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Enomura(10) **Pub. No.: US 2012/0193072 A1**(43) **Pub. Date: Aug. 2, 2012**(54) **HEAT EXCHANGER**(52) **U.S. Cl. 165/81; 165/84**(76) **Inventor: Kaoru Enomura, Izumi-shi (JP)**(21) **Appl. No.: 13/395,155**(22) **PCT Filed: Nov. 24, 2009**(86) **PCT No.: PCT/JP2009/069815**

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A small heat exchanger can efficiently exchange heat, and can be produced at low cost in comparison with a conventional heat exchanger. In the heat exchanger, a heat-transfer tube can be easily replaced so that the heat exchanger can be used for a treatment which requires a low flow rate. A heat-transfer tube produced in the form of a coil is attached to, for example, a lower closing portion and an inner tube, which are integrally produced. The heat-transfer tube is pulled in the U-direction to reduce the diameter of the coiled portions and, thus, is closely bonded or welded to the inner tube. An outer tube and an upper closing portion are attached so that there is a slight gap between the outer tube and the outer diameter of the heat-transfer tube.

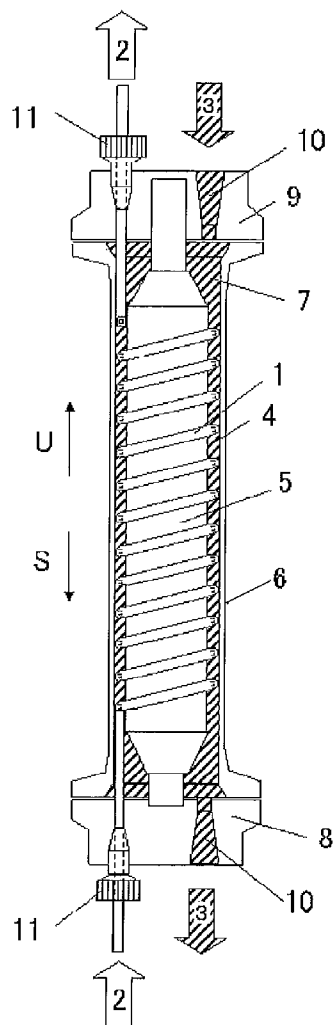


FIG. 1

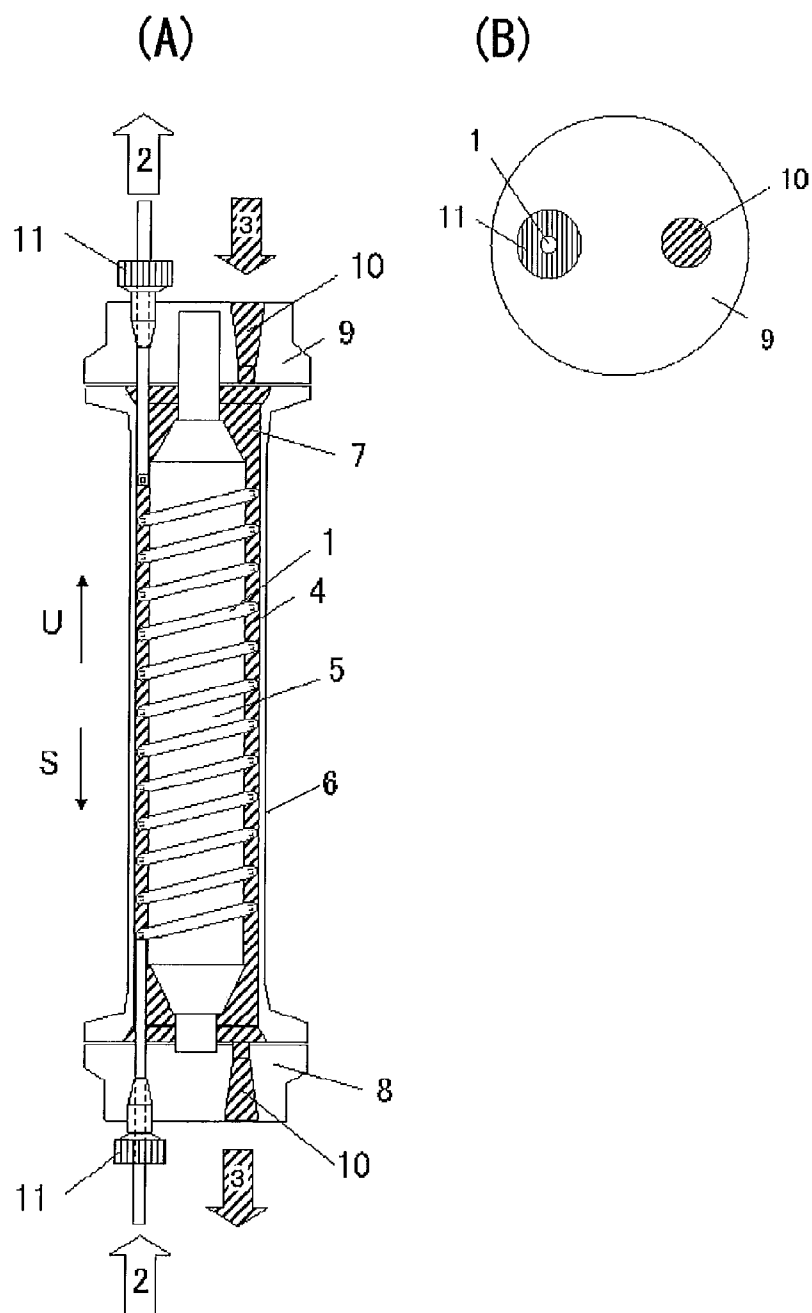


FIG. 2

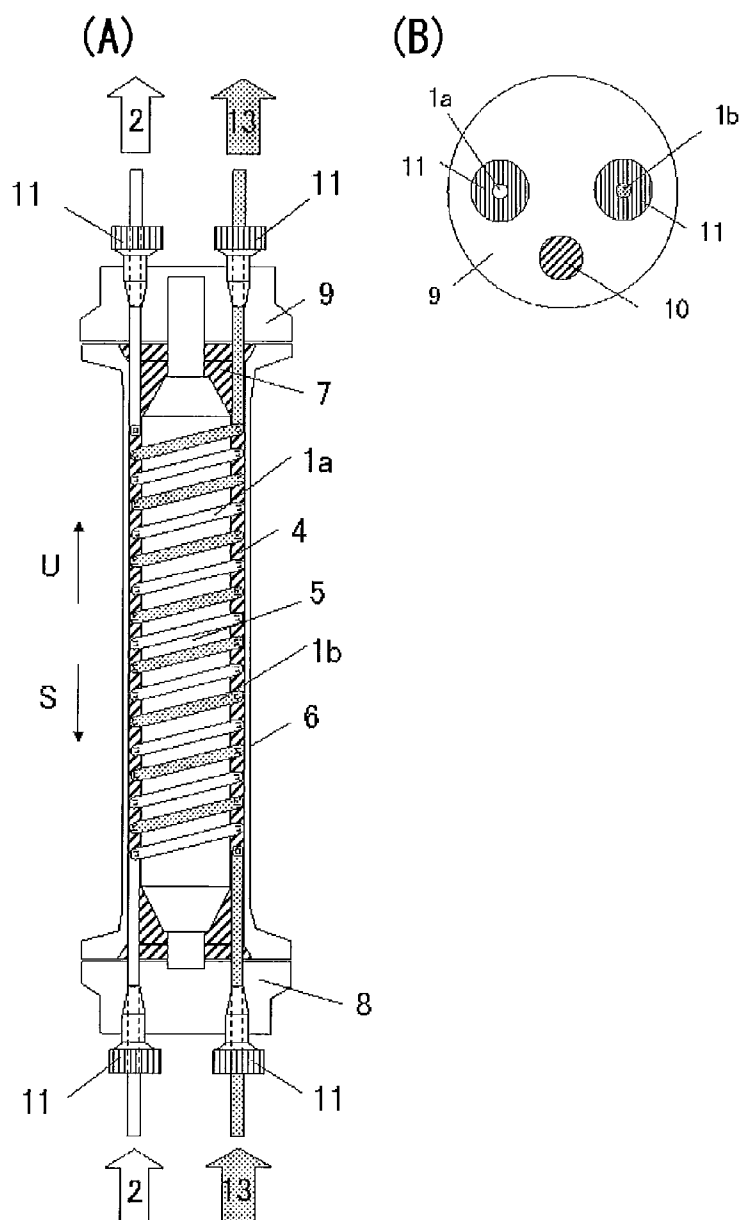


FIG. 3

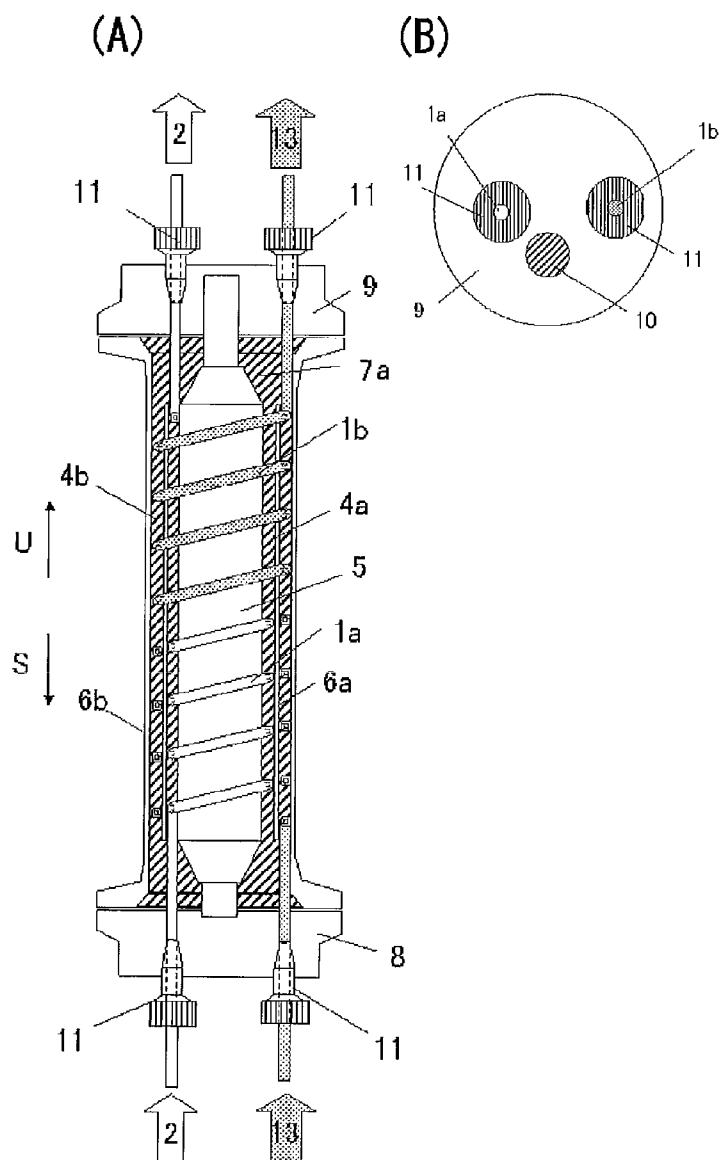
