements and set up of the shell heat exchanger.

[0050] The pressure inside the shell heat exchanger 1 is typically larger than the surrounding pressure outside of the shell heat exchanger 1 - such as 5 Bar, 20 Bar or 60 Bar higher than the surrounding pressure (or even higher). However, the shell heat exchanger 1 may also be configured for operating with mediums of pressures lower than the pressure of the surroundings - such as 0.1 Bar, 0.5 Bar or 0.9 Bar lower than the surrounding pressure (or even lower). The pressure of the mediums may also differ from each other. For example, the pressure of the medium flowing through the plurality of tubes 5 in the tube heat exchanging area 4 may be different from the pressure of the medium flowing through the flow channel 7 in the plate heat exchanging section and the pressure of the surroundings may be lower, higher or in the middle of the pressure of the mediums. Due to the pressure difference between the surroundings and the inside of the shell heat exchanger the wall thickness of the shell 6 is particularly designed for withstanding large pressure differences without functional failures such as leak of for example refrigerant, explosion in the case of pressurization as compared to the surroundings or buckling of the shell 6 in the case of negative pressure as compared to the surroundings. The sufficient strength of the shell 6 is achieved by designing the shell 6 as a solid wall with a large material thickness such that the vessel may be certified for use of pressurized or negatively pressurized mediums as compared to the surroundings.

[0051] The filler elements 15 illustrated in fig. 2 could be a liquid separator, filter, mesh, demister, strainer or other filler elements which may be present inside the shell 6 of the shell heat exchanger 1 and which may be necessary for the operation of the shell heat exchanger or may contribute with additional functions. Or the filler elements 15 could be passive elements primarily designed to fill out a space inside the shell.

[0052] In this embodiment, the plurality of heat exchanging tubes 5 in the tube heat exchanging section 4 are fully enclosed within a tube heat exchanging section shell 20. However, in another embodiment, the tubes 5 in the tube heat exchanging section 4 may be partially enclosed within the tube heat exchanging section shell 20 (see for example fig. 3). In this embodiment, a part of the tube heat exchanging shell 20 is also a part of the shell 6. However, in another embodiment, the tube heat exchanging shell 20 is not a part of the shell 6 and may enclose the tube heat exchanging section as e.g. a circular, rectangular, triangular shaped shell or other shape.

[0053] In an embodiment with a fully enclosing tube heat exchanging section shell 20, a refrigerant may flow around the tubes 5 in the one or more tube heat exchanging sections 4 which is different from the refrigerant which flows around the heat transfer plates 3 of the plate heat exchanging section 2.

[0054] In this embodiment, the tube heat exchanging section comprises heat exchanging tubes 5 with smooth outer surface, but in another embodiment, the heat exchanging tubes 5 in the tube heat exchanging section 4 may comprise fins, extended surfaces, a corrugated surface or other modifications of the surface for increasing the surface area and/or improving heat transfer. Furthermore, in this embodiment, the outer and inner cross-sectional shape of the heat exchanging tubes 5 are both circular. However, in another embodiment, the outer and/or inner cross-sectional shape of the tube 5 may be polygonal, triangular, elliptic or another shape. The inner and outer cross-sectional shape could also differ from each other. For example, the inner cross-sectional shape could be circular and the outer cross-sectional shape could be wavy.

[0055] In the embodiment of fig. 1, the heat exchanging tubes 5 in the heat exchanging section 4 are arranged inside the shell as one-pass tubes (also known as straight-tube), wherein the heat exchanging tubes 5 extend along the entire length of the shell 6 of the shell heat exchanger 1. However, in another embodiment, the heat exchanging tubes 5 in the heat exchanging section 4 are bent in the shape of an "U" (u-tube configuration as shown in fig. 6), multi-pass configuration or other configuration inside the shell 6 of the shell heat exchanger 1 for improvement of the heat transfer.

[0056] In the embodiment of fig. 2, the tube heat exchanging section 4 is arranged at the substantially top part of the shell 6 of the shell heat exchanger 1 and the substantially bottom part inside the shell 6. However, in another embodiment, the tube heat exchanging section 4 could be arranged in any part inside the shell 6 of the shell heat exchanger 1 but separate from the plate heat exchanging section 2.

[0057] In another embodiment, the heat exchanging tubes 5 in the tube heat exchanging sections 4 are not connected and may be arranged to extend along the length of the shell 6 of the shell heat exchanger 1. In an embodiment where several tube heat exchanging sections 4 are present, which may not be connected, a different fluid may be fed through each of the tube heat exchanging sections 4 as well as the plate heat exchanging section 2. For example, a first fluid may be fed through the plate heat exchanging section 2 via plate heat exchanging inlet 18 and outlet 19, a second fluid through the tube heat exchanging section 4 at the top part of the shell heat exchanger and a third fluid through the tube heat exchanging section 4 at the bottom part of the shell heat exchanger. The heated fluids could be fed to different installations depending on the requirements. Said fluids may be water, marmalade, milk, brine or any other kind of fluid.

