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

(11) EP 1 562 016 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.08.2005 Bulletin 2005/32

(51) Int Cl.[7]: **F28D 7/16**, F28F 9/22

(21) Application number: **05002286.2**

(22) Date of filing: **03.02.2005**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR LV MK YU

(30) Priority: **04.02.2004 JP 2004027861**

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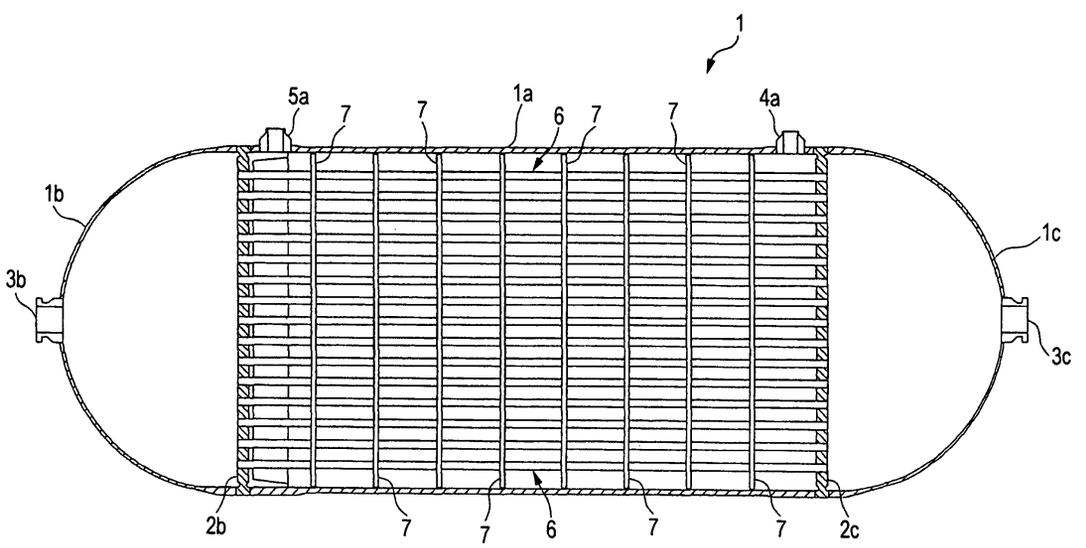
(54) Multi-tube heat exchanger

(57) Multi-tube heat exchanger (1) including a bundle of tubes (6) which form fluid passages of first heat exchanging fluid, an outer shell (1a) which covers the bundle of tubes (6) and form a fluid passage of second heat exchanging fluid, and a baffle plate (7) which is arranged inside the outer shell (1a) in a direction intersecting an axial direction of the bundle of tubes (6) and provided with a plurality of through holes (8) through which respective tubes (6) of the bundle are passed. Each of the through holes (8) has such a shape that a portion of an outer peripheral face of the tube (6) comes into contact with a portion of an inner peripheral face of the through hole (8), and a gap for passing the second heat exchanging fluid is formed between the other portion of the inner peripheral face and the outer peripheral face of the tube (6).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a multi-tube heat exchanger for saving energy in plants of various types, architectures and so on, or for conducting chemical reactions, and more particularly to a structure of a baffle plate which is employed in the multi-tube heat exchanger.

2. Related Art

[0002] As a type of heat exchanger structure, there has been known a multi-tube heat exchanger. This type of heat exchanger includes a number of tubes bundled into a tube bundle which are arranged inside an outer shell, and heat exchanging fluids having respectively different temperatures are supplied into the multi-tubes and inside the outer shell, thereby to conduct heat exchange between the heat exchanging fluids through walls of the multi-tubes. There have been known some types of this heat exchanger in which a baffle plate is provided at the right angle with respect to an axial direction of the tubes for the purpose of supporting the tube bundle, and at the same time, for the purpose of preventing drift of the heat exchanging fluid which flows inside the outer shell so as to change a state of flow thereby to enhance heat exchanging efficiency. The baffle plate is provided with through holes corresponding to an outer shape of the tubes so that the multi-tubes may be passed therethrough (For example, Japanese Patent Publication No. JP-A-05-106993 and Japanese Patent Publication No. JP-A-06-185891).