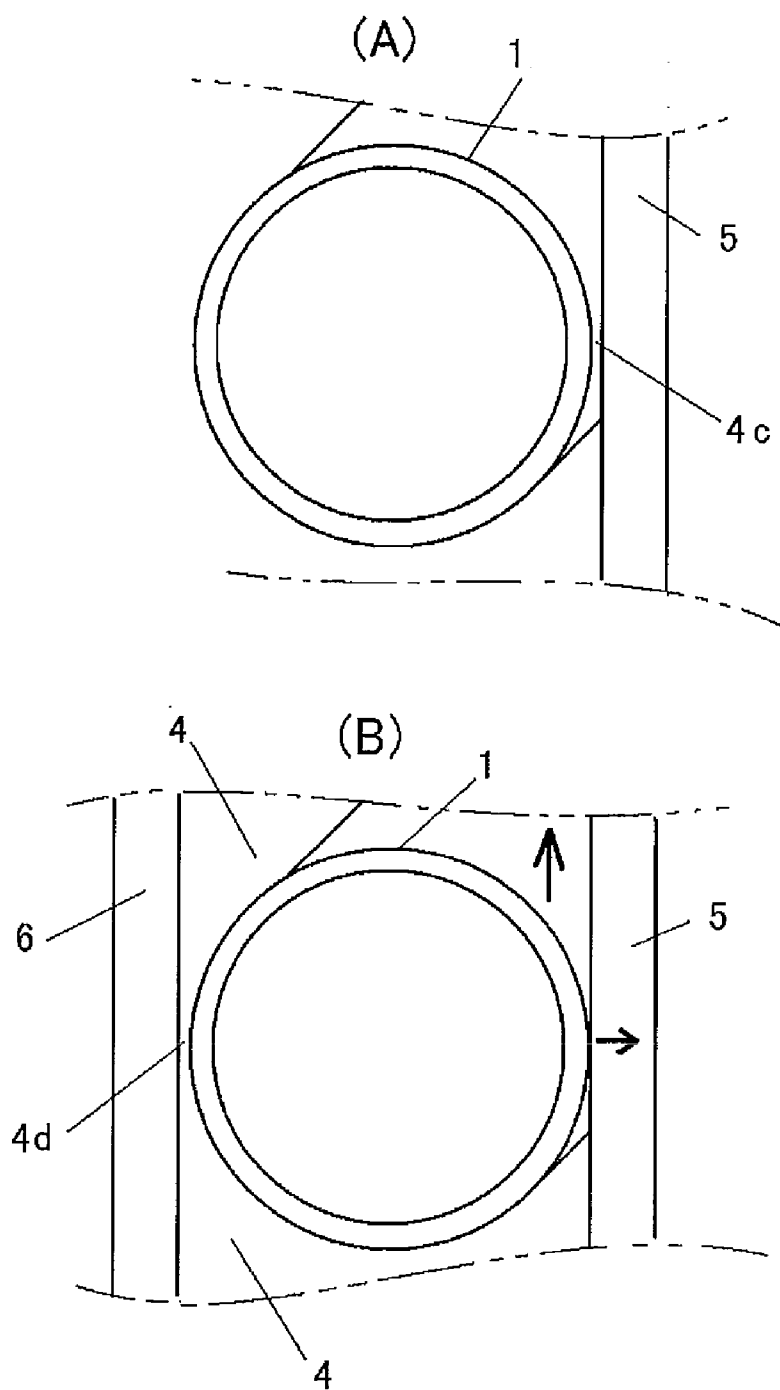


FIG. 4



HEAT EXCHANGER

TECHNICAL FIELD

[0001] The present invention relates to a heat exchanger. More specifically, the present invention relates to a heat exchanger such as a heater or a cooler capable of performing low flow processing of a fluid to be processed, especially, for the use of chemical experiments.

RELATED ART

[0002] Examples of performance generally required for the heat exchanger include heat exchanging performance, corrosion resistance, pressure tightness, robustness, cleaning properties, and downsizing. The heat exchanger also requires low cost production thereof. A multipipe heat exchanger, a double-pipe heat exchanger, a coiled heat exchanger, a plate heat exchanger, and the like are mainly used as the conventional heat exchanger. Such heat exchangers, however, have the complex structures or have difficulties in downsizing, is costly, and low cleaning properties. Especially, examples of the heat exchanger to be used in low flow processing, more specifically, in chemical experiments generally include a glass coil type heat exchanger and a glass double-pipe heat exchanger. In this case, the good heat exchanging performance is not expected because of low thermal conductivity of the glass itself. However, a large effort is required in cleaning the processed product adhering to a coil, or a perfect cleaning cannot be realized in some cases. As a result, many heat exchangers must be prepared, which is costly. Further, there is a high breakage risk. More specifically, in a case where a harmful processed product is passed, security measures therefore will also be costly.

[0003] As disclosed in Patent Document 1, conventionally known is a heat exchanger including a coiled heat-transfer tube placed in a space defined between an inner tube and an outer tube, wherein an inside space of the heat-transfer tube is used as one of flow paths, a coiled space between coiled sections of the heat-transfer tube in the space is used as the other flow path, and wherein an efficient heat exchange is achieved between one fluid and the other fluid.

[0004] However, in the heat exchanger disclosed in Patent Document 1, the heat-transfer tube is not fixed to either one of an outer peripheral surface of the inner tube or an inner peripheral surface of the outer tube but the heat-transfer tube is only naturally mounted. Therefore, in a case of a high-viscosity fluid, the heat-transfer tube expands or contracts due to a flow resistance, which may cause, for example, pitches between coiled sections to be non-uniform and partially narrower or tighter.