[0058] In this embodiment, the cross-sectional shape of the heat transfer sheets 3 is substantially circular. However, in another embodiment, the heat transfer plates may be of elliptic, oval, polygonal, circle segment/sector, quadrant, semicircular or any combination thereof.

[0059] Fig. 3-5 illustrate embodiments of the shell heat exchanger configured as an evaporator.

[0060] An evaporator is typically a part of a refrigeration cycle which transfers energy from a first fluid, e.g. water, to a second fluid, e.g. a refrigerant, for the purpose of providing cold water to or lowering the temperature of e.g. an industrial or domestic installation. Due to the temperature difference between the water and the refrigerant, heat will transfer from the water to the refrigerant in accordance with the second law of thermodynamics. In this example, the temperature of the water will fall as a result of the heat transfer from the water to the refrigerant and consequently the temperature of the refrigerant rise and/or it may evaporate, hence the term "evaporator".

[0061] Thus, in this embodiment, the shell heat exchanger 1 is configured as an evaporator, wherein the water to be cooled may be fed through the plate heat exchanging section inlet 18 and/or one or more of the plurality of heat exchanging tubes 5 in the tube heat exchanging section 4. A refrigerant, which may be of lower temperature than the water, is fed through the shell inlet 13 in the direction indicated by the arrows. Due to the heat transfer mechanism as mentioned above, the water, now colder or in a different state (ice slurry may be produced due to the chilling of water), flows out of the shell heat exchanger 1 through the plate heat exchanging section outlet 19 and the refrigerant, now hotter or in a different state, flows towards the separator 10, which at least partially separates a medium flowing through the shell heat exchanger 1, in the direction indicated by the arrows. After the refrigerant flows through the separator 10, it may flow out through the shell outlet 14 and circulate in the refrigeration cycle.

[0062] In this embodiment, the shell heat exchanger 1 is configured as an evaporator in connection with a refrigeration cycle. However, it should be emphasized, that in another embodiment the shell heat exchanger 1 may also be configured to operate in connection with other industrial or domestic applications such as air conditioning, chemical plants, power stations, heat pumps or other industrial areas. Furthermore, in this embodiment, water is fed through the plate heat exchanging section 2 and the tube heat exchanging section 4. However, in another embodiment, different fluid mediums such as marmalade, milk, brine, a refrigerant, steam or any other kind of fluid. may be fed through the flow channel 7 in the plate heat exchanging section 2 and/or flow channel 8 of the tube heat exchanging section 4 and/or the shell inlet 13 and outlet 14.

[0063] In this embodiment, the cross-section of the shell 6 of the shell heat exchanger 1 is of a circular shape. However, in another embodiment, the cross-section of the shell 6 could be of an oval shape, an elliptic shape, a polygonal shape, complex shape or any other shape.

[0064] In this embodiment, the separator 10 is a liquid separator 11 for separating oil, water, refrigerant or other liquids from the fluid flow, wherein the liquid could be in droplet form. However, in another embodiment, the separator 10 could be a filter, demister, strainer, mesh or any other kind of separator for at least partially separating the fluid flow.

[0065] Fig. 6 illustrates the shell heat exchanger 1 as seen from the side.

[0066] A fluid may be introduced through the shell inlet 13 which flows around the heat transfer plates 4 in the pate heat exchanging section 2 and the heat exchanging tubes 5 in the tube heat exchanging section 4 without intermixing with the mediums flowing therein. Heat may be transferred across the heat transfer plates 3 and the walls of the heat exchanging tubes 5. The support structure 9, which in this case also serves as a flow director inside the shell 6, obstructs the fluid such that a two-pass configuration is obtained as illustrated by the stippled line. Eventually, the fluid flows through the shell outlet 14 in either a different state and/or higher/lower temperature depending on the configuration of the shell heat exchanger 1 and the state or temperature of the other fluids.

[0067] In this embodiment, the tube heat exchanging section inlet 21 and tube heat exchanging section outlet 22 are connected to a manifold 23 wherein the connections are at the end covers of the shell 6 of the shell heat exchanger 1. However, in another embodiment, the connections to the manifold 23 may be arranged inside the shell 6 of the shell heat exchanger 1.

[0068] In this embodiment, the same medium flows through the heat exchanging pipes 5 in the tube heat exchanging section 4. However, in another embodiment, a plurality of tube heat exchanging sections 4 may be provided in the shell heat exchanger. Accordingly, different mediums may flow in the tubes of the tube heat exchanging sections 4 which may accordingly have individual inlets 21 and outlets 22 in the shell 6 of the shell heat exchanger 1.

[0069] In this embodiment, a single support structure 9 is arranged as a flow director such that a two-pass configuration is achieved in the shell heat exchanger 1. The support structure 9 fixates the tubes 5 to the shell 6 and may simultaneously guide the surrounding flow such that a two-pass configuration is achieved. However, in another embodiment, a plurality of support structures 9 may be arranged to direct the flow such that a multi-pass configuration is achieved in the shell heat exchanger 1. The support structure 9 may be positioned at the top part in the shell 6 of the shell heat exchanger 1 as well as at the bottom part in the shell 6 of the shell heat exchanger 1.

