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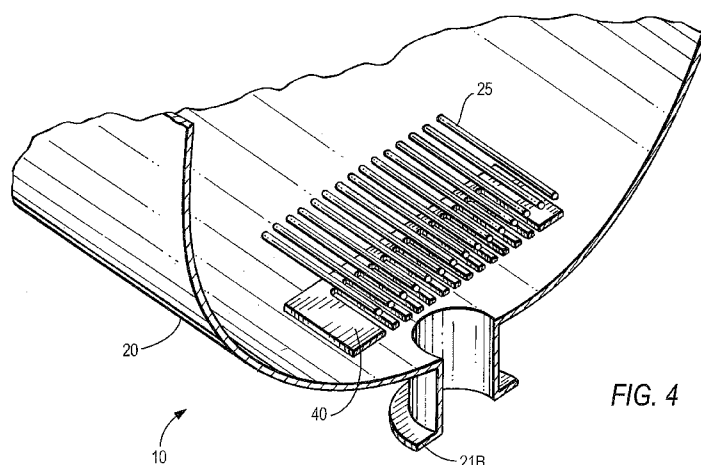
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(54) Title: SLOTTED IMPINGEMENT PLATES FOR HEAT EXCHANGERS



(57) Abstract: Impingement plates for shell and tube heat exchangers are positioned between the inlet openings and the tubes with the surfaces of the impingement plates being normal to the flow path of the liquid entering the shell from the inlet openings and having a plurality of openings through which a portion of the liquid passes before contacting the tubes. The openings can be formed as elongated parallel slots that are positioned parallel to the tubes and function to enhance the fluid flow, especially in the area that is immediately downstream from the impingement plates, thereby reducing fluid stagnation, fouling and tube erosion and prolonging the useful life and time in service between maintenance shut downs.



SLOTTED IMPINGEMENT PLATES FOR HEAT EXCHANGERS

Field of the Invention

[0001] The invention relates to impingement plates for shell and tube heat exchangers.

Background of the Invention

[0002] Fluid heat exchangers are widely used in the industry. One common heat exchanger is known as a shell and tube heat exchanger and includes a cylindrical housing or shell encompassing a bundle of tubes. In this type of heat exchanger, heat from a first fluid flowing through the tubes is transferred to a second fluid flowing through the housing, as a result of the second fluid flowing in contact with the outer surfaces of said tubes. The second fluid enters the shell through a nozzle and is directed initially to an impingement plate which deflects and redirects the second fluid to flow toward and about the outer surfaces of said tubes, as generally disclosed in U.S. Patent No. 3,938,588.

[0003] The inlet fluid initially has a high velocity and dynamic force when it impacts on the impingement plate. In many conventional shell and tube type heat exchangers the impingement plate adjacent the inlet nozzle protects the tubes from direct impact of the high velocity inlet fluid, but often creates operational problems when fluid flowing downstream of the impingement plate has reduced velocity due to the vortex effect of fluid motion at the sides of the impingement plate. This results in fouling accumulation on surfaces of the tubes, particularly in the region designated herein as "fouling area" immediately downstream from the conventional impingement plate. Such fouling retards heat transfer to tubes in that area and furthermore may create a corrosive environment on the outer surfaces of said tubes. If

the fouling and corrosion becomes severe enough, eventually the heat exchanger must be completely shut down and retubed.

[0004] Figs. 1-2 illustrate a prior art cylindrical double split flow H-type heat exchanger 10, as classified by Tubular Exchanger Manufacturers Association (TEMA), being formed of a cylindrical shell housing or shell 20 encompassing a bundle of tubes. This type of heat exchanger is often used for vaporizing duties where low pressure drop is required. In the prior art shell and tube heat exchanger shown in Figs. 1-2 it is typical for tubes to transport a first fluid of relatively elevated temperature, the heat from this fluid in the tubes being transferred to a second fluid flowing from inlets 21A, 21B to outlets 22A, 22B. For convenience herein, the fluid within the tubes will be designated “tube-side fluid” and the fluid flowing from inlets 21A, 21B to outlets 22A, 22B and flowing across and in contact with the outer surfaces of the tubes will be designated “shell-side fluid”.

