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

(11) EP 2 156 128 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
04.04.2012 Bulletin 2012/14

(21) Application number: **08760085.4**

(22) Date of filing: **27.05.2008**

(51) Int Cl.:
F28D 7/16 *(2006.01)* ***F28F 9/22*** *(2006.01)*
F28F 9/26 *(2006.01)*

(86) International application number:
PCT/EP2008/056487

(87) International publication number:
WO 2008/145652 (04.12.2008 Gazette 2008/49)

(54) **HEAT EXCHANGER SHELL ASSEMBLY AND METHOD OF ASSEMBLING**

WÄRMETAUSCHERGEHÄUSEANORDNUNG UND MONTAGEVERFAHREN

ENSEMBLE DE COQUILLE D'ÉCHANGEUR DE CHALEUR ET SON PROCÉDÉ D'ASSEMBLAGE

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR

(30) Priority: **31.05.2007 EP 07109296**

(43) Date of publication of application:
24.02.2010 Bulletin 2010/08

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Description

Field of the Invention

[0001] The present invention relates to a heat exchanger shell assembly and a method of assembling a heat exchanger shell structure.

Background of the Invention

[0002] A shell-and-tube heat exchanger is an indirect heat exchanger. Heat is transferred between a fluid passing through the tubes of a tube bundle (the tube side) extending in a heat exchanger shell, and a fluid passing through the space outside the tubes (the shell side). Details of shell-and-tube heat exchangers can for example be found in Perry's Chemical Engineers' Handbook, 7th edition, 1997, McGraw-Hill Inc., page 11-33 to 11-46.

[0003] Shell-and-tube heat exchangers can be distinguished according to the number of passes for fluid in the shell side and in the tube side. In each pass, the respective fluid flows substantially along the entire length of the heat exchanger, which is typically horizontally elongated. In multiple shell passes, the fluid flow meanders a plurality of times back and forth the length of the shell.

[0004] The heat exchanger shell has inlet and outlet nozzles for the shell-side fluid. For a single shell-side pass heat exchanger, an inlet nozzle is typically arranged at one end of the shell, in particular on top of the shell, and an outlet nozzle is arranged at the opposite end, in particular at the bottom. The same is true for an uneven number of passes. In case of two shell-passes (or in fact an even number), the inlet and outlet nozzles are suitably arranged at the same end.

[0005] When retrofitting a heat exchanger such as for modified use or improved performance, it can be desired to adapt the number of passes. For example, if a tube bundle with transverse supports comprising expanded metal baffles is to be installed, a higher number of shell-side passes can be preferred for optimum performance. Expanded metal is produced from sheet metal that is slit and expanded. Expanded-metal baffles are for example known from International patent applications with publication Nos. WO 2003/067170, W02005/015107 and W02005/061982, incorporated herein by reference, and turn out to have significant advantages in practice, such as less fouling tendency, lower pressure drop, and improved heat transfer due to turbulence created in the shell fluid. In expanded metal baffles spanning the cross-section of the available shell pass, the flow of shell fluid is longitudinal. In a conventional heat exchanger using segmental baffles, the flow meanders even with one shell side pass along the main flow path in the shell, so that the effective length of the shell-side flow is longer than the longitudinal extension of the shell. When expanded metal baffles are used, it is preferred to use a higher number shell-side passes to optimise the shell flow path length, and this can particularly be done in view of the low pressure drop caused by the expanded metal baffles.

[0006] A problem is encountered when the number of shell-side passes is to change between even and uneven, since then one of the nozzles is unsuitably located. In principle, it can be envisaged to arrange an internal flow path for shell-side fluid from one end of the shell to the other. It is an object of the invention to provide a heat exchanger shell arrangement that allows to modify the number of shell-side passes.