[0003] It has been also proposed to provide the baffle plate with pass holes for passing the fluid, for the purpose of reducing fluid resistance while the heat exchanging fluid moves. Figs. 3A and 3B show a baffle plate 30 which is provided with a number of through holes 31 through which tubes 40 are adapted to pass, and additionally provided with small pass holes 32 around the through holes 31.

[0004] Moreover, it has been proposed that instead of the above described baffle plate, metal plates 35 in a strip shape are assembled like a latticework, as shown in Figs. 4A and 4B, by alternately engaging slits formed therein with each other or by welding. The tubes 40 are passed through the latticework to be supported, and the heat exchanging fluid is supplied through gaps 41 around the tubes 40. Further, an improvement of this art in which waves are formed in the metal plates in correspondence with the outer shape of the tubes has been proposed.

[0005] However, in the heat exchanger in which the small pass holes are formed in the baffle plate, there has been a problem that the fluid cannot favorably pass through the small pass holes due to their insufficient opening rate, and a request for lowering the fluid resistance cannot be fully satisfied.

[0006] Moreover, in the heat exchanger in which the metal plates are assembled like a latticework, although the fluid can relatively favorably flow, supporting strength for the tubes is insufficient, and therefore, it is necessary to employ the metal plates having a larger width (in the axial direction of the tube). As the results, there has been a problem that a heat transfer area between the heat exchanging fluid and outer walls of the tubes has been decreased. There has been another problem that because stability in strength and dimension is insufficient, it is difficult to fix positions of the holes, and consequently, arrangement of the tubes is liable to be confused. Specifically, in the conventional structure, it has been impossible to satisfy all the requirements such as compact arrangement of the tubes, dimensional stability, and the opening rate.

SUMMARY OF THE INVENTION

[0007] The invention has been made in view of the above described circumstances as the background, and it is an object of the invention to provide a multi-tube heat exchanger in which tubes can be stably fixed with sufficient stability in strength and dimension, and at the same time, a flow of heat exchanging fluid can be favorablymade, whereby fluid resistance can be decreased without lowering heat exchanging efficiency.

[0008] Specifically, according to the invention, there is provided a multi-tube heat exchanger comprising a bundle of tubes which form fluid passages of first heat exchanging fluid, an outer shell which covers the bundle of tubes and form a fluid passage of second heat exchanging fluid, and a baffle plate which is arranged inside the outer shell in a direction intersecting an axial direction of the bundle of tubes and provided with a plurality of through holes through which respective tubes of the bundle are passed, characterized in that a part or all of the through holes have such a shape that a portion of an outer peripheral face of the tube comes into contact with a portion of an inner peripheral face of the through hole, and a gap for passing the second heat exchanging fluid is formed between the other portion of the inner peripheral face and the outer peripheral face of the tube.

[0009] It is desirable that the through hole has a shape symmetrical with respect to a point. In this manner, support of the tubes and a flow of the heat exchanging fluid can be made maintaining a good balance.

[0010] Moreover, it is further desirable that the through hole has a substantially rhombic shape, wherein a pair of rounded opposed corner portions to be internally contacted with the outer peripheral face of the tube, and the other pair of opposed corner portions have a shape to be separated from the outer peripheral face of the tube. As described above, the outer peripheral

face of the tube is internally contacted with a pair of the opposed corner portions respectively, whereby the tube can be stably held. Moreover, the other pair of the opposed corner portions have the shape to be separated from the outer peripheral face of the tube, whereby the flow of the heat exchanging fluid can be ensured. Further, the other pair of the opposed corner portions may be formed either in an angled shape or in a rounded shape. In case of forming them in a rounded shape, the above described gap can be reliably obtained, by making their curvature smaller than a curvature of the tube.

[0011] The aforesaid through holes are regularly arranged, for example in a plurality, according to the arrangement of the tubes. Moreover, a plurality of the aforesaid baffle plates may be arranged in a spaced relation in an axial direction of the tubes. The through holes can be formed by piercing the baffle plate by laser work or mechanical work. However, in this invention, a method of forming the through holes is not particularly limited, but it is possible to form the through holes by appropriate known means.

[0012] Further, the number of the tubes, manner of arranging the tubes and so on are not particularly limited, and it is possible to appropriately select the tubes out of straight tubes, U-shaped tubes, corrugated tubes, etc. Also, the shape of the outer shell is not particularly limited, and an appropriate shape can be selected according to necessity, as far as its essential function is fulfilled.