[0070] The support structure 9 of this embodiment is welded to the shell 6. However, in another embodiment it could be fixated to the shell 6 by bolts, screws, rivets or other fixation means or fixators. Furthermore, the support structure may be arranged as a trisection helical baffle, a quadrant helical baffle, sextant helical baffle or other type of support structure which extends along the entire length or part of the length of the shell heat exchanger 1 and which is also arranged as a flow director. Or in another embodiment the support structure 9 is only arranged to mutually fixate the tubes 5 and/or the support structure 9 is not connected to the shell 6.

[0071] The tubes 5 in the tube heat exchanging section 4 of this embodiment are arranged as a "u-bent". However, in another embodiment, the tubes 5 may be bent several times depending on the operational requirements. Furthermore, the tubes 5 in the tube heat exchanging section 4 of this embodiment are arranged such that the tubes are not joined together whereby the medium flowing through the tubes 5 is not mixed at any point during its path through the tubes 5. However, in another embodiment, some or all of the tubes 5 in a tube heat exchanging section may be joined to form a single heat exchanging tube 5 which assemble together at e.g. the middle of the shell heat exchanger in relation to its longitudinal direction for accommodating to e.g. a filler element of a complex geometry. After passing the filler element, the joined tubes 5 may again divide into individual heat exchanging tubes 5.

[0072] In this embodiment, the stack of heat transfer sheets 3 is arranged to extend substantially the entire length of the tubular shell 6 of the shell heat exchanger 1. However, in another embodiment, the stack of heat transfer plates 3 could be arranged to extend 1/4, 1/3, 2/3 or any other fraction of the length of the tubular shell 6 depending on operational requirements.

[0073] In this embodiment, the tube heat exchanging section 4 is arranged to extend substantially the entire length of the tubular shell 6 of the shell heat exchanger 1. However, in another embodiment, tube heat exchanging section could be arranged to extend 1/4, 1/3, 2/3 or any other fraction of the length of the tubular shell 6 depending on operational requirements. In another embodiment, the tubes could also be arranged to extend transversely in relation to the longitudinal direction of the shell.

[0074] In this embodiment, the heat exchanging pipes 5 of the tube heat exchanging section 4 are arranged to substantially run in parallel. However, in another embodiment, the tubes 5 could be arranged to twist around each other, cross each other, or converge towards each other.

[0075] In the embodiment of fig. 6, the heat exchanging tubes 5 in the tube heat exchanging section 4 are arranged in a "u-tube" arrangement, i.e. the heat exchanging tubes 5 in the upper part of the u-bent are connected to the lower part of the u-bent as a consequence of the u-bent itself. However, in another embodiment, the connection could be established from a hose, pipe, duct or other means for connecting the tubes 5.

[0076] The invention has been exemplified above with reference to specific examples of heat exchanging tubes 5, separators 10, support structure 9, heat transfer plates 3 and other. However, it should be understood that the invention is not limited to the particular examples described above but may be designed and altered in a multitude of varieties within the scope of the invention as specified in the claims.

List

[0077]

1. Shell heat exchanger
2. Plate heat exchanging section
3. Heat transfer plate
4. Tube heat exchanging section
5. Heat exchanging tube
6. Heat exchanger shell
7. First flow channel
8. Second flow channel
9. Support structure
10. Separator
11. Liquid separator
13. Shell inlet
14. Shell outlet

15. Filler elements
18. Plate heat exchanging section inlet
19. Plate heat exchanging section outlet
20. Tube heat exchanging section shell
21. Tube heat exchanging section inlet
22. Tube heat exchanging section outlet
23. Manifold

Claims

1. A shell heat exchanger (1) comprising
a plate heat exchanging section (2) comprising a stack of corrugated heat transfer plates (3), and
a tube heat exchanging section (4) comprising a plurality of heat exchanging tubes (5),
wherein said plate heat exchanging section (2) and said tube heat exchanging section (4) are arranged separate from each other and wherein said plate heat exchanging section (2) and said tube heat exchanging (4) are enclosed inside the same common heat exchanger shell (6).

2. A shell heat exchanger (1) according to claim 1, wherein said shell (6) has a tubular shape and wherein said tubular shell is closed at both ends.

3. A shell heat exchanger according to claim 2, wherein said stack of corrugated heat transfer plates (3) is arranged to extend substantially the entire length of said tubular shell.

4. A shell heat exchanger (1) according to claim 2 or 3, wherein said tube heat exchanging section (4) is arranged to extend substantially the entire length of said tubular shell.

5. A shell heat exchanger (1) according to any of the preceding claims, wherein said plurality of heat exchanging tubes (5) are substantially running in parallel.

6. A shell heat exchanger (1) according to any of the preceding claims, wherein said plurality of heat exchanging tubes (5) are arranged to extend in a longitudinal direction of said shell (6).

7. A shell heat exchanger (1) according to any of the preceding claims, wherein said plurality of heat exchanging tubes (5) are arranged to extend transversely in relation to a longitudinal direction of said shell (6).