[0005] As shown in FIG. 2, housing 20 has two shell side fluid inlets 21A, 21B and two shell side fluid outlets 22A, 22B. The inner tubes are in communication with a tube side inlet 27 and a tube side outlet 28. The illustrated heat exchanger includes conventional impingement plates 40A, 40B situated inward and adjacent of the inlet nozzles and between said inlet nozzles and a bundle of tubes.

[0006] As shown in FIG. 2, fluid entering the shell 20 from inlets 21A, 21B initially strikes impingement plates 40A, 40B, and then follows primarily the path indicated by long arrows A, flowing between, around and engaging the outer surfaces of tubes in the tube bundle (not shown). Two horizontal divider baffles 41A, 41B and three vertical circular support baffles 30A, 30B, 30C are also positioned in the heat exchanger and further impinge the flow of the fluid.

[0007] Arrows A indicate how the fluid from inlets 21A, 21B tends to not flow in the fouling areas 22 shown in the dashed line generally semi-circular areas in the region of the

housing that is directly downstream from impingement plates 40A, 40B. As discussed above, it is in this region where deposits and fouling accumulate on the surfaces of tubes (not shown). This accumulation inhibits heat exchange with the fluid flowing within tubes by reducing the ability of the in-flowing fluid to freely circulate around these tubes and thus reduces the efficiency of the heat transfer. Also, this fouling may cause corrosion on the surfaces of these tubes.

[0008] The above-mentioned areas of fouling and accumulation designated with reference number 22 and shown in Fig. 2, are not precise areas, but are the regions where the above-mentioned fouling occurs. In addition, fouling can also occur downstream of the divider baffles 41A, 41B.

Summary of the Invention

[0009] The improved impingement plate of the present invention for use in a shell and tube heat exchanger are positioned between the inlet openings and the tubes, the surfaces of the plates being normal to the flow path of the liquid entering the shell from the inlet openings and are provided with a plurality of openings through which a portion of the liquid passes before contacting the tubes. In one aspect of the invention, the openings are formed as elongated parallel slots and the impingement plate is positioned so that the slots are parallel to the tubes. The openings enhance the fluid flow, especially in the area that is immediately downstream from the impingement plates. This improved fluid flow prevents fluid stagnation by allowing a portion of the pressurized liquid to pass through the plate, the majority being diverted around the periphery of the plate to prevent tube erosion, and therefore avoids unnecessary shut downs of the heat exchanger for service.

Brief Description of the Drawings

[0010] For convenience and clarity in describing these embodiments, similar elements or components appearing in different figures will have the same reference numbers.

[0011] FIG. 1 is a perspective view of a prior art double split flow H-type heat exchanger.

[0012] FIG. 2 is a cross section view of the prior art heat exchanger taken along line 2-2 of FIG. 1.

[0013] FIG. 3 is a perspective view of an impingement plate according to one embodiment of the invention, showing a plurality of slots in the surface of the impingement plate.

[0014] FIG. 4 is a perspective view of the inside of the heat exchanger, showing the new impingement plate.

Detailed Description of the Invention

[0015] A preferred embodiment of the impingement plate of the invention is illustrated in Figs. 3-4. For simplicity and clarity, the heat exchanger 10 in Fig. 4 will be shown as having the same housing or shell 20 as in Figs. 1-2 and also having the same inlets 21A, 21B, outlets 22A, 22B and bundle of tubes 25. As mentioned above, in the present embodiments it is understood that flowing in these tubes 25 is a relatively hot fluid, with heat transfer from the outer surfaces of these tubes 25 to the relatively cooler second fluid flowing from inlets 21A, 21B through the shell housing to outlets 22A, 22B.

[0016] Figures 3-4 illustrate in the heat exchanger housing 20, the impingement plate 40 which is generally planar. Although the impingement plate 40 is shown as being rectilinear, other shapes can be used. The impingement plate 40 includes a plurality of openings 45A, 45B through which a portion of the shell-side fluid passes before contacting

the tubes. The openings are preferably in the form of elongated slots which are parallel to each other, but other shapes and orientations can also be used. The openings extend along substantially the entire length of the plate. In one embodiment, the openings constitute about 70-90% of the surface area of the impingement plate, and preferably about 80%. In the embodiment shown, the openings form two columns separated by a portion of the impingement plate that forms a central support member 47 which can be provided for enhanced structural integrity.