[0013] More specifically, according to the invention, each the tube can be supported by a portion of the inner peripheral face of the through hole which is formed in the baffle plate, and therefore, the tube can be stably fixed with high positional accuracy. Moreover, the gap is formed between the through hole and the outer peripheral face of the tube so that the heat exchanging fluid can pass it through, and the heat exchanging fluid can be smoothly passed. Further, contact between the heat exchanging fluid and the tube will not be interrupted by the through hole, but the heat exchanging fluid will be directly brought into contact with the tube while it passes the aforesaid gap. As the results, the heat exchanging efficiency will be further enhanced.

[0014] As described herein above, the multi-tube heat exchanger according to the invention includes a bundle of tubes which form the fluid passages of the first heat exchanging fluid, the outer shell which covers the bundle of the tubes and form the fluid passage of the second heat exchanging fluid, and the baffle plate which is arranged inside the outer shell in a direction intersecting the axial direction of the bundle of the tubes and provided with a plurality of the through holes through which respective tubes of the bundle are passed, and a part or all of the through holes have such a shape that a portion of the outer peripheral face of the tube comes into contact with a portion of the inner peripheral face of the through hole, and the gap for passing the second heat exchanging fluid is formed between the other portion of the inner peripheral face and the outer peripheral face of the tube. Therefore, the multi-tube heat exchanger according to the invention has the following advantages;

(1) Because of good dimensional accuracy, sufficient fixation of the tubes can be performed, and a sufficient wall thickness of the baffle plate can be selected, whereby the strength will be ensured.
(2) Due to an increased opening area and decrease of the fluid resistance, a drop of flow rate of the heat exchanging fluid inside the outer shell can be prevented, whereby heat transfer efficiency will be improved.
(3) Because pitch of the through holes can be minimized and the arrangement of the tube bundle can be made compact, an inner diameter of the outer shell can be made smaller, thus enabling production cost of the heat exchanger to be decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a sectional view showing an entirety of a heat exchanger in an embodiment of the invention;
Figs. 2A and 2B show a part of a baffle plate in the same embodiment in an enlarged scale, in which Fig. 2A is a front view showing arrangement of through holes, and Fig. 2B is a perspective view showing a tube in a state passed through the through hole;
Figs. 3A and 3B show a baffle plate as one example of background art, in which Fig. 3A is front view showing arrangement of through holes, and Fig. 3B is a plan view showing tubes in a state passed through the through holes; and
Figs. 4A and 4B show metal plates assembled like a latticework as another example of the background art, in which Fig. 4A is a front view showing the latticework and arrangement of tubes, and Fig. 4B is a plan view showing the tubes in a state passed through the latticework.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Now, an embodiment of the invention will be described referring to Figs. 1 and 2A and 2B.

[0017] An outer shell 1 mainly includes a body part 1a in a cylindrical shape, and head parts 1b, 1c in a semicircular shape which are continued from both ends of the body part 1a. Inside the outer shell 1, there are provided partition walls 2b, 2c for separating a space inside the body part 1a from spaces inside the head parts 1b, 1c. The head parts 1b, 1c are respectively provided with fluid ports 3b, 3c which are open to the exterior and communicated with the spaces defined by the partition walls 2b, 2c. The body part 1a is provided with fluid ports 4a, 5a which are open to the exterior and communicated

with the spaces defined by the partition walls 2b, 2c.

[0018] Further, a number of tubes 6 bundled into a tube bundle are bridged between the partition walls 2b, 2c. Both ends of the tubes are respectively communicated with the spaces inside the head parts 1b, 1c which are defined by the partition walls 2b, 2c.

[0019] In the space inside the body part 1a, a plurality of baffle plates 7, 7 for regularly disturbing a flow of the fluid are arranged in a spaced relation in an axial direction of the tubes 6, and the fluid can move across the baffle plates 7, 7 through openings (not shown) which are provided in a part thereof. Each of the baffle plates 7, 7 is provided with through holes 8, 8 in regular arrangement, through which the tubes 6 are adapted to pass. The though holes 8 are formed by piercing the baffle plate 7 by laser work or so, and has a substantially rhombic shape which is symmetrical with respect to a point, as shown in Figs. 2A and 2B. Inner faces of a pair of opposed corner portions 8a at a larger opening degree are in a rounded shape having a larger curvature than a curvature of an outer peripheral shape of the tube 6. On the other hand, the other pair of opposed corner portions 8b at a smaller opening degree are in a rounded shape having a smaller curvature than the curvature of the outer peripheral shape of the tube 6. A distance between the pair of the opposed corner portions 8a, 8a which have the larger opening degree is substantially equal to an outer diameter of the tube 6 at the largest position, and slightly larger than the tube 6. In case where the largest distance between the opposed corner portions 8a, 8a is too close to the outer diameter of the tube 6, it will be difficult to insert the tube 6, and on the contrary, in case where the distance is too large, supporting performance for the tube 6 will be deteriorated. Therefore, the above described distance may be determined taking these factors into consideration.