Summary of the Invention

[0007] To this end the present invention provides a heat exchanger shell arrangement comprising an outer shell having a nozzle at its lower side; an inner shell member within the outer shell and forming an intermediate space with the outer shell, the inner shell member having an opening at its lower side;
wherein the arrangement further comprises a seal member arranged to fit in the intermediate space, the seal member providing a sealed passageway for fluid between the opening and the nozzle.

[0008] By arranging an inner shell member, it is possible to direct shell side fluid from one shell end to the other, using the intermediate space. The inner shell space, in which the actual heat exchange with a tube bundle is to take place, needs to be sealed against the intermediate space, otherwise shell side fluid could flow along a shortcut route, lowering heat transfer efficiency. A seal member between inner shell member and outer shell is provided for this purpose. Preferably, the seal member is a gravity seal member, wherein sealing force is provided by the gravity force exerted on the seal member by the inner shell member. In particular, the seal member is not connected to at least one of the outer shell and the inner shell member, preferably it is not connected to both the outer shell and the inner shell member. This allows particularly easy installation of the shell arrangement, since the sealing member can be pushed into the intermediate space after the inner shell member is arranged in the outer shell, and sealing is simply accomplished lowering the inner shell so that its weight, suitably together with the weight of the tube bundle, exerts the sealing force for the sealing member. Moreover, by not connecting the inner and outer shells via the seal member, different temperature expansion between the outer shell and inner shell member can be accommodated.

[0009] Heat exchangers as defined in the preamble of claim 1 are known from BE-A-449817, US-A-2006/0289153, DE-A-102005049067 and NL-A-7212921, none of these describe a seal member providing a sealed passageway according to the present invention.

[0010] In a suitable embodiment, the seal member is a plate having upper and lower surfaces that are arranged to conform to the outer shell and inner shell member surrounding the nozzle and the opening, preferably comprising a gasket at the upper and/or lower surface.

[0011] In a particular embodiment, the nozzle forms a first nozzle of the outer shell and the opening forms a first opening of the inner shell member, the outer shell further comprises a second nozzle and the inner shell member comprises a second opening, and the second nozzle and the second opening are arranged to be fluid communication via the intermediate space.

[0012] The invention further provides a method of assembling a heat exchanger, comprising
providing an outer shell having a nozzle at its lower side and an inner shell member having an opening;
sliding the inner shell member into the outer shell to form an intermediate space with the outer shell and to reach a position in which the opening is above the nozzle;
arranging the inner shell member in a lifted position in the outer shell;
sliding a seal member into the intermediate space, the seal member providing a passageway for fluid between the opening and the nozzle; and
lowering the inner shell member so that the gravity force exerted on the seal member acts as sealing force.

[0013] The method is particularly useful for revamping a heat exchanger, wherein the outer shell is maintained and a new tube bundle is arranged within an inner shell member.

Brief description of the Drawings

[0014] The invention will now be described in more detail and with reference to the accompanying drawings, wherein

Figure 1 shows schematically heat exchanger with a heat exchanger shell assembly according to the invention;
Figure 2 shows the heat exchanger of Figure 1 is cross-section along line II-II;
Figure 3 shows schematically a top view of the seal member 25 in Figures 1 and 2.

[0015] where the same reference numerals are used in different Figures, they refer to the same or similar objects.

Detailed Description of the Invention

[0016] Reference is made to Figures 1-3 showing schematically a heat exchanger 1 including a heat exchanger shell assembly or structure 2 according to the invention. The heat exchanger shell assembly 2 comprises an outer shell 4 and an inner shell member 5. The outer shell 4 has an inlet nozzle 8 (second nozzle) at its upper side and an outlet nozzle 9 (first nozzle) at its lower side. The inner shell member 5 extends cylindrically between a tube sheet 12 and floating head 14, thereby forming an intermediate space 16 with the outer shell. The inner shell member has an inlet opening (second opening) 21 in the form of a plurality of holes around its upper side near the end opposite to the inlet nozzle 8, and an outlet opening 23 (first opening) at its lower side at the same end. For handling during installation, the inner shell member 5 is preferably provided with longitudinal sliding bars 24 on which the inner shell member can be slid into the outer shell 4.

