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(54) SEALING STRUCTURE OF HEAT EXCHANGER AND HEAT EXCHANGER

(57) Provided is a sealing structure for a heat exchanger usingcaps which make installation processing of the caps easy and prevents liquid leakage, and a heat exchanger which, by working in combination with a flow channel member which impedes deformation, prevents space from forming between the cap and the flow channel member, thereby preventing liquid leakage. The heat exchanger (H) is provided with caps (2) which are installed by being inserted with pressure into the tubular flow channel member (1) and the openings on both ends of the flow channel member (1). The caps (2) are provided with a flow passage route (222) and diverging routes (271-278) for a heat medium to flow through, and an engaging member (23, 23b) which is a part to be engaged with the heat exchanger (H). The engaging member (23) has a larger radius than the inner diameter of the flow channel member (1), and concave grooves (251, 252) are formed along the entire perimeter of the engaging member in the longer direction of the circumference surface of the engaging member (23). The circumference surface of the engaging member (23) closely contacts the inner wall (12) of the flow channel member, and an open space (14) is formed

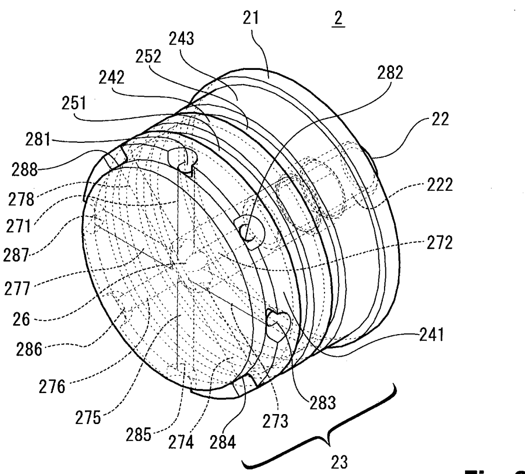

Fig. 3

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Description

[0001] The present invention relates to a sealing structure for a heat exchanger, as well as to a heat exchanger. More specifically, it relates to a heat-exchanger sealing structure and a heat exchanger wherein a part or the entirety of an outer peripheral surface of a fit-in portion pertaining to a cap that is used closely contacts an inner wall of a flow channel member to effect sealing.

Background art

[0002] The inventors of the present application, who carry out the development of heat exchangers, so far have proposed as a sealing structure for a heat exchanger a cap made of synthetic resin for tightly closing the interior such as shown with reference sign 3 in Figures 1 through 4 of patent literature 1 given below.

Prior art literature

Patent literature

[0003]

Patent literature 1: JP 2008 106974 A

[0004] The cap described in patent literature 1 has in a single piece an end stop portion with an outer diameter identical to an outer diameter of the flow channel member, and a fitting portion slightly smaller in diameter than an inner diameter of the flow channel member, with recessed grooves being formed in the outer peripheral surface of the fitting portion in two locations at a required distance in the longitudinal direction of the fitting portion around the entire circumference, a respective sealing material (an O-ring made of rubber, for example) being fitted into each of the recessed grooves, whereby a tightly closed state can be achieved between the outer peripheral surface of the fitting portion and the inner peripheral surface of the flow channel member.

Disclosure of the invention

Problems to be solved by the invention

[0005] The above tight-closing method is a method in widespread common use as a tight-closing method for pressured air and water supply members, being proven and a long-used and reliable general tight-closing method. With the above-described cap using O-rings,

(1) the installation work takes time because it includes multiple steps of application of grease to the O-rings, insertion of the O-rings into the recessed grooves, insertion of the cap into the pipe, and fixing of the cap and flow channel member with screws,

(2) further, depending on the level of skill of the worker, there may even more time than normally foreseeable be required, there also being the possibility that insufficient application of grease or twists of the O-rings during attachment cause leakage,

(3) ageing or deterioration due to frequent temperature changes in the flow channel member may occur in the O-rings that are fitted into the cap, and

(4) the O-rings, which are in contact with the inner wall of the flow channel member, may be worn by sliding because the cap attached to the flow channel member moves slightly due to changes in pressure, such that deteriorated or worn O-rings may lead to diminished sealing properties and become the cause of leakage of the heat medium.

[0006] The present inventors, through performing extensive further studies to solve the above problems, have come to envision a sealing structure for fitting the cap to the flow channel member, which prevents or suppresses leakage without using an O-ring.

[0007] In addition, because in a heat exchanger comprising the above sealing structure it is also conceivable that, when the flow channel member is expanded in the diametral or circumferential direction due to the heat of the heat medium, a gap arises between the cap and the inner wall of the flow channel member, with heat medium leaking from said gap, the present inventors, after performing yet further extensive studies to solve this problem, have come to envision a heat exchanger that, together with the above heat-exchanger sealing structure, comprises a flow channel member that impedes deformation.

(Objects of the invention)

[0008] Therefore, it is an object of the invention to provide a sealing structure for a heat exchanger using a cap which makes the mounting operation easy and prevents leakage, and furthermore to provide a heat exchanger comprising said sealing structure.
[0009] In addition, it is an object of the invention to provide a heat exchanger that, by comprising the above heat-exchanger sealing structure and deformation-impeding flow channel member, prevents gaps from occurring between the attached cap and the flow channel member, thereby preventing leakage.