[0017] The width of each opening can be in the range of about 3 mm to about 10 mm. The length of each opening can be in the range of about 125 mm to about 150 mm, depending on the size of the impingement plate. The space between the openings can be in the range of about 20 mm to about 50 mm. In a preferred embodiment, the width of each opening is about 6 mm, the length of each opening is about 136 mm, and the space between the openings is about 25 mm. However, the exact dimensions of the impingement plates and the openings, and the spacing between the openings in the plates can be varied, depending on the nature of the fluid, the velocity of the fluid, the intended heat transfer, etc.

[0018] Fig. 4 illustrates the placement of the impingement plate 40 in the shell 20 which is between the inlet 21B and the tubes 25. The tubes 25 are spaced-apart from each other and extend longitudinally in the shell 20 in a first direction, wherein a first liquid flows through the plurality of tubes. An inlet opening 21B admits a second liquid into the shell 20 in an inlet flow direction that is generally transverse to the tubes 25. The impingement plate 40 is positioned so that its surface is normal to the flow path of the second liquid entering the shell from the inlet opening 21B. A portion of the second liquid passes through the openings in the impingement plate 40 before contacting the tubes 25.

[0019] In a preferred embodiment, the impingement plate 40 is positioned so that the slots 45A, 45B are parallel to the tubes 25. Further, it is preferred that a portion of the slots

45A, 45B are aligned with the spaces between the tubes 25. This orientation helps to prevent fluid stagnation by allowing fluid to flow through the openings and between the tubes 25. This orientation also helps to prevent tube erosion by allowing impingement of the fluid by the surface of the impingement plate formed between the openings.

[0020] In one embodiment the area of the impingement plate 40 is about 10% to about 20% larger than the area of the inlet opening. For example, if the inlet opening is 10 inches in diameter, then the impingement plate can be about 11 inches by 11 inches.

[0021] The openings in the impingement plate allow the fluid to more effectively flow in area 22 (see FIG. 2) which greatly reduces or even prevents accumulation of deposits on the tubular surfaces in this area, and thus allows these tubular surfaces to maintain their most efficient heat transfer capability. Also, the elimination of these deposits reduces or prevents corrosion on these surfaces. Furthermore, the more efficient heat transfer from these surfaces increases protection of these tubes from overheating due to lack of heat transfer from them. And finally, as a consequence of this new structure and fluid-flow arrangement, there is an overall improved and more efficient heat transfer of the entire heat exchanger system.

[0022] The improvement by the new impingement plate overcomes or greatly reduces fouling accumulation on the tubes downstream of the impingement plates caused by very low velocity or absence of flow of the fluid in this area below the impingement plate assembly. With the new device, not only is there established an adequate fluid flow onto and around the surface areas of the tubes directly downstream from the impingement plate but a flow of adequate velocity to achieve cleaning and scrubbing and also to achieve recovery of heat from those surfaces.

[0023] The new impingement plate can be made of material similar or the same as that in prior art impingement plates such as stainless steel or other material resistant to corrosion and damage from the environment within the heat exchanger.

[0024] The divider baffles 41A, 41B in the shell can also include openings as described herein to prevent fouling in the areas that are immediately downstream of these divider baffles (see FIG. 2).

[0025] Although the present invention has been described in accordance with an H-type heat exchanger, persons of ordinary skill in the art will recognize that the present invention can be implemented in any type of heat exchanger having impingement plates.

[0026] As will be understood from the above description and the attached drawings, the present invention provides a new and functionally different impingement plate to reduce fouling accumulation, to enhance heat transfer and to reduce corrosion of tubes in a shell and tube heat exchanger.

[0027] While the invention has been described in conjunction with several embodiments, it is to be understood that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, this invention is intended to embrace all such alternatives, modifications, and variations which fall within the spirit and scope of the appended claims.

We claim:

1. A shell and tube heat exchange apparatus for the transfer of heat from a first liquid to a second liquid comprising:

a shell defining an interior space,

a plurality of spaced-apart tubes extending longitudinally in the shell, wherein the first liquid flows through the plurality of tubes,

an inlet opening for admitting the second liquid into the interior space in an inlet flow direction that is generally transverse to the tubes, and

an impingement plate positioned between the inlet opening and the tubes, the surface of the plate being normal to the flow path of the second liquid entering the shell from the inlet opening and having a plurality of openings through which a portion of the second liquid passes before contacting the tubes.