[0017] A seal member 25 is placed in the intermediate space 16, the seal member providing a sealed passageway 26 for fluid between the outlet opening 23 and the outlet nozzle 9.

[0018] The seal member 25 is only very schematically shown in Figure 1, and is best seen in Figures 2 and 3. Its basic structure is formed of an arcuated plate 28 conforming to the outer shell and inner shell member. A handle 31 serves for handling the seal member during installation. The inner shell member is provided with a plate 30 that is welded around the outlet 23, to form a contact surface for the seal member.

[0019] For optimum sealing the seal member is provided with top and bottom gasket rings 32,33, suitably arranged in a circular groove seating machined into plate 28 of the seal member. A suitable gasket material is polytetrafluoroethylene (PTFE) for temperature resistance up to 250 degree C. Good results have been obtained with 100% expanded PTFE (e-PTFE), multidirectional orientated fibre structure, type Gore-Tex Series 300. The temperature range of this material is between -240 °C and +250 °C, with allowable peak temperatures up to 315 °C. A PTFE tape of 3 mm thickness was used. For the sealing of the floating head and baffle sealing tape with a thickness 2 mm was used. Before placement of the gasket rings, the seating was cleaned with alcohol and the gasket was glued into the seating.

[0020] Thus, the seal member 25 is arranged to seal by gravity. It can be introduced loosely into the intermediate space 16 while the inner shell is lifted. Sealing force is provided by the gravity force exerted on the seal member by the inner shell member, and sealing is achieved without the seal member being fastened to either one of the shells 4,5. After installation of the seal member, the inner shell member does not rest on the sliding strips 24 in the vicinity of the outlet opening 23.

[0021] The inner shell member houses the tubes 35,36 extending from the tube sheet 12 to floating head 16, and the tubes contribute to the weight pressing on the seal member. The weight can for example be more than 1000 kg such as 5000 kg. A longitudinal baffle 38 with an opening 39 serves to provide a two-pass configuration of the shell side. For mechanically mounting the longitudinal baffle, the inner shell member can be constructed of upper and lower half shells, between which the longitudinal baffle is clamped.

[0022] Turning now to the tube side of the heat exchanger 1, only few tubes 35,36 are shown for the sake of clarity. The tube side of the heat exchanger 31 is indicated with dots. In this embodiment the tube side has a two-tube-pass arrangement. The tube side has an inlet 41 to a tube inlet header 43. The tube inlet header is in

fluid communication with the lower part of the tube bundle, tubes 36 which extend to the tube end sheet 44 connected to the floating head 14 which in turn is in fluid communication with the upper part of the tube bundle, tubes 35 extending into the tube outlet header 47 where the outlet 49 from the tube side is arranged. The inlet and outlet tube heads 43,47 are separated by a horizontal plate 51 extending horizontally along in the centre of the outer shell 4 from the shell end to the tube sheet 12 in which the tubes are fixed. The tube sheet is secured to the shell by flanges (not shown), through which the inlet end of the shell can be opened for inserting or removing the internals. Flanges through which the end part of the shell can be removed are also arranged at the rear end near floating head 14.

[0023] The tube end sheet 44 at the opposite end also fixes the tubes, but unlike the tube sheet 12, the tube end sheet 44 and the floating head 14 to which it is connected, are not connected to the shell 34, i.e. the end header is floating. This allows thermal expansion of the tubes within the shell. Instead of an end header, which receives and distributes all tube fluid, also separate U-tubes could be applied.

[0024] The tubes are supported by a plurality of transverse baffles 65. They can in particular be expanded metal baffles, but rod baffles or other baffles can also be applied. In Figure 2, an expanded metal grid 66 is illustrated supporting the tubes 35 in the upper half. Only few tubes are shown extending and supported by through the windows of the expanded metal structure. Suitably the tubes 36 in the lower half are supported in the same way.