Means for solving the problems

[0010] Means of the present invention employed in order to achieve the above object are as follows.
The present invention is a heat-exchanger sealing structure, being a sealing structure for an end portion of a heat exchanger having a tubular flow channel member with a cap attached by press-fitting to an opening portion at either end of the flow channel member, wherein the cap comprises a fit-in portion for being fitted into an opening end portion of the heat exchanger and a flow passage route formed to guide a heat medium from outside the flow channel member to inside the flow channel member or to emit the heat medium from inside the flow channel member to outside the flow channel member, wherein the fit-in portion of the cap is larger in diameter than an inner diameter of the flow channel member, and at least one recessed groove in a longitudinal direction of an outer peripheral surface of the fit-in portion is formed around an entire circumference of the fit-in portion, and wherein the outer peripheral surface of the fit-in portion closely contacts an inner wall of the flow channel member, an open space portion being formed between the recessed groove and the inner wall of the flow channel member.
[0011] In the above heat-exchanger sealing structure, the tubular flow channel member may be provided with a coating on its entire inner wall or on a part of the inner wall that contacts the outside surface of the fit-in portion.
[0012] The present invention is a heat exchanger comprising the above heat-exchanger sealing structure.
[0013] The present invention is a heat exchanger comprising the above heat-exchanger sealing structure, wherein at an outside surface of the flow channel member constituting the heat exchanger a plurality of grooves or strip-shaped recesses is formed along a portion or the entirety of a longitudinal direction of the surface.
[0014] The "heat exchanger" as referred to in the present description and appended claims is suited to be used for a variety of applications, for example as an air conditioner or radiant heating and cooling apparatus for architectural spaces such as houses, shops, offices, factories, gymnasia, theatres, assembly rooms, libraries, studios, hospitals, nursing homes, inns, hotels, event halls, warehouses (including refrigerated warehouses), precision rooms, cleanrooms, sterile rooms and the like, as an air conditioner or radiant heating and cooling apparatus for agricultural facilities such as hencoops, piggeries, cowsheds, greenhouses and the like, or as a water temperature regulator for pools, aquaria, fish farms, spa facilities and the like, or even as a humidity control apparatus, drying apparatus, far-infrared heating apparatus, snow melting system and heat recovery equipment.
[0015] The cap of which the fit-in portion is slightly larger in diameter than the inner diameter of the flow channel member is not particularly limited by its material as long as the latter is able to seal the heat medium in circulation, and can be formed of various known materials, e.g. metal such as stainless steel, aluminium or copper, ceramic material, wood, bamboo, carbon fibres, synthetic resin, as well as of a combination thereof. Furthermore, in order to increase adhesion to the inner wall of the flow channel member, at least the fit-in portion is formed preferably of a material having elasticity, semi-rigidity or rigidity to a degree that allows compression in the central axis direction, being suitable for use if formed for example of synthetic resins such as polyoxymethylene (e.g. DURACON, registered trademark of Polyplastics Co., Ltd.), MC NYLON (registered trademark of Nippon Polypenco Ltd.), fluorine resin, epoxy glass, phenolic resin, or silicone rubber.
[0016] For the "flow channel member", for example a metal such as stainless steel or aluminium, a synthetic resin including synthetic fibres, carbon fibres and the like is preferably used.
[0017] On the outside surface of the flow channel member, a coating layer can be provided. As the coating layer, for example paints and coatings can be employed. If the flow channel member is made of aluminium, aluminium anodisation treatment (alumite treatment) involving colourisation (e.g., black, blue, green, red, yellow, grey, white, gold or silver) with a dye adsorbed on the surface and the like are preferably used.
[0018] As the coating layer, in order to improve the heat exchange efficiency (heat exchange property), a layer excellent in thermal conductivity as well as heat dissipation and heat absorption properties may be provided. In order to suitably adjust the humidity exterior to the flow channel member, also a layer excellent in hydrophilic, hygroscopic and moisture

desorption properties may be provided. Further, in order to improve odour and VOCs (volatile organic compounds) outside the flow channel member and clean the air, also a layer having excellent antibacterial and adsorptive-degradation properties may be provided. Moreover, a coating layer excellent in the ability to generate negative ions, which enable to obtain a environmental healing space, may be provided.

[0019] As coating layers with hydrophilic, hygroscopic and moisture desorption properties or antibacterial and adsorptive-degradation properties, layers formulated with carbon such as activated carbon, activated alumina, silica gel, titanium dioxide, crosslinked sodium polyacrylate, titanium oxide, ion exchange resin, bentonite, diatomaceous earth and the like are given as examples without limitation thereto. Further, as coating layers that generate negative ions, for example layers formulated with activated carbon, ceramics, tourmaline etc may be mentioned without limitation thereto.

[0020] The "flow passage route", as long as being enabled to guide heat medium from outside the flow channel member to inside the flow channel member, or being enabled to emit heat medium from inside the flow channel member to outside the flow channel member, is not intended to limit aspects in particular. As an example of a flow passage route for guiding heat medium from outside the flow channel member to inside the flow channel member may be given a configuration that passes through from the basal end side to the distal end side, comprising a guide-in portion provided on the basal end side of the cap to guide in the heat medium, a distribution section provided in the interior of the cap wherein a distal end of the guide-in portion radially diverges, and discharge sections where respective flow channels diverged from the distribution section open at the outer peripheral side of the cap distal end, so as for the heat medium to flow efficiently along the inner wall of the flow channel member.