[0005] In consideration of production and disassembly of the heat exchanger of Patent Document 1, in a case of attachment and detachment of the coiled heat-transfer tube in the space defined between the inner tube and the outer tube, if a clearance between the heat-transfer tube, and the inner tube and the outer tube is increased, the attachment and the detachment of the coiled heat-transfer tube becomes easier. However, the coiled heat-transfer tube becomes freely movable in the space and thus a problem due to the expansion and contraction of the heat-transfer tube may arise. On the other hand,

if the clearance is eliminated, the attachment and detachment of the heat-transfer tube will be difficult.

RELATED ART DOCUMENT

Patent Document

[0006] Patent Document 1: JP2002-147976A

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0007] In view of the above, the present invention is to improve one type of heat exchangers, which includes a coiled heat-transfer tube placed in a space defined between an inner tube and an outer tube. An inside space of the heat-transfer tube is used as one of flow paths, and a coiled space defined between coiled sections of the heat-transfer tube in the space is used as the other flow path. Heat is exchanged between one fluid and the other fluid. More specifically, a purpose of the present invention is to provide a heat exchanger to/from which the heat-transfer tube can be attached or detached with ease. Further, another purpose of the present invention is to provide a heat exchanger capable of controlling a variation of the flow path area caused by a deformation of the heat-transfer tube due to a flow resistance. The present invention is directed to provide the heat exchanger that can achieve either one of the above described purposes. A more specific purpose of the present invention is to provide a heat exchanger that is small, has a good heat exchange property, and can perform low flow processing in which a fluid to be processed can be passed, especially, in various chemical experiments, with a cost less than those of the conventional heat exchangers.

Means for Solving the Problem

[0008] To solve the above problems, the invention recited in claim 1 provides a heat exchanger. The heat exchanger includes a coiled heat-transfer tube 1 placed in a space 7 defined between an inner tube 5 and an outer tube 6. An inside space of the heat-transfer tube 1 is used as one of flow paths, and a coiled space 4 between coiled sections of the heat-transfer tube 1 in the space 7 is used as the other flow path. Heat is exchanged between one fluid and the other fluid. The heat exchanger also includes a tensioning mechanism for keeping an expansion or contraction force for expanding or contracting a diameter of the coiled heat-transfer tube 1 than a diameter the heat-transfer tube 1 naturally has. The heat is exchanged between one fluid and the other fluid while the expansion and contraction force is applied to the heat-transfer tube 1 by the tensioning mechanism.

[0009] The invention recited in claim 2 provides the heat exchanger of claim 1, wherein the heat-transfer tube 1 may not be fixed either one of an outer peripheral surface of the inner tube 5 or an inner peripheral surface of the outer tube 6, and the tensioning mechanism may expand or contract a diameter of the coiled heat-transfer tube 1 than a diameter the tube naturally has, thereby bringing the heat-transfer tube 1 into close contact with or pressure contact against the inner tube 5 or the outer tube 6.

[0010] The invention recited in claim 3 provides the heat exchanger of claim 1 or 2, wherein a load in a coil axis direction applied may be equal to or less than 10 kg when the heat-transfer tube 1 varies a length of the coil in the coil axis direction by 10% in comparison with the length of the tube as it naturally has.

[0011] The invention recited in claim 4 provides the heat exchanger of claim 3, wherein the heat-transfer tube 1 may be made of a material selected from the group consisting of metals such as stainless steel, hastelloy, inconel, titanium, copper, and nickel; acrylic resins such as ABS, polyethylene, polypropylene, and PMMA; fluorine based resins such as polycarbonate, PTFE, and PFA; and an epoxy resin.

[0012] The invention recited in claim 5 provides the heat exchanger of claim 4, wherein an outer diameter of the heat-transfer tube 1 is equal to or less than 28 mm.

[0013] The invention recited in claim 6 provides a heat exchanger. The heat exchanger includes a coiled heat-transfer tube 1 placed in a space 7 defined between an inner tube 5 and an outer tube 6. An inside space of the heat-transfer tube 1 is used as one of flow paths, and a coiled space 4 between coiled sections of the heat-transfer tube 1 in the space 7 is used as the other flow path. Heat is exchanged between one fluid and the other fluid. In the heat exchanger, the coiled heat-transfer tube 1 is elastically deformed from its natural state so as to be brought into close contact with or pressure contact against the inner tube 5 or the outer tube 6 and the heat is exchanged between one fluid and the other fluid while the heat-transfer tube 1 is elastically deformed.

Effect of the Invention

[0014] The heat exchanger according to the present invention keeps a state that the expansion or contraction force is applied to the heat-transfer tube 1 by the tensioning mechanism in use, i.e., at least during the heat exchange. Therefore, the heat-transfer tube always receives the force and thus a deformation of the heat-transfer tube due to the flow resistance hardly occurs even if the heat-transfer tube does not contact the inner tube 5 or the outer tube 6. Therefore, a non-uniform deformation of the coiled heat-transfer tube 1 can be reduced. More desirably, even if the heat-transfer tube 1 is not fixed to either one of the outer peripheral surface of the inner tube 5 and the inner peripheral surface of the outer tube 6, the deformation occurs less by bringing the heat-transfer tube 1 to close contact with or pressure contact against the inner tube 5 or the outer tube 6 by an action of the tensioning mechanism.

[0015] Another operation and effect of the heat exchanger according to the present invention is to make the coiled heat-transfer tube 1 be easily attached or detached. More specifically, the heat-transfer tube 1 is placed freely with a suitable clearance defined between the inner tube 5 and the outer tube 6. Then, the heat-transfer tube 1 is placed in a tensed state to generate the expansion and contraction force to be brought into contact with either one of the inner tube 5 or the outer tube 6. The expansion and contraction force is then kept by the tensioning mechanism, thereby keeping the contacting state. Upon disassembly and the like, the expansion or contraction force is released to allow the heat-transfer tube to be detached with ease. Alternatively, the heat-transfer tube is placed in a pressure contact state by applying the expansion or contraction force after it is attached without the clearance (i.e., in the contacting state). Then, the pressure contact state is kept by the tensioning mechanism. Upon disassembly, the expansion or contraction force is released to allow the heat-transfer tube to be detached relatively easier.