2. The apparatus of claim 1, wherein the plurality of openings in the impingement plate are elongated slots.

3. The apparatus of claim 2, wherein the slots extend along substantially the entire length of the plate.

4. The apparatus of claim 2, wherein the slots are parallel to each other.

5. The apparatus of claim 2, wherein the impingement plate is positioned so that the slots are parallel to the tubes.

6. The apparatus of claim 5, wherein a portion of the slots are aligned with the spaces between the tubes.

7. The apparatus of claim 2, wherein the width of each slot is about 6 mm and the space between the slots is about 25 mm.

8. The apparatus of claim 2, wherein the length of each slot is about 136 mm.

9. The apparatus of claim 1, wherein the impingement plate is rectilinear and generally planar.

10. The apparatus of claim 2, wherein the slot openings constitute about 80% of the surface area of the impingement plate.

11. The apparatus of claim 2, wherein the area of the impingement plate is about 110% of the area of the inlet opening.

12. The apparatus of claim 1, wherein the shell and tube heat exchanger is a double split flow H-type further comprising:

a second inlet for admitting a portion of the second liquid into the interior space in an inlet flow direction that is generally transverse to the tubes; and

a second impingement plate positioned between the second inlet and the tubes, the surface of the plate being normal to the flow path of liquid entering the shell from the second inlet, the second impingement plate having a plurality of openings through which a portion of the second liquid passes before contacting the tubes.

13. A generally planar diffusing impingement plate configured and dimensioned for interpositioning between a liquid inlet opening in the exterior wall of a shell and tube heat exchanger and the tubes of the heat exchanger, the surface of the plate being generally planar and having a plurality of elongated spaced-apart slotted openings for diffusing and passing a portion of liquid contacting the surface of the plate.

14. The plate of claim 13, wherein the plurality of openings in the impingement plate are elongated slots that extend from proximate opposing ends of the plate.

15. A method of mitigating fouling on and corrosion of a portion of the tubes in a shell and tube heat exchanger that are in the flow path of a heat transfer liquid entering the heat exchanger through an inlet opening, the method including:

providing a generally planar diffusing impingement plate having a plurality of elongated spaced-apart openings, and

positioning the plate proximate the liquid inlet opening to thereby diffuse and pass only a portion of the flowing liquid into direct contact with the tubes adjacent the plate.

16. The method of claim 15, wherein the plurality of openings in the impingement plate are elongated slots and the slots are aligned parallel to the tubes.