8. A shell heat exchanger (1) according to any of the preceding claims, wherein said plate heat exchanging section (2) comprises a first flow channel (7) through said shell (6), wherein said tube heat exchanging section (4) comprises a second flow channel (8) through said shell (6), and wherein said first flow channel (7) is separate from said second flow channel (8).

9. A shell heat exchanger (1) according to claim 8, wherein said tube heat exchanging section (4) comprises a support structure (9) arranged to mutually fixate said plurality of heat exchanging tubes (5), wherein said support structure (9) is arranged to be a flow director in relation to said plate heat exchanging section (2).

10. A shell heat exchanger (1) according to any of the preceding claims, wherein said shell heat exchanger (1) further comprises a separator (10) arranged inside said shell (6) to at least partially separate a medium flowing through said shell heat exchanger (1).

11. A shell heat exchanger (1) according to claim 10, wherein said separator (10) is a liquid separator (11).

12. A shell heat exchanger (1) according to any of the preceding claims, wherein the centre of said plate heat exchanging section (2) and/or the centre of said tube heat exchanging section (4) are offset to the centre of said shell (6).

13. A shell heat exchanger (1) according to any of the preceding claims, wherein the cross-sectional shape of said stack of corrugated heat transfer plates (3) is arranged to follow a part of the inside circumference of said shell (6).

14. A shell heat exchanger (1) according to any of the preceding claims, wherein said shell heat exchanger (1) is arranged to operate at an inside pressure different from the outside pressure of said shell.

15. Use of a shell heat exchanger (1) according to any of the preceding claims for exchanging heat between at least two mediums wherein the pressure of at least one of said mediums is different from the pressure surrounding said shell heat exchanger (1).