[0021] For the "heat medium", as long as it is sufficiently capable of storing heat energy, there is no type to be specified in particular, with both liquids and gases being possible.
As a liquid, for example water (including hot water, cold water, etc.), antifreeze liquid (e.g. a 37% solution of propylene glycol blended with corrosion inhibitor: operating temperature range -20°C to 70°C), oil or the like may be suitably used.
As a gas, for example a refrigerant gas capable of cooling and heating (in case of heating: carbon dioxide, in case of cooling: ammonia, in case of heating and cooling: HFCs (hydrofluorocarbons) and other new refrigerants) may be suitably used.

[0022] For the "coating" provided on the inner wall of the flow channel member of the heat exchanger, for example, when the flow channel member is made of aluminium overall or at the surface, aluminium anodisation (alumite treatment) and the like may be mentioned.

[0023] The "grooves or strip-shaped recesses" as referred to in the present description and appended claims, may for example be formed by carrying out rolling with a blade (cutter) pressed against the surface of the flow channel member, or machining using a lathe or the like (so-called knurling), or may be moulded by known techniques such as extrusion.

(Operation)

[0024] The operation of the heat-exchanger sealing structure and of the heat exchanger according to the present invention will be explained.

<Sealing structure of the heat exchanger>

[0025] The assembly of the heat exchanger is done by press-fitting a (fit-in portion of a) cap to either end of the flow channel member.
After the assembly of the caps and both ends of the flow channel member, the outer peripheral surface of the fit-in portions of the caps and the inner wall of the flow channel member are in close contact, with open space portions having formed between the inner wall of the flow channel member and the recessed grooves of the fit-in portions.
The places where the outer peripheral surface of the fit-in portions closely contacts the inner wall of the flow channel member provide sealing lest the heat medium leak from inside the flow channel member, and generate a frictional force at the closely contacting portion so that the caps are unlikely to come off.

[0026] On the other hand, the open space portions formed between the recessed grooves and the inner wall of the flow channel member, by reduction of the close-contact portions at the location of the recessed grooves lessen the friction force that occurs at the fit-in portion during the press-fitting, such that the cap can be fitted more easily (the force necessary for press-fitting the cap is reduced).
Moreover, even supposing that a small amount of heat medium leaked into an open space portion due to a scratch or the like having occurred where an outer peripheral surface of the fit-in portion is in close contact with the inner wall of the flow channel member, said open space portion would act as a liquid stopper (liquid reservoir) so as not to let the heat medium leak any further (to the basal end side), with other outer peripheral surfaces on the basal end side by close contact with the inner peripheral wall of the flow channel member providing sealing that further prevents the heat medium from leaking.

[0027] For structures where the tubular flow channel member is provided with a coating on its entire inner wall or on a part of the inner wall that contacts the outside surface of the fit-in portion, due to said coating, the adhesion between the fit-in portion (the outer peripheral surface of the fit-in portion or a protrusion formed on the fit-in portion) of the cap and the inner wall of the flow channel member is further enhanced.
In addition, because scratches and splinters that were generated on the face of the inner wall during machining etc of the flow channel member are covered by the coating, scratching or defects on the outer peripheral surface of the fit-in portion will be less likely to occur during press-fitting of the cap.

<Heat exchanger>

[0028] A heat exchanger comprising the above sealing structure, by letting heat medium flow from the outside into the interior of the flow channel member, performs heating or cooling of the outside by way of heat exchange with the heat medium.
At this time, the heat medium passes through the flow passage route formed in the cap on one side to be guided from outside the flow channel member to inside the flow channel member, passes through inside the flow channel member, and passes through the flow passage route formed in the cap on the other side to be emitted from inside the flow channel member to the outside. During this time, the sealing structure prevents the heat medium from leaking from outside the flow passage route of the caps, and the caps from falling off.

<Heat exchanger wherein a plurality of grooves or strip-shaped recesses is formed along a portion or the entirety of a longitudinal direction of the outside surface of the flow channel member>

[0029] Depending on the material of which the flow channel member is formed, forces striving to expand or contract the flow channel member in the diametral direction may arise due to the heat of the heat medium when the heat medium flows inside the flow channel member.
At this time, the plurality of grooves or strip-shaped recesses formed along the portion or the entirety of the longitudinal direction of the outside surface of the flow channel member causes expansion and contraction locally within regions of elastic deformation, such that by this action the forces striving to expand or contract the flow channel member in the diametral direction are dispersed and the pipe diameter of the flow channel member is kept constant. As a result, an accurately tightening action is effective wherever the caps and the flow channel member are in contact, such that quality instabilities arising from machining errors are eliminated.
[0030] In addition, the grooves or strip-shaped recesses of the flow channel member enable a larger outer surface area than that of an ordinary pipe (without surface machining) to be provided, such the heat exchange efficacy is high and heating or cooling to the outside is swiftly performed.