[0020] In a state where the tubes 6 are respectively passed through the through holes 8, outer walls of the tubes 6 come into contact with the opposed corner portions 8a, 8a, whereby the tubes 6 will be supported. On this occasion, the distance between the opposed corner portions 8a, 8a is substantially equal to the outer diameter of the tube 6, and as the distance between the opposed corner portions 8a, 8a becomes gradually smaller following the rhombic shape at both sides of the opposed corner portions, the tube 6 will be held in a stabilized position. On the other hand, gaps between the opposed corner portions 8b, 8b and the outer wall of the tube 6 become gradually larger at both sides of the opposed corner portions 8a, 8a toward the opposed corner portions 8b, 8b, and thus, gaps 9 which will be the largest at the opposed corner portions 8b, 8b can be obtained. The multi-tube heat exchanger in the embodiment of the invention is constructed in the above described manner.

[0021] Then, operation of the above described multi-tube heat exchanger will be explained.

[0022] A first heat exchanging fluid to be subjected to heat exchange (for example, cold water) is introduced from one of the fluid ports in the head parts 1b, 1c, for example the fluid port 3b, into the head part 1b. Then, the first heat exchanging fluid moves from the space inside the head part 1b through the tubes 6 into the space inside the other head part 1c, and discharged from the fluid port 3c to the exterior. On the other hand, the second heat exchanging fluid (for example, hot water) is introduced from the fluid port 4a into the space inside the body part 1a. Then, the second heat exchanging fluid moves while it is guided by surfaces of the baffle plates 7 and the openings which are not shown, and comes into contact with the outer walls of the tubes 6 thereby to conduct the heat exchange with the first heat exchanging fluid which flows inside the tubes 6. A portion of the second heat exchanging fluid will pass the baffle plates 7 through the gaps 9 of the through holes 8 through which the tubes 6 are passed. Because the second fluidmoves along the outer walls of the tubes 6 on this occasion, the heat exchange between the second fluid and the tubes 6 will be further promoted.

[0023] As described above, because the second fluid passes the baffle plates 7 through the gaps 9, it is possible to decrease the fluid resistance of the second heat exchanging fluid, and a drop of flow rate of the second heat exchanging fluid can be prevented generally. As the results, heat exchanging efficiency by the second heat exchanging fluid will be improved.

[0024] Moreover, as described above, the tubes 6 can be reliably held by the through holes 8 with high stability and high dimensional accuracy, and therefore, regularity of arranging the tube bundle can be maintained even though pitch between the through holes are minimized. As the results, the heat exchanger can be made compact.

[0025] Although the invention has been described referring to the above described embodiment, the invention is not limited to the description of the embodiment. It is apparent that appropriate modifications can be made within a scope of the invention.

Claims

1. A multi-tube heat exchanger comprising:

a plurality of tubes which form a first fluid passage of a first heat exchanging fluid,
an outer shell which covers said tubes and forms a second fluid passage of a second heat exchanging fluid, and
a baffle plate arranged inside said outer shell, intersecting an axial direction of said tubes and provided with a plurality of through holes through which said tubes are passed,

wherein at least one of said through holes has a shape such that a portion of an outer peripheral

face of said tube is brought into contact with a portion of an inner peripheral face of the through hole, and a gap for passing said second heat exchanging fluid is formed between another portion of said inner peripheral face and the outer peripheral face of said tube.

2. A multi-tube heat exchanger according to claim 1, wherein said through hole has a shape symmetrical with respect to a point.

3. A multi-tube heat exchanger according to claim 1, wherein said through hole has a substantially rhombic shape which has a pair of rounded opposite corner portions to be internally contacted with the outer peripheral face of said tube, and another pair of opposed corner portions are separated from the outer peripheral face of said tube.