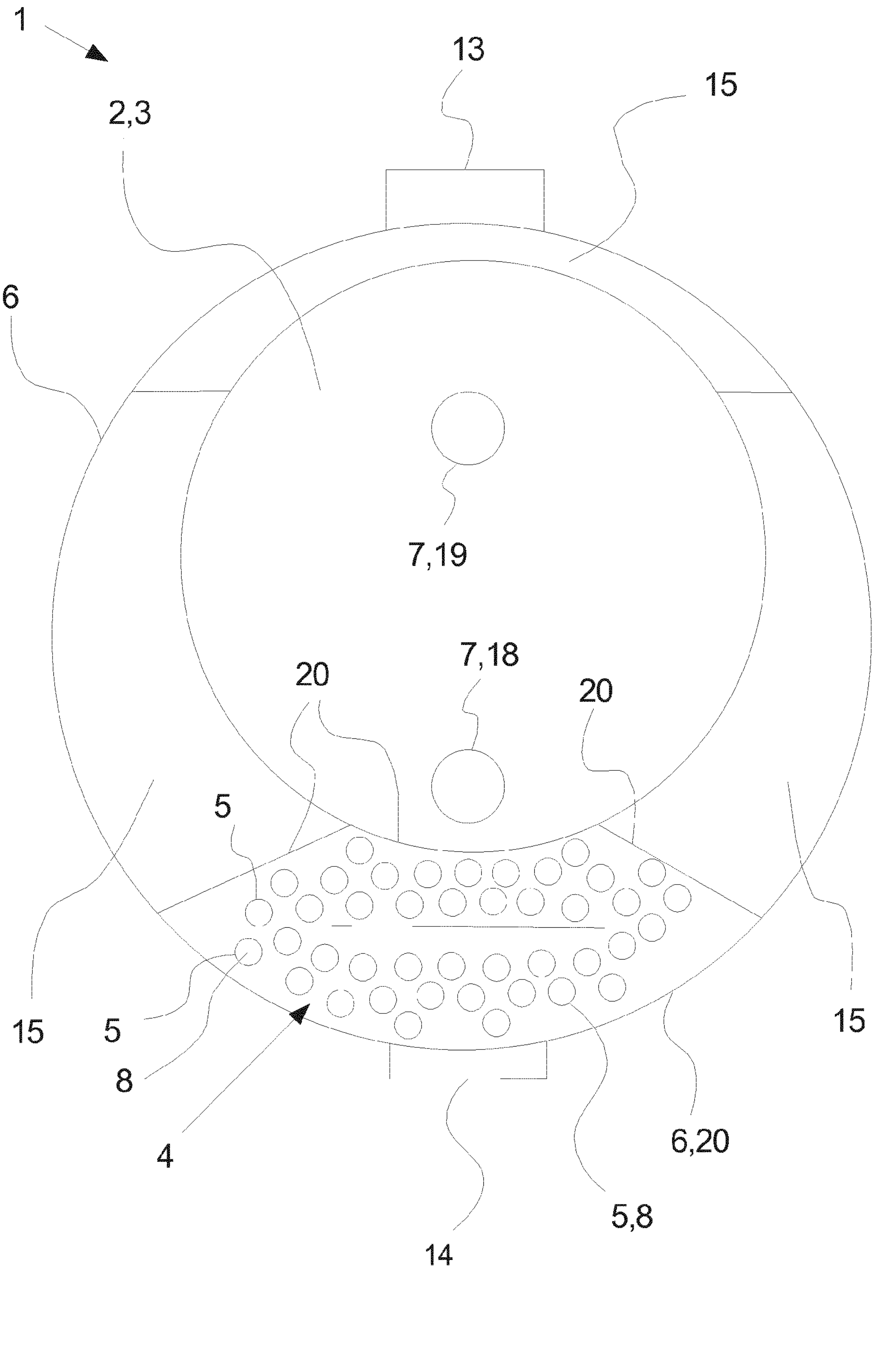

Fig. 1

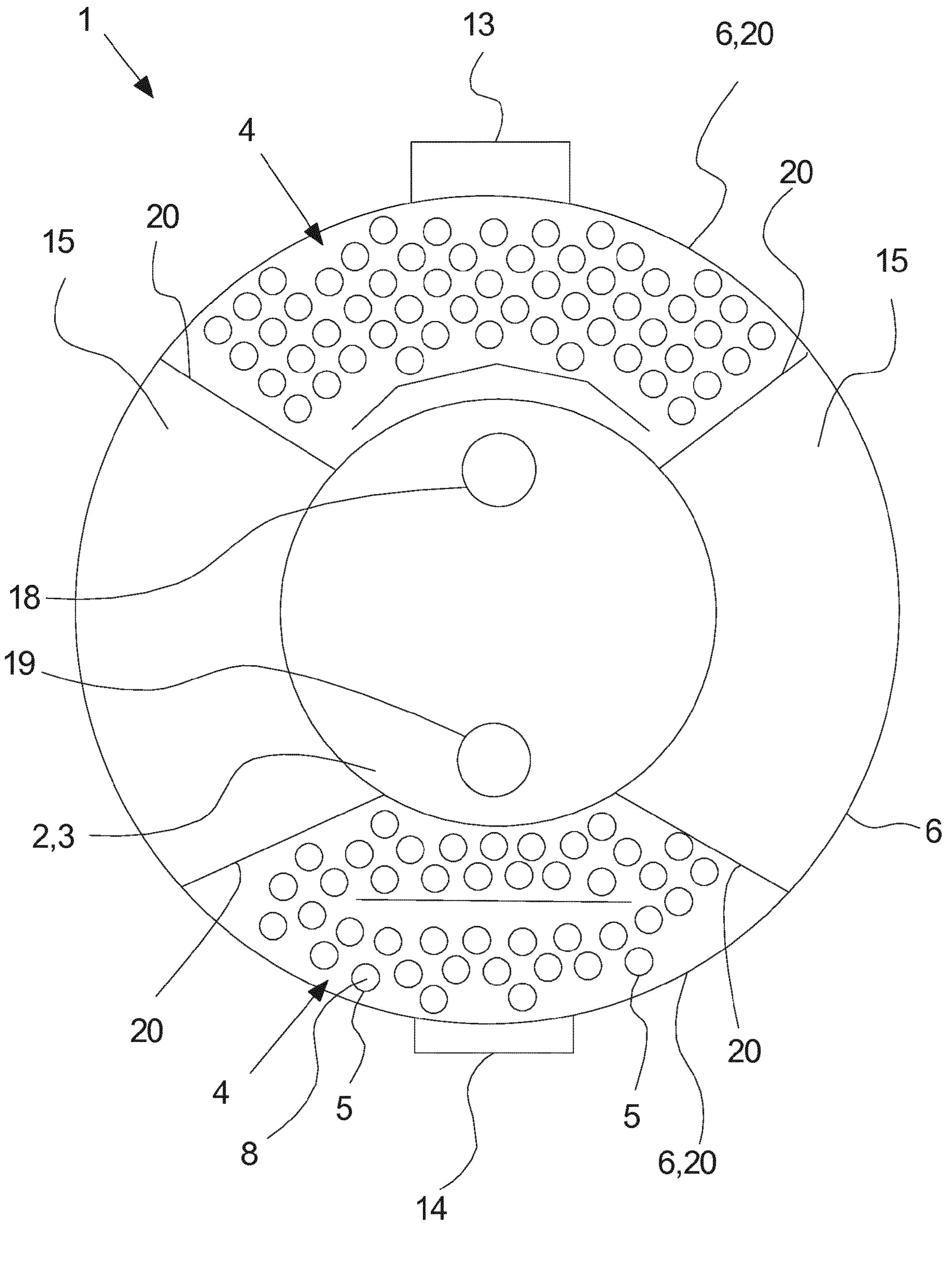

Fig. 2

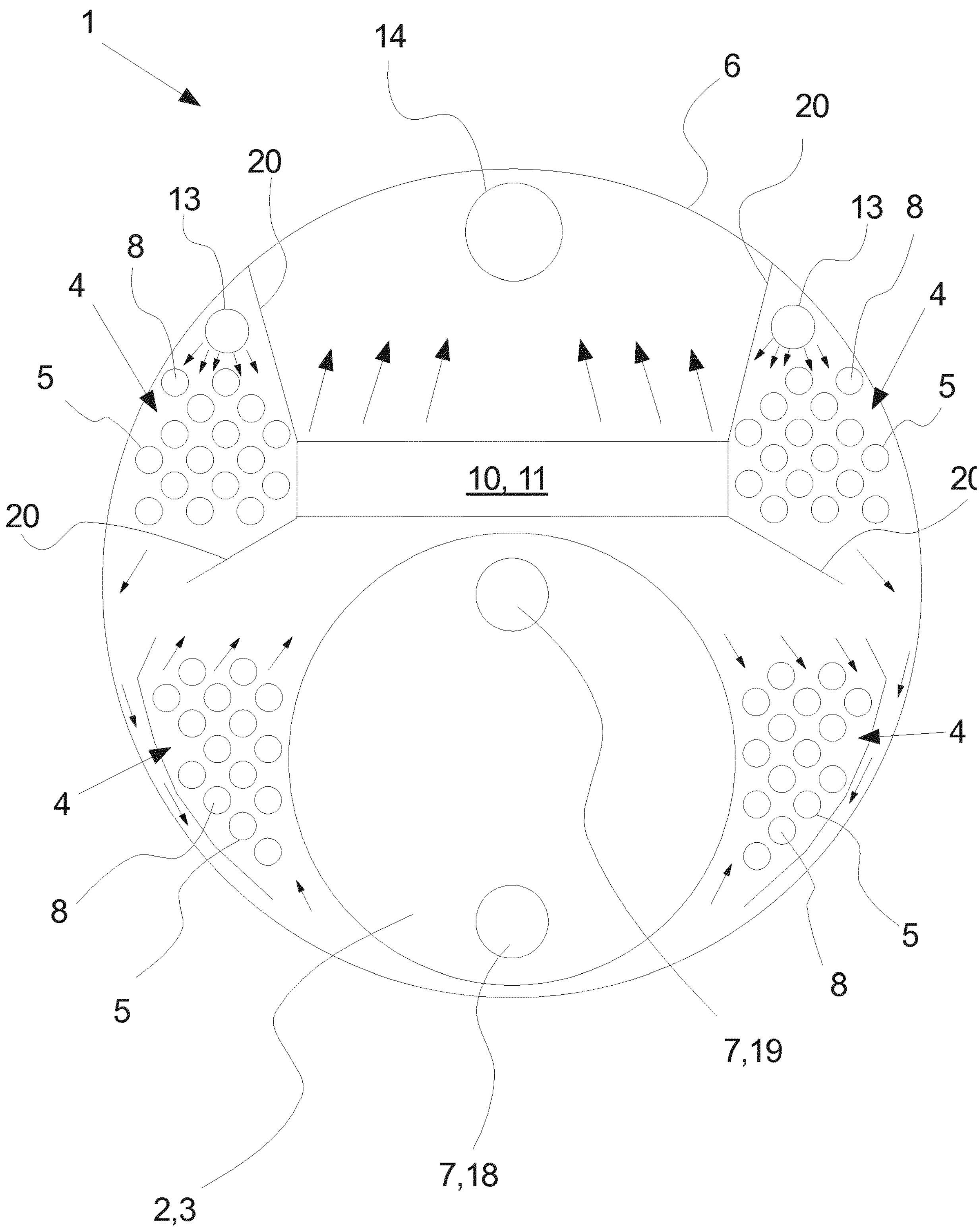