[0016] More specifically, in addition to an effective heat exchange, the heat-transfer tube can be replaced easily even when a clogging or adhesion occurs in the heat-transfer tube. Therefore, disposal of or expensive cleaning the heat

exchanger itself is no longer necessary as it is required in the conventional heat exchangers. Further, an occurrence of the expansion or contraction of the heat-transfer tube due to a flow of heating medium can be avoided. Still further, since the structure can be simplified in comparison with the conventional ones, manufacturing steps can be reduced. As a result, the heat exchanger can be provided with lower cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1(A) illustrates a configuration of a heat exchanger according to one embodiment of the present invention and FIG. 1(B) is a plan view thereof.

[0018] FIG. 2(A) illustrates a configuration of a heat exchanger according to another embodiment of the present invention and FIG. 2(B) is a plan view thereof.

[0019] FIG. 3(A) illustrates a configuration of a heat exchanger according to still another embodiment of the present invention and FIG. 3(B) is a plan view thereof.

[0020] FIG. 4(A) is an enlarged view of a substantial portion of the heat exchanger according to the embodiment of the present invention in assembling and FIG. 4(B) is an enlarged view of a substantial portion of the heat exchanger when the assembling processing is completed.

BEST MODE FOR CARRYING OUT THE INVENTION

[0021] One embodiment of the present invention is described below with reference to the accompanying drawings. The terms “up,” “down,” “left” and “right” as used herein only refers to relative positional relationships but do not specify absolute positions.

[0022] As illustrated in FIG. 1, a heat exchanger of this embodiment includes an inner tube 5 and an outer tube 6 which have a substantially circular lateral cross section, wherein upper ends and lower ends of the inner tube 5 and the outer tube 6 are closed by an upper closing part 9 and a lower closing part 8, respectively. In this example, the inner tube 5 and the lower closing part 8 are integrally formed. According to another embodiment, not the lower closing part 8 but the upper closing part 9 may be integrally formed with the inner tube 5. Alternatively, none of the lower closing part 8 or the upper closing part 9 is integrally formed with the inner tube 5 but may be formed detachably.

[0023] A coiled heat-transfer tube 1 is placed in the space 7 defined between the inner tube 5 and the outer tube 6 such that the coiled heat-transfer tube 1 closely contacts with or pressure contacts against at least either one of an outer perimeter of the inner tube 5 or an inner perimeter of the outer tube 6. The coiled heat-transfer tube 1 pierces through the upper closing part 9 and the lower closing part 8, thereby being contactable with pipes outside the heat exchanger. However, the heat-transfer tube 1 is not fixed to either one of the outer peripheral surface of the inner tube 5 or the inner peripheral surface of the outer tube 6. A coiled space 4 is defined between turns of the coiled heat-transfer tube 1. The coiled space 4 having predetermined intervals is enclosed by the vertically adjacent different turns of the heat-transfer tube 1 and the inner and outer tubes 5, 6. The illustrated coiled heat-transfer tube 1, inner tube 5 and outer tube 6 are implemented in a cylindrical shape having a vertically uniform diameter. However, they may be formed into a shape having a vertically varying diameter (i.e., a circular truncated cone shape or an inverted circular truncated cone shape).

[0024] A fluid **2** to be processed, e.g., water, an organic solvent, a solution obtained by dissolving a solute, or a micro-particle dispersion liquid, passes through an inside of the heat-transfer tube **1**. A preferable material for the heat-transfer tube **1** can expand and contract and has a high corrosion and pressure resistance, and robustness against the target fluid to be processed through the heat-transfer tube. Examples of the material for the heat-transfer tube include a metal such as stainless steel, hastelloy, inconel, titanium, copper, and nickel; an acrylic resin such as ABS, polyethylene, polypropylene, and PMMA; a fluorine based resin such as polycarbonate, PTFE, and PFA; and an epoxy resin.

[0025] The external section of the heat-transfer tube **1** as the coiled space **4** (in other words, the coiled space **4** defined between the heat-transfer tube **1** and the heat-transfer tube **1**) is a space for passing a heating medium **3**. The heating medium **3** enters and exists through nozzles **10** formed in the upper closing part **9** and the lower closing part **8**, respectively. Accordingly, the heating medium **3** can be passed through the space **7** and the coiled space **4**. To efficiently and effectively exchange heat of the fluid **2** to be processed, the fluid **2** to be processed is passed upwardly (i.e., in a U direction) in FIG. **1** and the heating medium **3** is passed downwardly (i.e., in an S direction) to create an absolute counterflow. Accordingly, both of the fluid **2** to be processed and the heating medium **3** are prevented from an increase of a pressure loss, resulting in securing a large overall heat-transfer coefficient. However, a flow of both fluids in the same direction should not be excluded from consideration.

[0026] Assembly and disassembly of the heat exchanger according to the present invention are described below. Initially, the heat-transfer tube **1** is assembled with the lower closing part **8** and the inner tube **5** which are integrally formed. The above attachment can be performed smoothly by defining a suitable clearance **4c** between the inner tube **5** and the heat-transfer tube **1** (See FIG. **4(A)**). After the attachment, the heat-transfer tube **1** is fixed to the lower closing part **8**. The fixation is performed with what having a tensioning mechanism **11**. The tensioning mechanism **11** keeps the expansion or contraction force for expanding or contracting the diameter of the coiled heat-transfer tube **1** than the diameter the coiled heat-transfer tube **1** naturally has. In the illustrated example, an interlocking joint **11** is employed as the tensioning mechanism **11**. In another embodiment, the tensioning mechanism may include a clamp, a saddle band, a strap, and a bracket. In addition, the tensioning mechanism may be a fixation by, for example, welding or bonding (not illustrated). The tensioning mechanism **11** may be configured only to keep the expansion or contraction force, whereas, generation of the expansion or contraction force may be performed by another mechanism. However, in a case of the interlocking joint **11**, it generates as well as keeps the expansion or contraction force.