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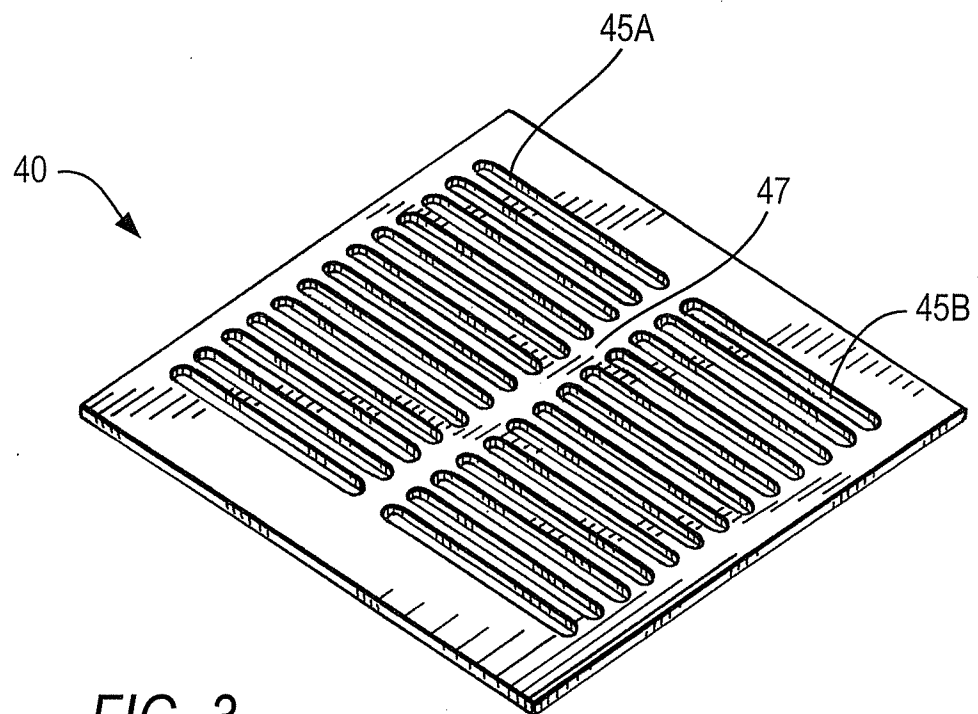
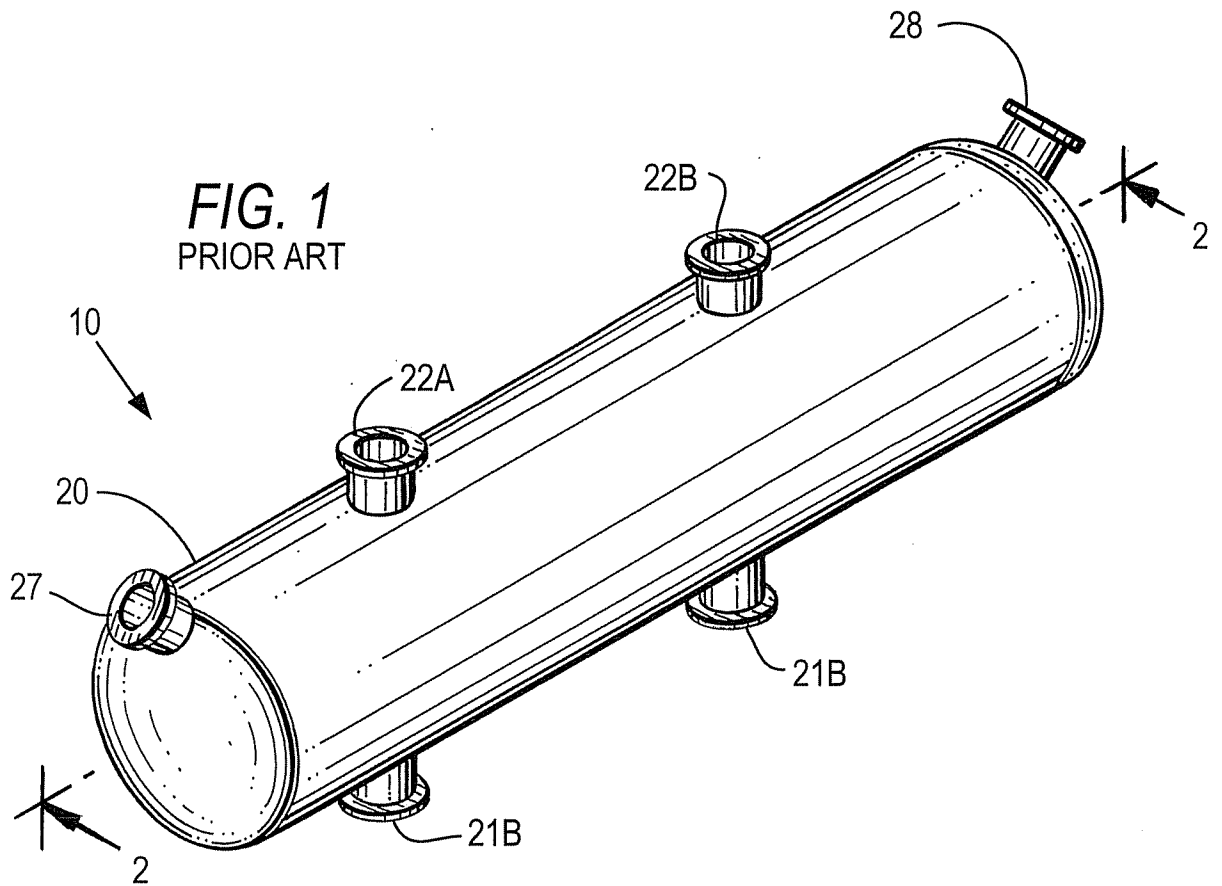
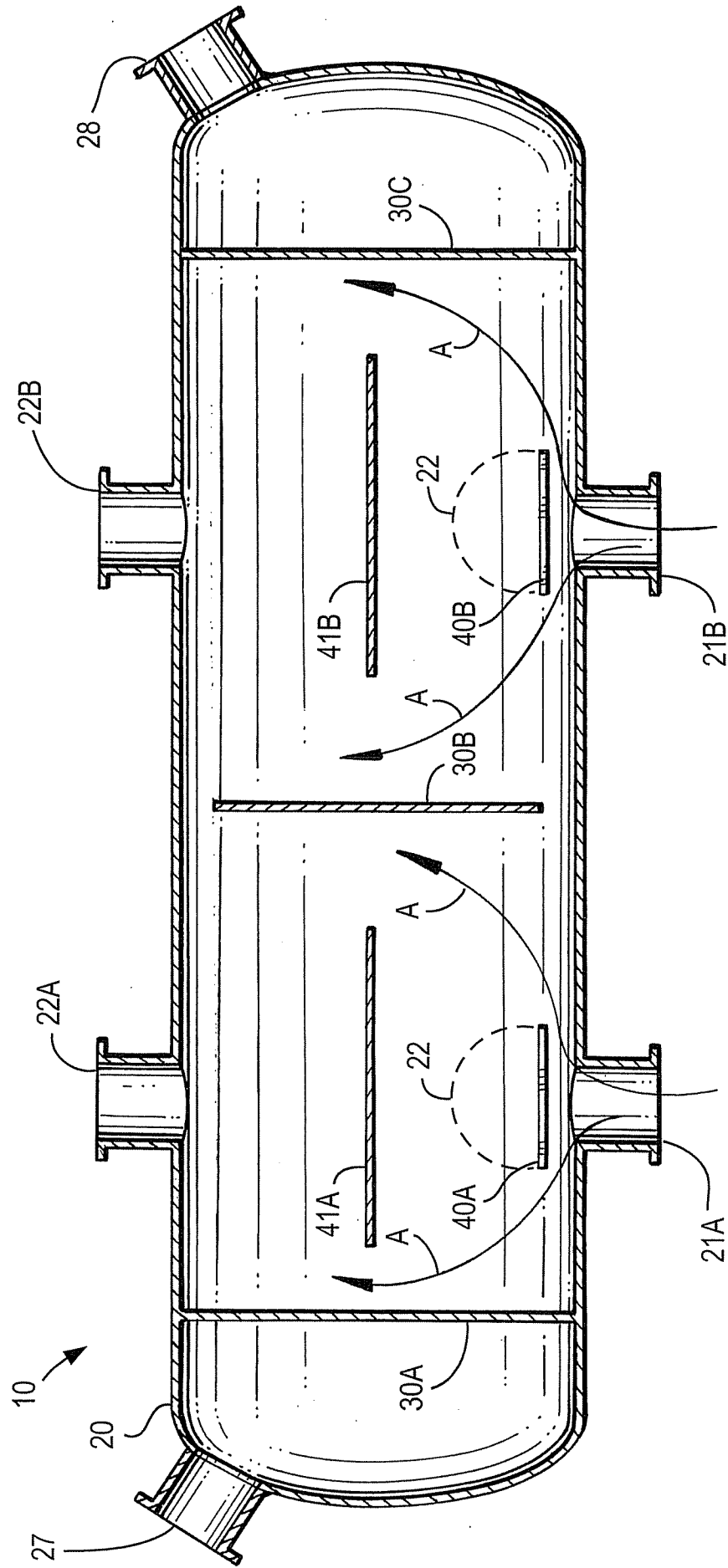
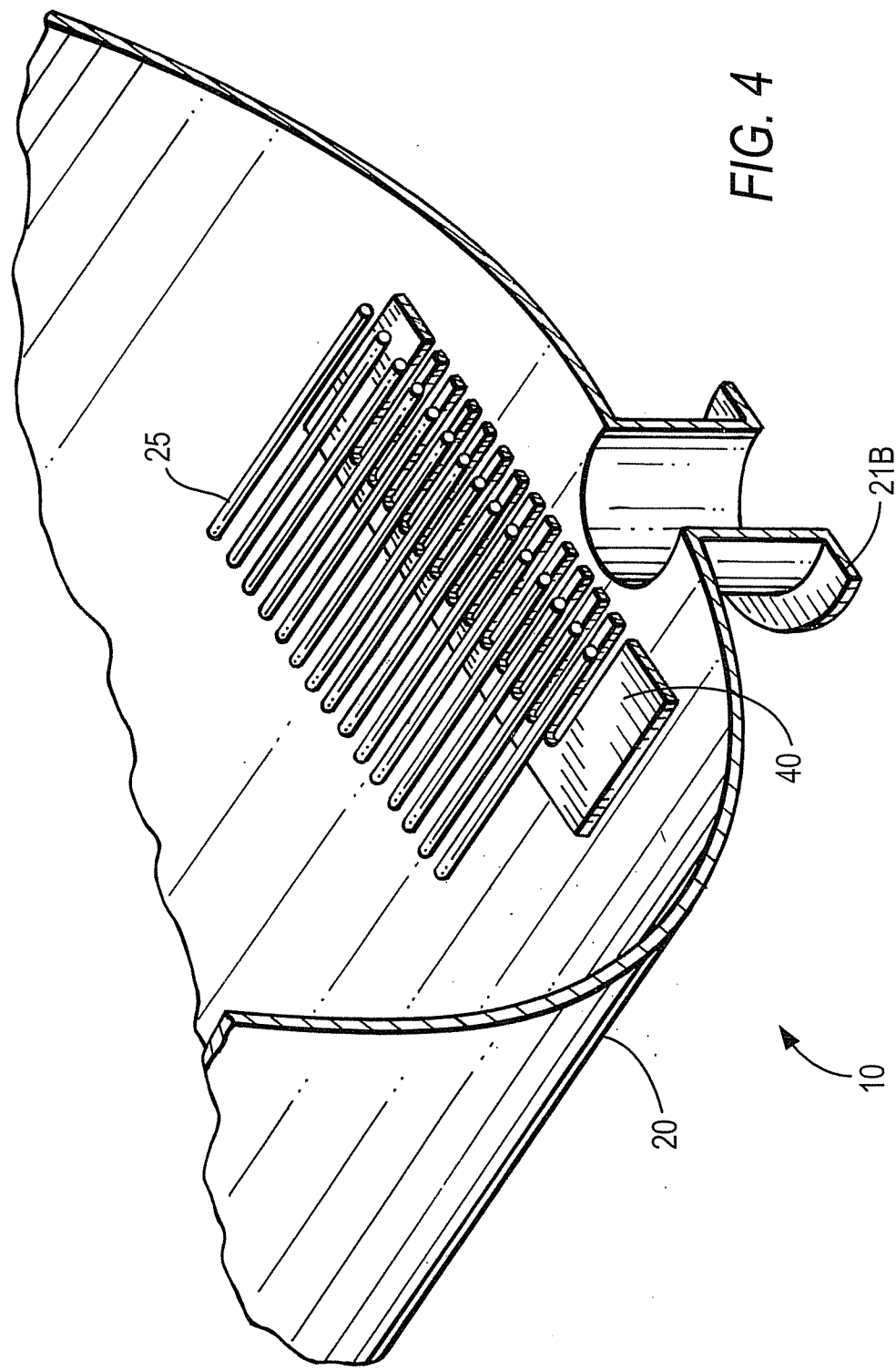


FIG. 3

FIG. 2
PRIOR ART





INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/026788

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F28F 3/02 (2011.01)

USPC - 165/113

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - F28F 3/02 (2011.01)

USPC - 110/322; 122/235.17; 138/37, 38; 165/104.11, 113, 114, 134.1, 159, 167; 210/180; 220/563

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Patent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,550,775 A (EDWARDS et al) 05 November 1985 (05.11.1985) entire document	1-11, 13, 14
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Y		12, 15, 16
Y	US 3,938,588 A (COIT et al) 17 February 1976 (17.02.1976) entire document	12
Y	US 2009/0242178 A1 (AL-ANIZI et al) 01 October 2009 (01.10.2009) entire document	15, 16
A	US 4,880,055 A (NIGGEMANN et al) 14 November 1989 (14.11.1989) entire document	1-16
A	US 4,311,187 A (SMALL) 19 January 1982 (19.01.1982) entire document	1-16
A	US 4,494,171 A (BLAND et al) 15 January 1985 (15.01.1985) entire document	1-16

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

14 April 2011

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