Fig. 3

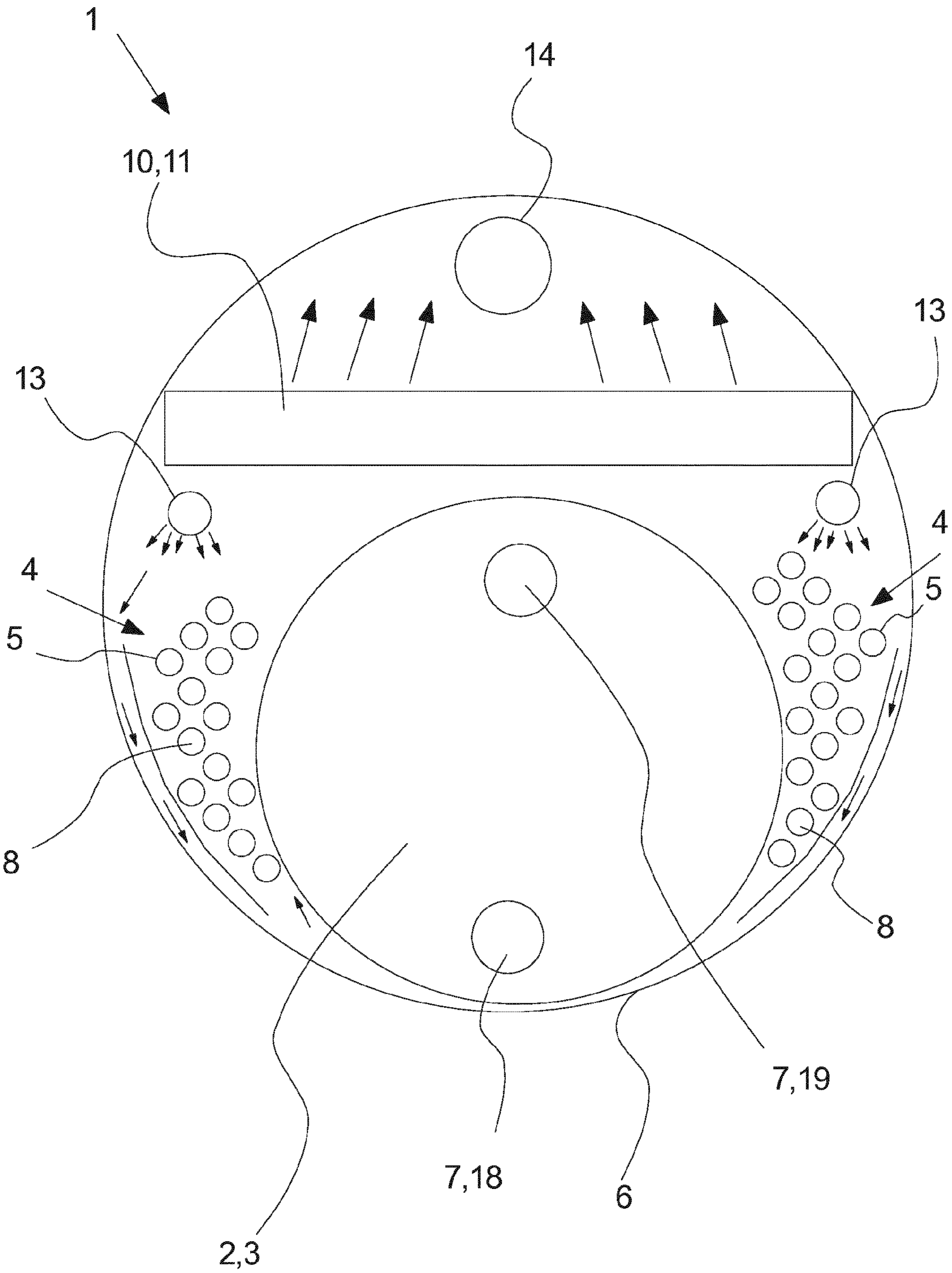

Fig. 4

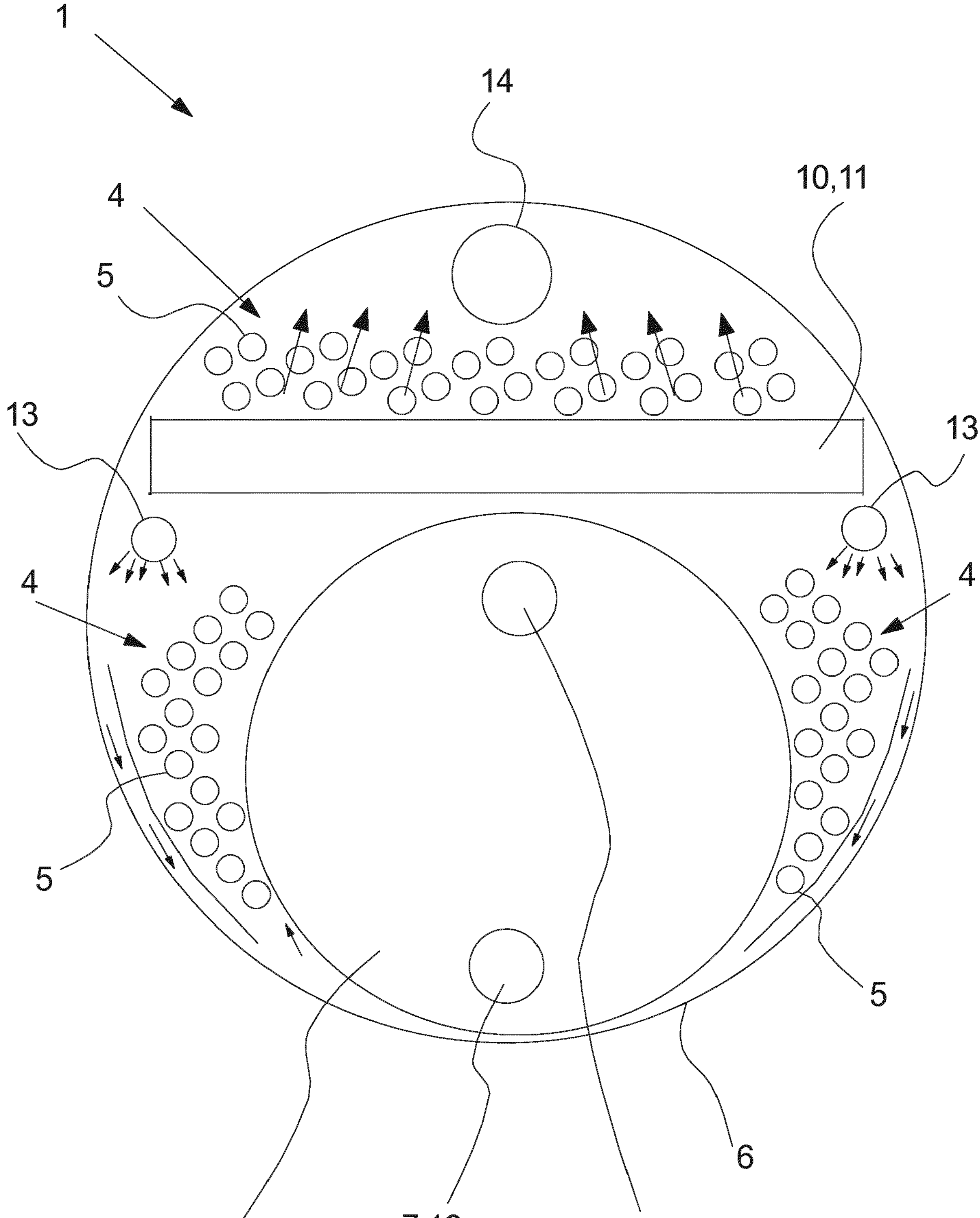