[0027] Then, the heat-transfer tube **1** is pulled in the U direction to reduce the diameter of the coiled heat-transfer tube **1**, thereby bringing the heat-transfer tube **1** into close contact with or pressure contact against the inner tube **5** (FIG. **4(B)**). Thereafter, the outer tube **6** slightly spaced by a gap **4d** from the outer diameter of the assembled coiled heat-transfer tube **1**, and the upper closing part **9** are assembled therewith. The outer tube **6** and the upper closing part **9** may be integrally formed or may be formed so as to be disassembled.

[0028] More specifically, the slight gap **4d** is kept while the heat-transfer tube **1** is pulled in the U direction. The outer tube **6** is then mounted to the outside of the heat-transfer tube **1** and

the upper closing part **9** is temporally attached thereto. During the temporal attachment, while the heat-transfer tube **1** is still pulled in the U direction, an upper end of the heat-transfer tube **1** is fixed to the upper closing part **9**, thereby completing the attachment between the outer tube **6** and the upper closing part **9**. The tensioning mechanism **11** of the upper closing part **9** may be configured to be adjustable of an upper end position of the outer tube **6** in the same manner as the interlocking joint **11** of the lower closing part **8** or may be an unadjustable fixing mechanism.

[0029] At the time, for enabling an easy assembling and disassembling, when the coiled heat-transfer tube **1** that can be expanded or contracted is varied by 10% of the expansion or contraction amount with respect to a length the coiled heat-transfer tube **1** naturally has, the load is preferably equal to or less than 10 kg. Also, for the purpose of the low flow processing, for example, in various chemical experiments, the outer diameter of the heat-transfer tube **1** is preferably equal to or less than 28 mm. Thereby, the coiled heat-transfer tube **1** having a smaller coil diameter can be produced and thus the heat exchanger of a smaller size can be provided.

[0030] The above example is suitable for the heat-transfer tube **1** naturally having an inner diameter larger than the outer diameter of the inner tube **5**. However, in a case where the inner diameter the heat-transfer tube **1** naturally has is larger than the outer diameter of the inner tube **5** and the outer diameter the heat-transfer tube **1** naturally has is larger than the inner diameter of the outer tube **6**, the following method is employable. During the above described temporal attachment, the tensile force in the U direction is released. Accordingly, the coiled heat-transfer tube **1** attempts to resume its natural size. As a result, the coiled heat-transfer tube **1** is brought into close contact with or pressure contact against the inner peripheral surface of the mounted outer tube **6**. In that state where the heat-transfer tube close contacts with or pressure contacts against the outer tube **6**, the upper end of the heat-transfer tube **1** is fixed to the upper closing part **9** to complete the attachment between the outer tube **6** and the upper closing part **9**.

[0031] Alternatively, in a case where the inner diameter of the heat-transfer tube **1** it naturally has is larger than the outer diameter of the inner tube **5** and the outer diameter of the heat-transfer tube **1** it naturally has is smaller than the inner diameter of the outer tube **6**, the following method is also employable. In other words, the heat-transfer tube **1** is attached with a suitable clearance **4c** between the inner tube **5** and the heat-transfer tube **1**, and the outer tube **6** having a slight gap with the outer coil diameter of the heat-transfer tube **1** is assembled with the upper closing part **9**. In this state, the heat-transfer tube **1** is pulled in the vertical direction so that the upper end and the lower end thereof separate from each other by, for example, operating the interlocking joint **11** to generate the expansion or contraction force (i.e., a contraction force in this case). Thereby, the diameter of the coiled heat-transfer tube **1** is reduced to bring the heat-transfer tube **1** into close contact with or pressure contact against the inner tube **5**. The expansion or contraction force is then kept to secure the close contact or pressure contact state.

[0032] In the above embodiment, the heat-transfer tube **1** is brought into close contact with or pressure contact against the inner tube **5**. However, in another embodiment, the heat-transfer tube **1** is pushed downwardly into the outer tube **6** from above, i.e., in the S direction (in other words, the upper end is brought closer to the lower end) to increase the coiled

diameter, thereby bringing the heat-transfer tube 1 into close contact with or pressure contact against the outer tube 6. Further, in the above example, the upper end and the lower end of the heat-transfer tube 1 is pushed or pulled in the coil axial direction. However, the upper end and the lower end of the heat-transfer tube 1 may be pushed or pulled in a direction in which a helical structure of the coil extends. The pushing or pulling direction can be changed, as required, provided that the expansion or contraction force can be generated. In the above description, the vertical orientation is exemplified, but the orientation may be inverted. More specifically, up and down can be interpreted as one side and the other side, respectively.

[0033] According to the above invention, the heat-transfer tube 1 can be placed in the space 7 defined between the inner tube 5 and the outer tube 6 so as to be on a concentric circle of the inner and the outer tubes. Therefore, the coiled space 4 sandwiched between the adjacent coiled sections of the heat-transfer tube 1 in the space 7 can be used as a flow path of the heating medium 3. The heat exchanger according to the present invention can be disassembled with ease according to a reversed procedure of the above assembling method.