[0025] Normal operation of the assembled heat exchanger 1 will now be discussed. When the heat exchanger is used in a crude preheat train of a crude distilling unit, tube-side fluid can be (cold) crude oil and shell-side fluid can be (hot) long residue from the crude distillation unit. For such an application with considerable fouling risk, expanded metal baffles in the shell side are advantageous because they suppress fouling. Tube-side fluid is passed via inlet 41 and tube inlet header 43 along the tubes 36, and further via the floating head 14 to along the upper part of the tube bundle to outlet header 47 and outlet 49. During that passage, it is heated by exchanging heat with the shell side fluid.

[0026] Hot shell-side fluid is introduced via inlet nozzle 8 into the outer shell, where it flows along the intermediate space towards the inlet 21 of the inner shell member. This inlet is formed of a plurality of holes spread around the upper part of the inner shell member. In this way an optimum distribution of shell fluid around the tubes 35 is achieved. The shell-side fluid flows towards the tube sheet 12, turns via the opening 39 and continues towards the outlet 23. From outlet 23 it passes through the passageway 26 formed by the seal member to the outlet nozzle 9, with a lower temperature than at the inlet nozzle 8.

[0027] The lower half of the intermediate space (annulus) between outer shell 4 and inner shell member 5 is filled with non- or slow flowing shell fluid. This fluid will adopt a temperature somewhere near the tube side inlet temperature. Since the seal member does not interconnect outer shell 4 and inner shell member 5, they can thermally expand differently in response to different temperatures they will have in the course of operation.

[0028] Now a method of assembling the heat exchanger shell structure 2 of Figure 1 will be discussed. First the outer shell is provided, not including the end portions of the tube inlet/outlet header and the floating head, so that suitably both longitudinal ends are open. In the case of a revamp, the outer shell of the original heat exchanger is maintained, and new internals, typically tube bundle and internal shell, are provided. The tube sheets, inlet/outlet headers, floating head may need to be modified or replaced. The inner shell member 5, suitably including the tube bundle, is slid on the sliding bars 24 into the outer shell until the opening 23 is directly above the outlet nozzle 9. Then the inner shell member is lifted sufficiently so that the seal member can be passed into the intermediate space between the outlet opening 23 and the outlet nozzle 3. The inner shell member is lowered, so that the gravity force exerted on the seal member acts as sealing force. Then the heat exchanger can be completed by attaching the end parts with flanges.

[0029] If cleaning of the heat exchanger is required, it can be disassembled in reverse order, cleaned, and assembled again.

Claims

1. A heat exchanger shell assembly (2) comprising
   an outer shell (4) having a nozzle (9) at its lower side;
   an inner shell member (5) within the outer shell (4) and forming an intermediate space (16) with the outer shell (4), the inner shell member (5) having an opening (23) at its lower side;
   wherein the heat exchanger shell assembly further comprises a seal member (25) arranged to fit in the intermediate space (16), **characterized in that** the seal member (25) provides a sealed passageway (26) for fluid between the opening (23) and the nozzle (9).

2. The heat exchanger shell assembly according to claim 1, **characterised in that** the seal member (25) is a gravity seal member, wherein sealing force is provided by the gravity force exerted on the seal member (25) by the inner shell member (5).

3. The heat exchanger shell assembly according to claim 1 or 3, **characterised in that** the seal member (25) is, during normal operation, not connected to at least one of the outer shell (4) and the inner shell member (5), preferably is not connected to both the outer shell (4) and the inner shell member (5).

4. The heat exchanger shell assembly according to any one of claims 1-3, **characterised in that** the seal member (25) is a plate (28) having upper and lower surfaces that are arranged to conform to the outer shell and inner shell member surrounding the nozzle and the opening, preferably comprising a gasket at the upper and/or lower surface.