4. A multi-tube heat exchanger according to claim 1, wherein a plurality of said through holes are regularly arranged.

FIG. 1

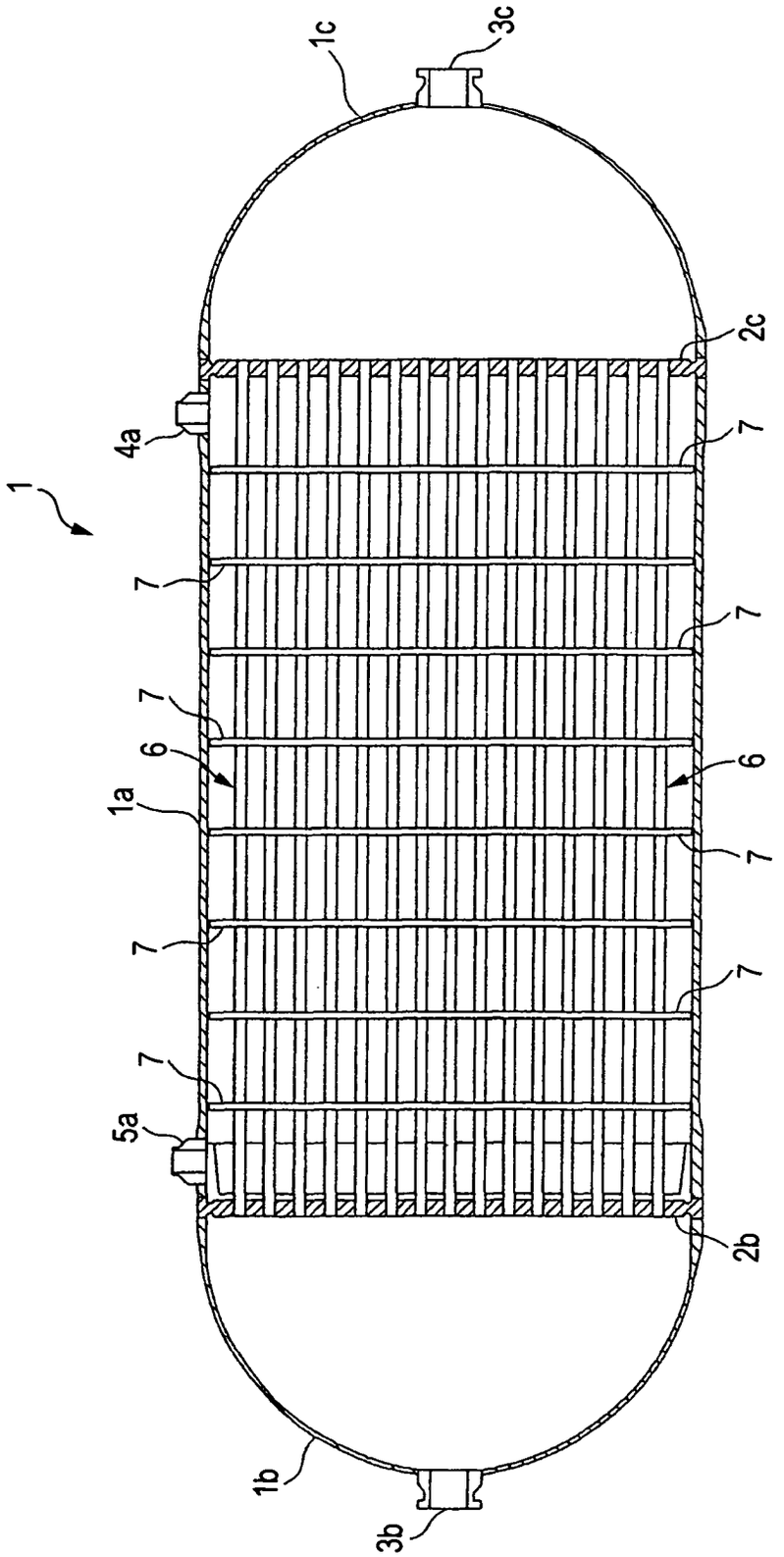

FIG. 2A

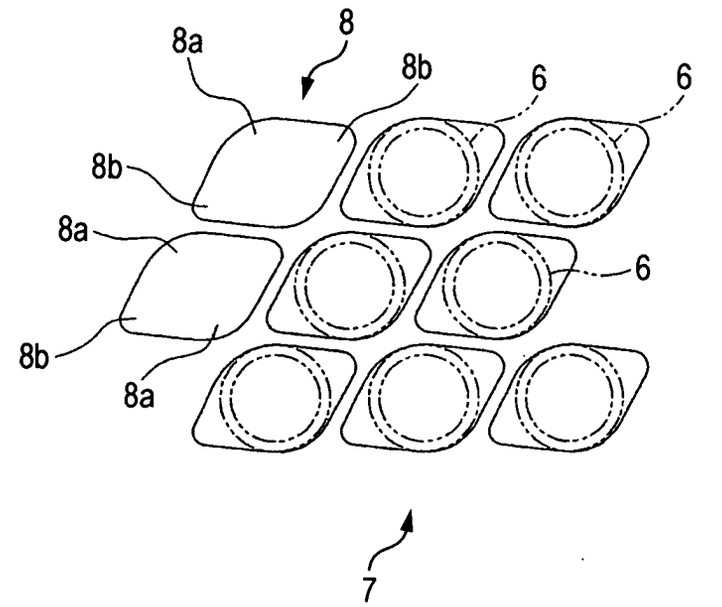