[0034] In the case where the coiled heat-transfer tube 1 is not fixed in the space 7, the heat-transfer tube 1 may expand or contract due to the flow resistance of the heating medium 3, which may invite a case that the pitches between the coiled sections of the heat-transfer tube 1 become tight. In other words, the flow resistance of the heating medium 3 causes the coiled sections of the heat-transfer tube 1 become closer to each other and finally the coiled heat-transfer tube 1 may move to a direction the coiled space 4 is eliminated. In this case, since the heating medium 3 becomes not to pass smoothly in the coiled space 4, there arises a problem that the heat exchange cannot work at all, that the effective/efficient heat exchange cannot be performed, or that breakage or short-life of the heat-transfer tube 1 may be induced. In the present invention, although the heat-transfer tube 1 is not fixed, the heat-transfer tube 1 close contacts with or pressure contacts against at least either one of the outer perimeter of the inner tube 5 or the inner perimeter of the outer tube 6. Therefore, the coiled heat-transfer tube 1 can be prevented from the displacement caused due to the flow resistance that is generated by the flow of the heating medium 3. As a result, the above described problems can be solved.

[0035] The heat-transfer tube 1 may include a plurality of heat-transfer tubes. The number of the heat-transfer tubes 1 to be assembled together is not particularly limited. The number is determined according to a necessary flow rate of the fluid to be processed or the number of types of fluids to be treated. Examples of assembling the plurality of heat-transfer tubes are illustrated with reference to FIGS. 2(A) and 2(B), and FIGS. 3(A) and 3(B). For example, as illustrated in FIG. 2, in a case of assembling the heat-transfer tubes 1 having the same coiled diameter, the heat-transfer tube 1a and the heat-transfer tube 1b are assembled with the lower closing part 8 (or the upper closing part 9) and the inner tube 5, which are integrally formed, and are fixed at different positions on the lower closing part 8. Then, the heat-transfer tube 1a and the heat-transfer tube 1b are brought into close contact with or pressure contact against the inner tube 5 by the above described mechanism, followed by being further assembled with the outer tube 6 and the upper closing part 9 (or the lower closing part 8). Accordingly, the plurality of heat-transfer tubes 1 can be assembled. In another embodiment, as illustrated in FIG.

3, the coiled heat-transfer tubes 1 may be implemented in a manner that the diameters of the coiled heat-transfer tubes are located on concentric circles. In this case, the heat-transfer tube 1a is assembled with the lower closing part 8 (or the upper closing part 9) and the inner tube 5 which are integrally formed. The heat-transfer tube 1a is then brought into close contact with or pressure contact against the inner tube 5 by the above described mechanism. Then, the outer tube 6a spaced from the outer diameter of the coiled heat-transfer tube 1a by the slight gap is assembled therewith. Subsequently, the heat-transfer tube 1b is assembled with the lower closing part 8 (or the upper closing part 9) to bring the heat-transfer tube 1b into close contact with or pressure contact against the outer peripheral surface of the outer tube 6a by the above described mechanism. Then, the outer tube 6b and the upper closing part 9 (or the lower closing part 8) are assembled therewith. Accordingly, the plurality of heat-transfer tubes 1 can be assembled. In the embodiment illustrated in FIG. 3, the coiled spaces 4a and 4b are defined. Even in a case where more than three heat-transfer tubes are assembled together, this configuration can be implemented using a material and an assembling method similar to those described above. In this case, the assembly can be performed by a combination of the assembly based on the same diameter and the assembly based on the concentric circles.

[0036] As described above, passed through the heat-transfer tube 1 is the fluid 2 to be processed such as water, organic solvent, solution that is produced by dissolving solute, and microparticle dispersion liquid to be used in the low flow processing, more specifically, used in various chemical experiments. Therefore, the heat-transfer tube 1 often needs to be replaced depending on experiment descriptions. Furthermore, in a case where solid and powder contained in the fluid 2 to be processed, or solute dissolved in the fluid 2 to be processed is precipitated due to a change of temperature or concentration or due to drying, such solid matters may adhere or clog inside the heat-transfer tube 1 to invite a necessity of replacement of the heat-transfer tube 1.

[0037] In a submerged heat exchanger or double-pipe heat exchanger which is used in the typical low flow processing, especially, in various chemical experiments, a good efficiency in heat exchange cannot be expected. Therefore, the structure of the heat exchanger according to the present invention solves the above problems of the submerged heat exchanger and the double-pipe heat exchanger. Further, as described above, in a case when the heat-transfer tube 1 is required to be replaced, the heat exchanger according to the present invention is characterized in that it can be assembled or disassembled very easily because the heat exchanger according to the present invention has a very simple structure in comparison with the multipipe heat exchanger and the plate type heat exchanger. Also, in addition to the easy replacement of the heat-transfer tube, the heat exchanger can be easily disassembled and cleaned, so that it is not necessary to dispose the heat exchanger itself or perform a costly cleaning of the heat exchanger as it is done in the conventional heat exchanger.

[0038] There are a plurality of modes for achieving the close contact with or the pressure contact against the inner tube 5 and the outer tube 6 by using the elastic deformation of the heat-transfer tube. Such modes are described below.

[0039] (First Mode) It is provided that the outer diameter of the inner tube 5 is α , the inner diameter of the outer tube 6 is β , the inner diameter of the coiled heat-transfer tube 1 is γ , and the outer diameter of the coiled heat-transfer tube 1 is θ . If the

inner diameter γ of the coiled heat-transfer tube **1** is larger than or equal to the outer diameter a of the inner tube **5** ($\alpha \leq \gamma$), when the inner tube **5** is inserted into the heat-transfer tube **1** leaving it in the natural state and, the heat-transfer tube **1** is pulled in a direction in which both ends separates from each other after the insertion, the outer diameter a of the inner tube **5** comes to be equal to the inner diameter γ of the heat-transfer tube **1** by the external force to bring the heat-transfer tube **1** into close contact with or pressure contact against the inner tube **5**. Here, even in a case of $\alpha \leq \gamma$, the inner diameter γ may be increased by compressing the heat-transfer tube **1** in order to facilitate the insertion.