5. The heat exchanger shell assembly according to any one of claims 1-4, **characterised in that** the nozzle forms a first nozzle (9) and wherein the opening forms a first opening (23), the outer shell (4) further comprising a second nozzle (8) and the inner shell member (5) comprising a second opening (21), and wherein the second nozzle (8) and the second opening (21) are arranged to be in fluid communication via the intermediate space (16).

6. A method of assembling a heat exchanger shell structure, comprising

- providing an outer shell (4) having a nozzle (9) at its lower side and an inner shell member (5) having an opening (23);
- sliding the inner shell member (5) into the outer shell (4), to form an intermediate space (16) with the outer shell (4) and to reach a position in which the opening (23) is above the nozzle (9);
- arranging the inner shell member (5) in a lifted position in the outer shell (4);
- sliding a seal member (25) into the intermediate space (16), the seal member (25) providing a passageway for fluid between the opening (23) and the nozzle (9); and
- lowering the inner shell member (5) so that the gravity force exerted on the seal member (25) acts as sealing force.

Patentansprüche

1. Wärmeaustauscher-Gehäuseanordnung (2) mit einem äußeren Gehäuse (4) mit einer Düse (9) an seiner unteren Seite;
einem inneren Gehäuseelement (5) innerhalb des äußeren Gehäuses (4), welches mit dem äußeren Gehäuse (4) einen Zwischenraum (16) bildet, wobei das innere Gehäuseelement (5) eine Öffnung (23) an seiner unteren Seite aufweist;
wobei die Wärmeaustauscher-Gehäuseanordnung ferner ein Dichtungselement (25) umfaßt, das so ausgebildet ist, daß es in den Zwischenraum (16) paßt, **dadurch gekennzeichnet, daß** das Dichtungselement (25) einen abgedichteten Durchgang (26) für Fluid zwischen der Öffnung (23) und der Düse (9) bildet.

2. Wärmeaustauscher-Gehäuseanordnung nach Anspruch 1, **dadurch gekennzeichnet, daß** das Dichtungselement (25) ein Schwerkraft-Dichtungselement ist, wobei die Dichtungskraft durch die Schwerkraft erzeugt wird, die auf das Dichtungselement (25) durch das innere Gehäuseelement (5) ausgeübt wird.

3. Wärmeaustauscher-Gehäuseanordnung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** das Dichtungselement (25) während des Normalbetriebes mit zumindest einem von beiden, dem äußeren Gehäuse (4) und dem inneren Gehäuseelement (5), nicht verbunden ist, vorzugsweise weder mit dem äußeren Gehäuse (4) noch dem inneren Gehäuseelement (5) verbunden ist.

4. Wärmeaustauscher-Gehäuseanordnung nach einem der Ansprüche 1-3, **dadurch gekennzeichnet, daß** das Dichtungselement (25) eine Platte (28) ist, die eine obere und eine untere Fläche aufweist, welche so angeordnet sind, daß sie dem äußeren Gehäuse und dem inneren Gehäuseelement entsprechen, welches die Düse und die Öffnung umgibt, vorzugsweise mit einer Dichtung an der oberen und/oder unteren Fläche.

5. Wärmeaustauscher-Gehäuseanordnung nach einem der Ansprüche 1-4, **dadurch gekennzeichnet, daß** die Düse eine erste Düse (9) bildet, und daß die Öffnung eine erste Öffnung (23) bildet, wobei das äußere Gehäuse (4) ferner eine zweite Düse (8) und das innere Gehäuseelement (5) eine zweite Öffnung (21) aufweist, und wobei die zweite Düse (8) und die zweite Öffnung (21) so angeordnet sind, daß sie über den Zwischenraum (16) in Fluidverbindung stehen.