Effect of the invention

[0031] According to the present invention, a sealing structure for a heat exchanger and a heat exchanger can be provided wherein, in the attachment operation for the caps, the quality of the product is stable because quality fluctuations resulting from the level of skill of the operating personnel are hard to occur, leakage is unlikely and the operation is facilitated by a reduction in work processes.
Moreover, according to the present invention, a heat exchanger can be provided wherein the cap mounting operation is simple, and a sealing structure of the heat exchanger works in combination with a flow channel member that impedes deformation to make gaps between the flow channel member and the attached caps unlikely to occur, thereby preventing leakage.

Brief explanation of the drawings

[0032]

[Figure 1] Perspective drawing of a heat exchanger according to the present invention.

[Figure 2] Cross-sectional drawing of a flow channel member in accordance with the heat exchanger of Figure 1 and explanatory drawing enlarging a portion thereof.

[Figure 3] Explanatory perspective drawing of a cap according to a first embodiment, showing its internal structure by dotted lines.

[Figure 4] Frontal drawing of the cap, showing its internal structure by dotted lines, in a state fitted to the heat exchanger of Figure 1.

[Figure 5] Explanatory drawing showing a heat exchanger in a state having been fitted with caps according to the first embodiment.

[Figure 6] Explanatory perspective drawing of a cap according to a second embodiment, showing its internal structure by dotted lines.

[Figure 7] Explanatory drawing showing a heat exchanger in a state having been fitted with caps according to the second embodiment.

Embodiments of the invention

[0033] Embodiments of the present invention will be explained in greater detail based on the figures.

<First embodiment>

[0034] Based on Figures 1 through 5, an embodiment of the present invention (first embodiment) will be explained in greater detail.
A heat exchanger H, which comprises a flow channel member in circular-tube shape having a required length and caps 2 sealing both ends thereof, is able to heat or cool the exterior by letting a heat medium flow through the flow channel member 1 to perform heat exchange of heat energy possessed by the heat medium, through the peripheral wall of the flow channel member 1 with the exterior.
A detailed explanation of the individual parts will be given below.

<Flow channel member 1 >

[0035] The flow channel member 1 formed in circular-tube shape comprises an outside surface 11 and an inner peripheral surface 12. Internal spaces generated between an outer peripheral surface of a core member 3, to be described, and the inner peripheral surface 12 of the flow channel member 1 provide flow channels 13 through which the heat medium flows.
The core member 3, being a regular hexagonal rod (regular hexagonal column) shape formed of thermally insulating polyethylene foam, is housed in the interior of the flow channel member 1 as shown in Figure 5. In addition, caps 2 formed of synthetic resin are detachably secured at both ends of the flow channel member 1 to seal the interior. A description of the caps 1 and the core member 3 will be given later.
[0036] While in the present embodiment the flow channel member 1 is formed of aluminium having excellent thermal conductivity, it is not limited thereto but may be formed of, for example, a metal such as stainless steel, a synthetic resin containing synthetic fibres, carbon fibres or the like.
[0037] On the outside surface 11, a large number of grooves extending in longitudinal direction over the length of the flow channel member 1 is formed, such as to cover (see Figure 1) the outside surface 11 by the grooves (no reference sign). In the present embodiment, the grooves are substantially sawtooth-shaped when viewed in cross section, being formed of alternately repeating obtuse-angled peaks and valleys, wherein for safety the vertices of the peak portions have been machined such as to become rounded (see Figure 2).
[0038] It should be noted that the appearance of the grooves is not limited to the above, but may for example be an appearance formed by alternately repeating peaks and valleys that are acute-angled in cross sectional view, an appearance formed by alternately repeating peaks and valleys of semicircular cross section, an appearance of spur gear shape or an appearance formed by alternately repeating peaks and valleys of other concavities and convexities.
[0039] Further, the outside surface 11 has been subjected to aluminium anodisation treatment (alumite treatment) over the entire area, to further enhance thermal conductivity, heat dissipation or heat absorption properties of the flow channel member 1. The surface 11 may be coloured with a dye adsorbed on the surface during anodisation.
[0040] The inner peripheral surface 12 is provided over its entire area with a coating to enhance adhesion with fit-in portions 23 of the caps 2, the coating being formed by aluminium anodisation (alumite treatment). It should be noted that the coating is not limited to being formed by alumite treatment, but may be formed by a known material having water resistance, heat resistance, chemical resistance and so forth in accordance with the circulating heat medium.
[0041] While in the present embodiment a coating layer formed by aluminium anodisation is provided on the outer peripheral surface portion of the flow channel member, it may not necessarily be provided if the flow channel member has sufficient thermal conductivity, heat dissipation properties or heat absorption properties. Furthermore, even if pro-

vided, the type of the coating layer is not limited to those described above but may be changed depending on functionality to be added.

[0042] For example, in order to improve the heat exchange efficiency of the heat exchanger H, a coating layer excellent in thermal conductivity as well as heat dissipation and heat absorption properties may be provided. Further, in order to suitably adjust the humidity exterior to the flow channel member of the heat exchanger H, a coating layer excellent in hydrophilic, hygroscopic and moisture desorption properties may be provided. Further, in order to improve odour and VOCs outside the flow channel member of the heat exchanger H and clean the air, a coating layer having excellent antibacterial and adsorptive-degradation properties may be provided, and moreover preferably a coating layer excellent in the ability to generate negative ions, which enable to obtain a environmental healing space, may be provided.