[0040] (Second Mode) If the inner diameter γ of the coiled heat-transfer tube **1** is smaller than the outer diameter a of the inner tube **5** ($\alpha > \gamma$), the inner tube **5** is inserted while the heat-transfer tube **1** is then compressed to expand the inner diameter γ . After the insertion, when the compressing force is released and the heat-transfer tube **1** is then pulled, as required, the outer diameter a of the inner tube **5** becomes equal to the inner diameter γ of the heat-transfer tube **1** due to the elastic deformation of the heat-transfer tube **1**, thereby bringing the heat-transfer tube **1** into close contact with or pressure contact against the inner tube **5**.

[0041] (Third Mode) If the outer diameter θ of the coiled heat-transfer tube **1** is smaller than or equal to the inner diameter β of the outer tube **6** ($\beta \geq \theta$), the heat-transfer tube **1** in its natural state is inserted into the outer tube **6** and, the heat-transfer tube **1** is then compressed after the insertion, the inner diameter β of the outer tube **6** comes to be equal to the outer diameter θ of the heat-transfer tube **1** by the external force, thereby bringing the heat-transfer tube **1** into close contact with or pressure contact against the outer tube **6**. Even in a case of $\beta \geq \theta$, the heat-transfer tube **1** may be pulled to reduce the outer diameter θ thereof in order to facilitate the insertion.

[0042] (Fourth Example) If the outer diameter θ of the coiled heat-transfer tube **1** is larger than the inner diameter β of the outer tube **6** ($\beta < \theta$), the heat-transfer tube **1** is pulled to reduce the diameter thereof, and then inserted into the outer tube **6**. After the insertion, when the pulling force is released and the heat-transfer tube **1** is then compressed, as required, the inner diameter β of the outer tube **6** comes to be equal to the outer diameter θ of the heat-transfer tube **1**, thereby bringing the heat-transfer tube **1** into close contact with or pressure contact against the outer tube **6**.

TABLE 1

Close-contacting component	Relation between diameters before insertion	State of heat-transfer tube 1 during insertion	External force after insertion
Inner tube 5	$\alpha \leq \gamma$	Natural state or compressed state	Pulling force
Inner tube 5	$\alpha > \gamma$	Compressed state	Unnecessary or Pulling force
Outer tube 6	$\beta \geq \theta$	Natural state or pulled state	Compressing force
Outer tube 6	$\beta < \theta$	pulled state	Unnecessary or Compressing force

DESCRIPTION OF REFERENCE NUMERALS

- [0043] **1**: Heat-Transfer Tube
 [0044] **3**: Heating Medium
 [0045] **4**: Coiled Space

- [0046] **5**: Inner Tube
 [0047] **6**: Outer Tube
 [0048] **8**: Lower Closing Part
 [0049] **9**: Upper Closing Part
 [0050] **11**: Tensioning Mechanism

1. A heat exchanger comprising a coiled heat-transfer tube placed in a space defined between an inner tube and an outer tube, an inside space of the heat-transfer tube being used as one of flow paths, a coiled space defined between coiled sections of the heat-transfer tube in the space being used as the other flow path, and heat being exchanged between one fluid and the other fluid, the heat exchanger further comprising:

a tensioning mechanism for keeping an expansion or contraction force acting to expand or contract a diameter of the coiled heat-transfer tube than a diameter the heat-transfer tube naturally has,

wherein the heat is exchanged between one fluid and the other fluid while the expansion or contraction force is applied to the heat-transfer tube by the tensioning mechanism.

2. The heat exchanger of claim 1, wherein the heat-transfer tube is not fixed to either one of an outer peripheral surface of the inner tube or an inner peripheral surface of the outer tube, and

wherein the diameter of the coiled heat-transfer tube is expanded or contracted than the diameter the heat-transfer tube naturally has, and the heat-transfer tube is brought into close contact with or pressure contact against the inner tube or the outer tube by the expansion or the contraction.

3. The heat exchanger of claim 1, wherein a load applied in a coil axis direction of the heat-transfer tube is equal to or less than 10 kg when a length of the coiled heat-transfer tube in the coil axis direction is varied by 10% in comparison with a length the coiled heat-transfer tube naturally has.

4. The heat exchanger of claim 3, wherein the heat-transfer tube is made of at least a material selected from the group consisting of metals such as stainless steel, hastelloy, inconel, titanium, copper, and nickel; acrylic resins such as ABS, polyethylene, polypropylene, PMMA; fluorine based resins such as polycarbonate, PTFE, and PFA; and an epoxy resin.

5. The heat exchanger of claim 4, wherein the outer diameter of the heat-transfer tube **1** is equal to or less than 28 mm.

6. A heat exchanger comprising a coiled heat-transfer tube placed in a space defined between an inner tube and an outer tube, an inside space of the heat-transfer tube being used as one of flow paths, and a coiled space defined between coiled sections of the heat-transfer tube in the space being used as the other flow path, heat being exchanged between one fluid and the other fluid,

wherein the coiled heat-transfer tube is elastically deformed from its natural state to be brought into close contact with or pressure contact against the inner tube or the outer tube, and the heat is exchanged between one fluid and the other fluid while the heat-transfer tube is elastically deformed.

7. The heat exchanger of claim 2, wherein a load applied in a coil axis direction of the heat-transfer tube is equal to or less than 10 kg when a length of the coiled heat-transfer tube in the coil axis direction is varied by 10% in comparison with a length the coiled heat-transfer tube naturally has.

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