FIG. 2B

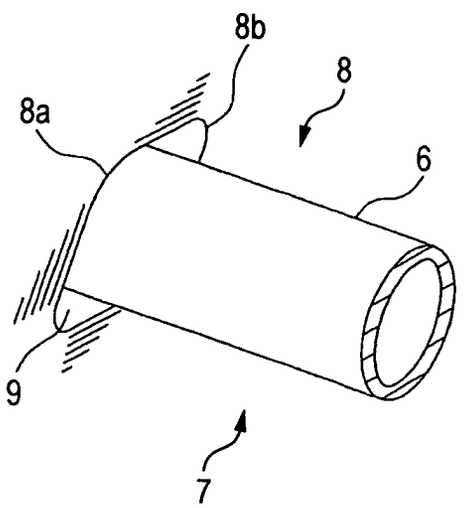

FIG. 3A

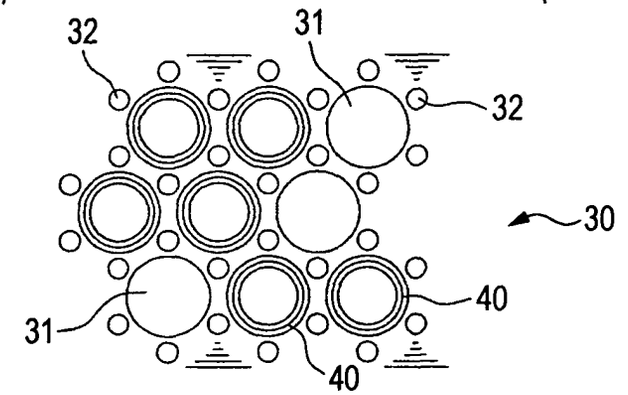

FIG. 3B

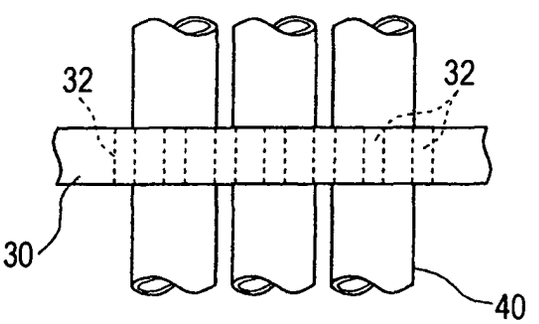

FIG. 4A

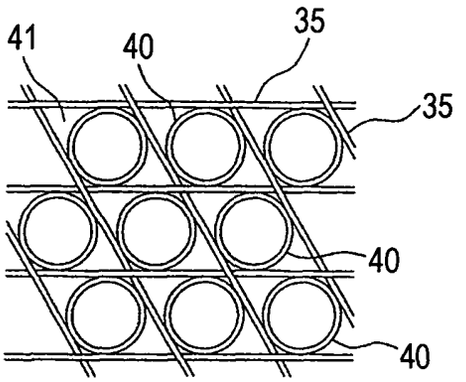

FIG. 4B