<Caps 2>

[0043] The caps 2 are moulded of polyoxymethylene, with identically structured caps being secured on both ends (inlet side and outlet side) of the flow channel member 1. Each cap 2 is secured in the same way by a mounting method and structure that will be described later.

The caps 2 constitute a means for distributing the heat medium flowing in from the outside of the heat exchanger H within the flow channel member 1 (i.e., into the respective flow channels 13 to be described later) and a means for joining the heat medium having passed through the flow channel member 1 to send it to a hose or flow pipe (being the flow passage route following next).

[0044] The caps 2 comprise in a single piece an end stop portion 21 with the same outer diameter as the outer diameter of the flow channel member 1 and a fit-in portion 23 to be fitted in with a slightly larger diameter than the inner diameter of the flow channel member 1. The end stop portion 21 is intended to act as a stopper when the cap 2 is mounted to the flow channel member 1 end portion by fitting in the fit-in portion 23.

[0045] At the outer peripheral surface of the fitting portion 23, recessed grooves 251, 252 are formed around the entire circumference at a required distance in two locations in the longitudinal direction of the fitting portion 23.

Note that the fitting portion 23 has a shape wherein the outer peripheral surface of the fitting portion 23 is triply divided by the recessed grooves 251, 252, each of the outer peripheral surfaces providing a respective sealing portion 241, 242, 243. In agreement with what was said above, the sealing portions 241, 242, 243 are slightly larger in diameter than the inner diameter of the flow channel member 1.

When the cap 2 is inserted into the flow channel member 1, the recessed grooves 251, 252 turn into open space portions 14 that are sealed between the outer peripheral surface of the fit-in portion 23 and the inner peripheral surface 12 of the flow channel member 1.

[0046] The cap 2 is provided with a connexion member 22 in the direction of the central axis from the centre of the outer end surface of the end stop portion 21 toward the interior.

The connexion member 22 is a cylindrical body capable of introducing the heat medium from outside the flow channel member to inside the flow channel member, or of discharging the heat medium from inside the flow channel member to outside the flow channel member, wherein the interior of the cylinder acts as a flow passage 222 through which the heat medium flows.

At the distal end (the part protruding from the end stop portion 21 toward the outside) of the connexion member 22, a threaded portion 224 is provided (see Figure 5) for being screwingly attached or connected to a hose, flow pipe or other such implement known in the art to become a flow passage route for the heat medium.

[0047] The other end (proximal end) of the connexion member 22 is situated inwards in the longitudinal direction of the cap 2, linking up, as shown in Figures 3, 4 and 5, to a distribution section 26.

The distribution section 26 is formed divergingly so as to distribute the heat medium from the other end of the flow passage 222 in radial directions (a total of eight directions) toward the outer periphery of the cap 2, with diverging flow channels 271, 272, 273, 274, 275, 276, 277, 278 (hereinafter denoted as "diverging flow channels 271-278" when making collective reference) that allow flow passage of the heat medium toward the outer periphery being provided extending from the distribution section 26.

The ends of the individual diverging flow channels 271-278 are linked to hole-shaped discharge sections 281, 282, 283, 284, 285, 286, 287, 288 (hereinafter denoted as "discharge sections 281-288" when making collective reference) formed along the outer circumferential direction of the cap 2, with the heat medium flowing from each discharge section into the flow channel member 1.

The discharge sections 281-288 are formed on the side of the distal end of the cap 2 at the peripheral surface of the sealing portion 241, the vicinity of each discharge section being cut out in a hemispherical shape that opens toward the distal side of the cap 2 (see Figure 3). Due to the hemispherical cut-outs the heat medium flowing out from the respective discharge sections is guided toward the other cap 2 fitted on the opposite side.

[0048] While in the present embodiment the connexion member 22 is formed by insertingly fixing a cylinder of required length that comprises the threaded portion 224 into a hole (being linked to the respective diverging flow channels 271-278, used with the same meaning further down in this paragraph) formed in the cap 2, it is not limited thereto but may, for example, be cast with the cap 2 as a single piece, or be formed by gluing on a cylinder of required length that comprises the threaded portion 224 along an extension of the hole formed in the cap 2.

<Core member 3>

[0049] The core member 3 is formed with polyethylene foam in a regular hexagonal column shape. The core member 3, being a solid body slightly shorter than the entire length of the flow channel member 1, by being housed inside the flow channel member 1 causes open spaces, which are to become flow channels 13 for the heat medium to flow through, to arise between the outer peripheral surface of the core member 3 and the inner peripheral surface 12 of the flow channel member 1.

[0050] The core member 3 is formed such as to abut with each edge portion over the entire length the inner peripheral surface 12 of the flow channel member 1, and is housed within the flow channel member 1 in a state where each edge portion has been brought into contact with the inner peripheral surface 12.

By housing in this way the core member 13 in the interior of the flow channel member 1, the flow channels 13 for the heat medium to flow through are formed by the inner peripheral surface 12 of the flow channel member 1 and the outer peripheral surface of the core member 3.

Since the core member 3 has a regular hexagonal column shape, the flow channels 13 are formed in six locations along the circumferential direction in a state of being partitioned from each other. The flow channels 13 enable the heat medium to be circulated in contact with substantially the entire surface of the inner peripheral surface 12 of the flow channel member 1.