6. Verfahren zum Zusammenbau einer Wärmeaustauscher-Gehäusestruktur, umfassend

- Vorsehen eines äußeren Gehäuses (4) mit einer Düse (9) an seiner unteren Seite und einem inneren Gehäuseelement (5) mit einer Öffnung (23);
- Gleitverschieben des inneren Gehäuseelementes (5) in das äußere Gehäuse (4) zur Bildung eines Zwischenraumes (16) mit dem äußeren Gehäuse (4) und zum Erreichen einer Position, an welcher sich die Öffnung (23) oberhalb der Düse (9) befindet;
- Anordnen des inneren Gehäuseelementes (5) in einer angehobenen Position in dem äußeren Gehäuse (4);
- Gleitverschieben eines Dichtungselementes (25) in den Zwischenraum (16), wobei das Dichtungselement (25) zwischen der Öffnung (23) und der Düse (9) einen Durchgang für Fluid bildet; und
- Absenken des inneren Gehäuseelementes (5),

so daß die auf das Dichtungselement (25) ausgeübte Schwerkraft als Dichtungskraft wirkt.

Revendications

1. Assemblage d'enveloppe (2) d'échangeur de chaleur comprenant :

   - une enveloppe externe (4) ayant une tuyère (9) sur son côté inférieur ;
   - un élément d'enveloppe interne (5) dans l'enveloppe externe (4) et formant un espace intermédiaire (16) avec l'enveloppe externe (4), l'élément d'enveloppe interne (5) ayant une ouverture (23) sur son côté inférieur ; dans lequel l'assemblage d'enveloppe d'échangeur de chaleur comprend en outre un élément d'étanchéité (25) aménagé pour s'ajuster dans l'espace intermédiaire (16), **caractérisé en ce que** l'élément d'étanchéité (25) fournit un passage scellé (26) pour du fluide entre l'ouverture (23) et la tuyère (9).

2. Assemblage d'enveloppe (2) d'échangeur de chaleur selon la revendication 1, **caractérisé en ce que** l'élément d'étanchéité (25) est un élément d'étanchéité par gravité, dans lequel la force d'étanchéité est fournie par la force de gravité exercée sur l'élément d'étanchéité (25) par l'élément d'enveloppe interne (5).

3. Assemblage d'enveloppe (2) d'échangeur de chaleur selon la revendication 1 ou 3, **caractérisé en ce que** l'élément d'étanchéité (25) n'est pas raccordé, au cours d'un fonctionnement normal, à au moins un élément choisi parmi l'enveloppe externe (4) et l'élément d'enveloppe interne (5), de préférence, pas raccordé à la fois à l'élément d'enveloppe externe (4) et à l'élément d'enveloppe interne (5).

4. Assemblage d'enveloppe (2) d'échangeur de chaleur selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** l'élément d'étanchéité (25) est une plaque (28) ayant des surfaces supérieure et inférieure qui sont aménagées pour se conformer à l'élément d'enveloppe externe et à l'élément d'enveloppe interne entourant la tuyère et l'ouverture, comprenant de préférence un joint d'étanchéité au niveau de la surface supérieure et/ou de la surface inférieure.

5. Assemblage d'enveloppe (2) d'échangeur de chaleur selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** la tuyère forme une première tuyère (9) et dans lequel l'ouverture forme une première ouverture (23), l'enveloppe externe (4) comprenant en outre une seconde tuyère (8) et l'élément d'enveloppe interne (5) comprenant une seconde ouverture (21) et dans lequel la seconde tuyère (8) et la seconde ouverture (21) sont aménagées pour être en communication de fluide via l'espace intermédiaire (16).

6. Procédé d'assemblage d'une structure d'enveloppe d'échangeur de chaleur, comprenant :

   - la mise en oeuvre d'une enveloppe externe (4) ayant une tuyère (9) sur son côté inférieur et un élément d'enveloppe interne (5) ayant une ouverture (23) ;
   - le coulissement de l'élément d'enveloppe interne (5) dans l'enveloppe externe (4), pour former un espace intermédiaire (16) avec l'enveloppe externe (4) et pour atteindre une position dans laquelle l'ouverture (23) se trouve au-dessus de la tuyère (9) ;
   - l'aménagement de l'élément d'enveloppe interne (5) dans une position soulevée dans l'enveloppe externe (4) ;
   - le coulissement d'un élément d'étanchéité (25) dans l'espace intermédiaire (16), l'élément d'étanchéité (25) mettant en oeuvre un passage pour le fluide entre l'ouverture (23) et la tuyère (9) ; et
   - l'abaissement de l'élément d'enveloppe interne (5) de sorte que la force de gravité exercée sur l'élément d'étanchéité (25) agisse comme force d'étanchéité.