Fig. 5

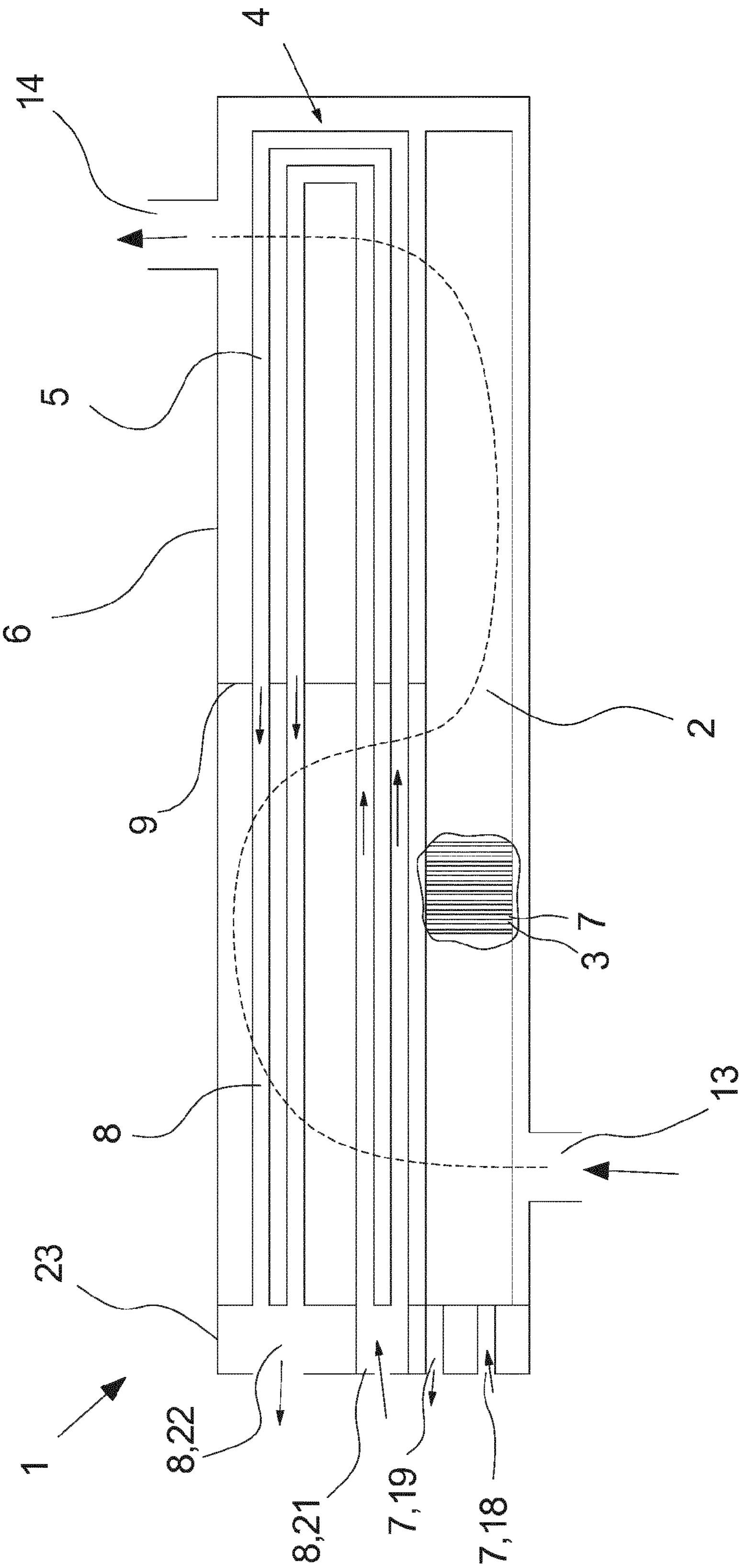

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 4873

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	16 April 2019	Jessen, Flemming

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