[0051] Besides, in each edge of the core member, flow passage grooves formed by cutting out the edge portion over a prescribed width in the axial circumferential direction may be provided, wherein a plurality of such flow passage grooves may be provided at an identical position along the longitudinal direction of the core member, and furthermore at a plurality of positions along the longitudinal direction as well. By letting the flow channels communicate, the flow passage grooves facilitate flow as they enable a smooth flow by averaging the pressure in each flow channel.

[0052] It is noted that the polyethylene foam used in this embodiment for the core member 3, being a closed-cell body, is also excellent in chemical resistance. Therefore, the heat medium does not infiltrate the core member 3, which enables to prevent or suppress degradation of the thermal insulation performance due to infiltration. Also, the occurrence of deformation and decomposition or dissolution when being chemically attacked is enabled to be prevented or mitigated. However, the core member it is not limited to said material but may be a metal such as aluminium, or a material having good thermal insulation such as polyethylene foam, polypropylene foam, rigid polyurethane foam, polyvinyl chloride foam, rubber (including synthetic rubber), synthetic resin, plastic or the like.

[0053] As long as the shape of the core member 3 is capable of forming flow channels in cooperation with the flow channel member, the shape is not particularly limited; as examples, a cylindrical column shape, polygonal column shapes such as a triangular column shape, quadrangular column shape, pentagonal column shape, hexagonal column shape, octagonal column shape and the like can be given. Furthermore, not only may the core member be a solid body, but it may also be a body having a void therein (e.g. a tubular body).

(Operation)

[0054] Referring to Figures 1 through 5, the sealing structure for a heat exchanger according to the present embodiment and the operation of the heat exchanger H will be explained.

<Sealing structure of the heat exchanger H>

[0055] The assembly of the heat exchanger H is done by press-fitting the fit-in portions 23 of the caps 2 to both ends of the flow channel member 1.

It is noted that, since the friction force that occurs at the fit-in portion during the press-fitting is lessened by reduction of the close-contact portions at the location of the recessed grooves 251, 252 provided in said part, the press-fitting is possible with less (weaker) force as compared to a cap where such grooves are not provided, thus making the caps 2 easy to fit in (the force required for press-fitting the caps 2 small).

[0056] After the assembly of the caps 2 and both ends of the flow channel member 1, the outer peripheral surface of the fit-in portions 23 of the caps 2 (i.e., the sealing portions 241, 242, 243) and the inner peripheral surface 12 of the end portions of the flow channel member 1 are in close contact, with open space portions 14 being formed between the inner peripheral surface 12 of the flow channel member 1 and the recessed grooves 251, 252 of the fit-in portions 23 (see Figure 5).

The places where the sealing portions 241, 242, 243 of the fit-in portions 23 closely contact the inner peripheral surface

12 of the flow channel member 1 provide sealing lest the heat medium leak from inside the flow channel member 1, and generate a frictional force so that the cap 2 is unlikely to come off.

[0057] The inner peripheral surface 12 with the coating by aluminium anodisation being provided further enhances, due to said coating, the adhesion of the sealing portions 241, 242, 243 of the caps 2 with the contacted parts.

[0058] Moreover, even supposing that a small amount of heat medium leaked into an open space portion 14 due to a scratch or the like having occurred where a sealing portion 241 (or 242) is in close contact with the inner peripheral surface 12, said open space portion 14 would act as a liquid stopper (liquid reservoir) so as not to let the heat medium leak any further (toward the end stop portion 21), with the sealing portion 242 (or 243) of the cap 2 by close contact with the inner peripheral surface 12 providing sealing that further prevents the heat medium from leaking.

[0059] Thus, during the attachment operation for the caps 2 it is sufficient to merely fit the caps into the flow channel member 1, with the quality of the product being stable because quality fluctuations resulting from the level of skill of the operating personnel are hard to occur, leakage being unlikely and the operation being facilitated by a reduction in work processes.

<Heat exchanger H>

[0060] The heat exchanger H comprising the above-described sealing structure is able to fulfil the function of heating a facility etc where it is installed when in the flow channels 13 a warm heat medium is made to flow through, and to fulfil the function of cooling a facility etc where it is installed when a cold heat medium is made to flow through. The temperature of the heat medium being made to flow through is intended to be set appropriately depending on the application and on where it is installed and is not particularly limited.

Also, a higher heating or cooling effect can be expected for an air conditioner comprising a plurality of heat exchangers H, due to action similar to the following.

[0061] By installing the heat exchanger H in air in a house or other facility etc, the outside surface of the flow channel member 1 is exposed with a required length to the space, for example.

The heat medium is heated or cooled to a required temperature by a temperature control unit (not shown) provided in the flow path, and fed by a pump into the heat exchanger H.

The heat medium is introduced through the connexion member 22 into the flow passage 222 of the cap 2, further passing from the distribution section 26 via the respective diverging flow channels 271-278 before being discharged from the discharge sections 281-288 to be sent to the respective flow channels 13 (See Figures 3 through 5.).

[0062] Furthermore, a switching means for enabling and disabling flow of the heat medium may be added to the distribution section 26 or the respective diverging flow channels 271-278. Accordingly, it is possible to select some of the flow channels 13 for the heat medium to be allowed to flow through, for example may within the flow channel member 1 the heat medium be disabled from flowing through flow channels 13 on a side where due to circumstances of placement heat exchange is not performed etc, such that furthermore efficient heat exchange without waste becomes possible.