Fig.1

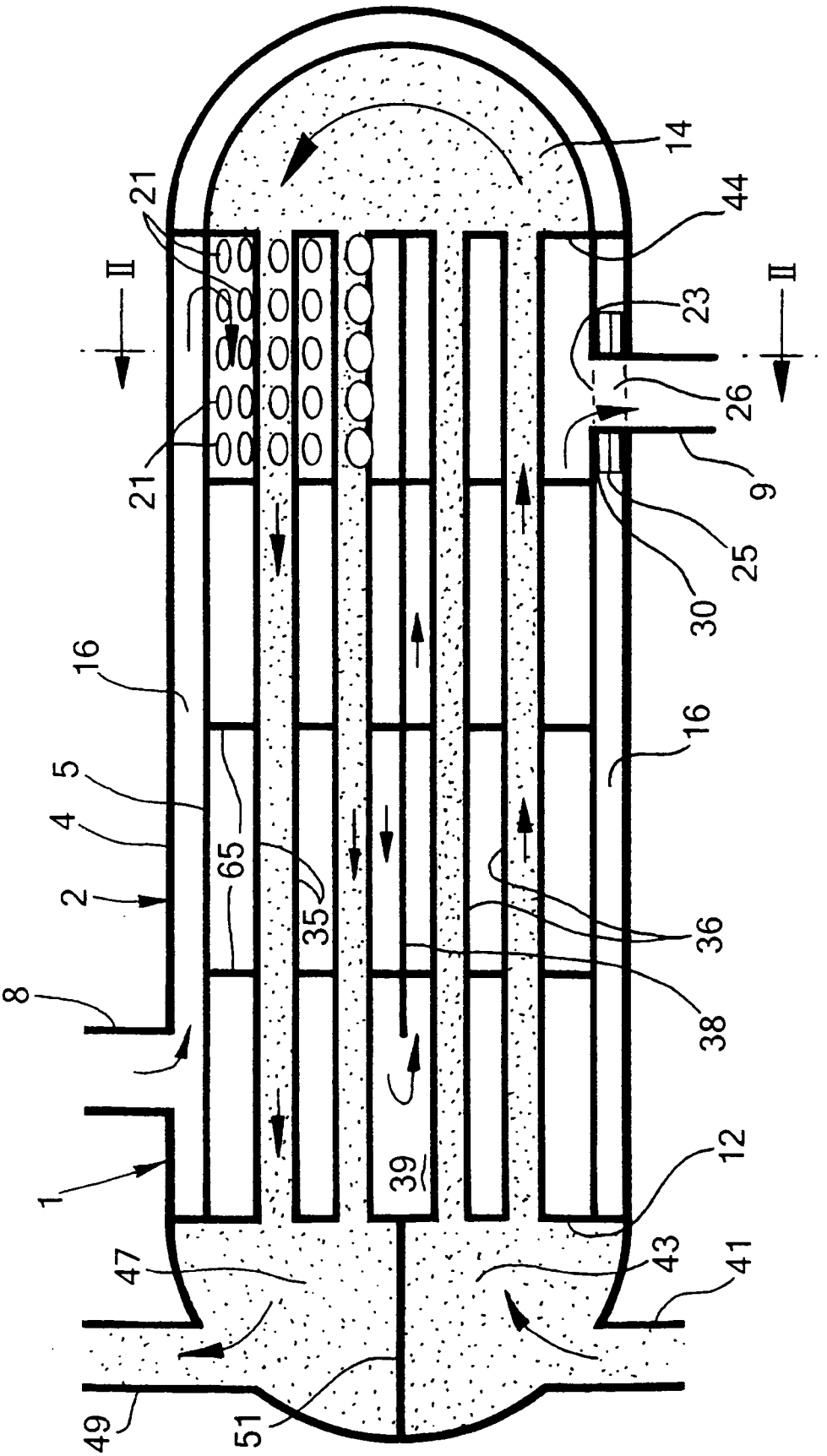


Fig.2

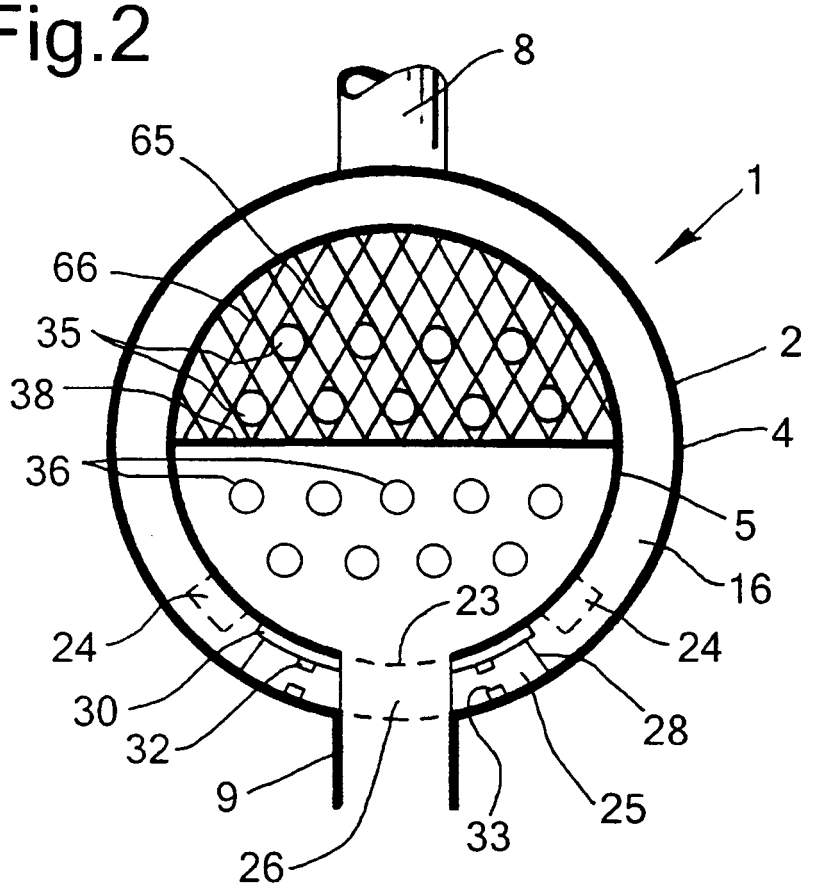
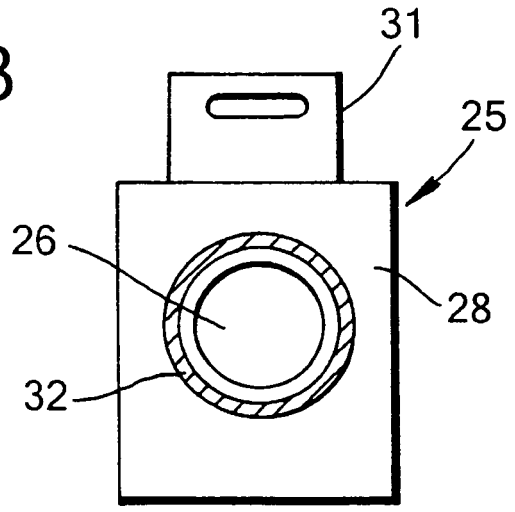


Fig.3



REFERENCES CITED IN THE DESCRIPTION

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