[0063] The heat medium passing through each flow channel 13 directly performs heat exchange with the flow channel member 1, while heat exchange with surrounding matter or the ambient air in contact with the outer surface of the flow channel member 1 is performed indirectly via the flow channel member 1. This heat exchange is performed by heat transfer due to convection, radiation or conduction.

In other words, if the temperature of the heat medium undergoing heat exchange with the flow channel member 1 is higher than the ambient air or matter, the temperature of the ambient air or matter rises due to the heat exchange between the flow channel member 1 and the ambient air or matter while the temperature of the heat medium falls.

And conversely, if the temperature of the heat medium undergoing heat exchange with the flow channel member 1 is lower than the ambient air or matter, the temperature of the ambient air or matter falls due to the heat exchange between the flow channel member 1 and the ambient air or matter while the temperature of the heat medium rises.

[0064] By being distributed as described above when the heat exchange is performed, the heat medium flows such that flow rate and flow velocity in the respective flow channels 13 become substantially uniform.

Moreover, the heat medium that flows through the interior of the flow channel member 1, without passing through the central portion of the flow channel member 1 where the core member 3 is accommodated, flows along the respective flow channels 13 touching substantially the entire inner peripheral surface 12 of the flow channel member 1 except the contact portions of the edge portions of the core member 3. In other words, by not letting the heat medium flow through the central portion of the flow channel member 1 where it cannot perform heat exchange while letting it flow in contact with the inner peripheral surface 12 where it can directly perform heat exchange, efficient heat exchange is possible. Moreover, because the core member 3 is excellent in thermal insulation, heat exchange between the heat medium and the core member 3 is virtually not performed, resulting in even higher efficiency.

[0065] That is, when comparing the heat exchanger H of the present invention to a common tubular heat exchanger lacking the core member 3, when the flow rate of the heat medium is made the same, i.e. when the amount of heat to be supplied is the same, the heat exchanger H of the present invention can increase or decrease the temperature of the flow channel member 1 to a predetermined temperature in a shorter time. In other words, the settling of the temperature of the outside surface of the flow channel member 1 is faster. Further, by taking the settling time of the temperature of the outside surface of the flow channel member 1 as benchmark, equivalent heating can be said to be possible at a lower flow rate (supply of a smaller heat amount).

[0066] Since at the outer peripheral surface of the flow channel member 1 (outside surface 11) a coating layer (a layer of anodised aluminium) to improve the thermal conductivity and heat dissipation properties or heat absorption properties is provided, heat exchange between the flow channel member 1 and the outside air is performed efficiently and well.

In addition, due to the grooves provided at the outside surface 11, a greater surface area can be provided than with an ordinary (non-machined surface) tube of the same diameter such that the heat dissipation effect is great, and heating or cooling to the outside is carried out quickly.

[0067] Besides, while forces striving to expand or contract the flow channel member 1 in the diametral direction may arise due to the heat of the heat medium when the heat medium flows inside the flow channel member 1, the grooves formed in the outside surface 11 at this time cause expansion and contraction locally within regions of elastic deformation, such that the forces striving to expand or contract the flow channel member 1 in the diametral direction are dispersed and the pipe diameter of the flow channel member 1 is kept constant. As a result, an accurately tightening action is effective wherever the caps 2 and the flow channel member 1 are in contact, such that quality instabilities arising from machining errors are eliminated.

[0068] As a means for providing thermal energy to the heat medium, for example a heating device utilising solar heat, the heat of the earth, wind power, hydraulic power, electric power etc, or a heat pump, air-source heat or the like are preferably used. However, it is not limited to these and may be another known means.

Also utilised may be waste heat and other secondary products without discarding them. For example, by using a material with excellent heat storage properties or high heat capacity for a heat storage section, heat accumulated during daytime may be used during nighttime, or heat accumulated during nighttime may be used during daytime. In the latter case, energy cost can also be made inexpensive by using off-peak electricity or the like.

<Second embodiment>

[0069] Another embodiment of the present invention (the second embodiment) will be described in greater detail on the basis of Figures 6 and 7.

The caps 2b in the present embodiment, shown in Figures 6 and 7, have a part of structure and function in common with the caps 2 shown in Figures 3 and 5, such that description of the common parts will be omitted and differences in structure and function will be explained below. Moreover, the same reference signs as for the caps 2 are assigned where the structure is in common.

<Caps 2b>

[0070] The caps 2b comprise in a single piece an end stop portion 21 with the same outer diameter as the outer diameter of the flow channel member 1, a fit-in portion 23b to be fitted in with a slightly larger diameter than the inner diameter of the flow channel member 1, and a central member fit-in portion 4 provided at a distal end (on the side opposite the end stop portion 21) of the fit-in portion 23b.

[0071] The central member fit-in portion 4 is formed with a smaller diameter than the fit-in portion, and has a slightly larger diameter than the inner diameter of a tubular core member 3a to be described later, such as to water-tightly seal the interior of the core member 3a by being fitted therein.

[0072] With the diameter of the central member fit-in portion 4 and the diameter of the fit-in portion 23b differing as described above (the central member fit-in portion 4 is smaller in diameter), a span between both portions is formed tapering off in the direction facing the distal end (i.e. toward the central member fit-in portion 4), such that this part becomes an inclined portion 420 (see Figures 6 and 7).

[0073] In the outer peripheral surface of the central member fit-in portion 4, one recessed groove 410 is formed around the entire circumference, substantially at the centre in the longitudinal direction of the central member fit-in portion 4.

Note that the central member fit-in portion 4 has a shape wherein the outer peripheral surface of the central member fit-in portion 4 is doubly divided by the recessed groove 410, providing respective sealing portions 412, 414. In agreement with what was said above, the sealing portions 412, 414 are slightly larger in diameter than the inner diameter of the core member 3a.

When the cap 2b is inserted into the core member 3a, the recessed groove 410 turns into an open space portion 14 that is sealed between the outer peripheral surface of the central member fit-in portion 4 and the inner peripheral surface of the core member 3a.

[0074] The other end (proximal end) of the connexion member 22 is situated inwards in the longitudinal direction of the cap 2, linking up to a distribution section 26b.

The distribution section 26 is formed divergingly so as to distribute the heat medium from the other end of the flow passage 222 in radial directions (a total of eight directions) toward the outer periphery of the cap 2b, with diverging flow channels 271 b, 272b, 273b, 274b, 275b, 276b, 277b, 278b (hereinafter denoted as "diverging flow channels 271 b-278b" when making collective reference) that allow flow passage of the heat medium toward the outer periphery being provided extending from the distribution section 26b.

[0075] The ends of the individual diverging flow channels 271 b-278b are linked to hole-shaped discharge sections 281 b, 282b, 283b, 284b, 285b, 286b, 287b, 288b (hereinafter denoted as "discharge sections 281 b-288b" when making collective reference) formed along the outer circumferential direction of the cap 2b, with the heat medium flowing from each discharge section into the flow channel member 1.

The discharge sections 281 b-288b are formed in the inclined portion 420 spaced apart by required distances (see Figures 6 and 7), provided in such a way that the heat medium flowing out from the respective discharge sections is guided toward the other cap 2 fitted on the opposite side.

<Core member 3a>

[0076] The core member 3a is a circular tube of aluminium formed in a cylindrical shape with both ends open, which by being housed inside the flow channel member 1 with the caps 2b fitted thereto causes an open space, which is to become a flow channel 13 for the heat medium to flow through, to arise between the outer peripheral surface of the core member 3a and the inner peripheral surface 12 of the flow channel member 1.

[0077] With regard to material and shape, the core member 3a is not limited in particular to the above material and shape but may be made of another metal such as stainless steel or a synthetic resin such as plastic, may be of e.g. a polygonal shape such as a triangular column shape, quadrangular column shape, pentagonal column shape, hexagonal column shape or octagonal column shape as long as capable of forming a flow channel in cooperation with the flow channel member, and may be partially a solid body as long as attachment to the central member fit-in portions 4 is possible.

[0078] While in the present embodiment the interior of the core member 3a is a cavity, it is not limited thereto. The interior of the core member 3a may also be filled with heat storage material, where substances with high heat capacity such as oil, antifreeze liquid, glycerin, silicone fluid and the like can be given as examples for the heat storage material, as well as cotton, a nonwoven fabric or the like impregnated with any of these.

[0079] Since the remaining parts of the caps 2b and the heat exchanger using the caps 2b are similar in structure to those in the first embodiment, their explanation will be omitted.

(Operation)

[0080] Referring to Figures 1, 2, 6 and 7, the sealing structure for a heat exchanger according to the present embodiment and the operation of the heat exchanger H2 will be explained.

<Sealing structure of the heat exchanger H2>

[0081] The assembly of the heat exchanger H2 is done by inserting and press-fitting the fit-in portions 23b of the caps 2b to both ends of the flow channel member 1.

When the central member fit-in portions 4 of the caps 2b are attached to both ends of the core member 3a, the friction force that occurs at the central member fit-in portions 4 is lessened by reduction of the close-contact portions at the location of the recessed grooves 410 provided in said parts, such that the attachment is possible with less (weaker) force as compared to a structure where such grooves are not provided, making the central member fit-in portion 4 and consequently the caps 2b easy to fit in (the force required for press-fitting the caps 2b small).

[0082] Thus, during the attachment operation for the caps 2b, too, the quality of the product is stable because quality fluctuations resulting from the level of skill of the operating personnel are hard to occur, with leakage being unlikely and the operation being facilitated by a reduction in work processes.

<Heat exchanger H2>

[0083] The heat exchanger H2 comprising the above-described sealing structure is able to fulfil either function of heating and cooling a facility etc where it is installed when in the flow channels 13 a warm or cold heat medium is made to flow through.

Also, a higher heating or cooling effect can be expected for an air conditioner comprising a plurality of heat exchangers H, due to action similar to the following.

[0084] In heat exchanger H2, the heat medium fed by a pump to the heat exchanger H is introduced through the connexion member 22 into the flow passage 222 of the cap 2b, further passing from the distribution section 26b via the respective diverging flow channels 271 b-272b before being discharged from the discharge sections 281 b-288b to be sent to the flow channel 13 (see Figures 6 and 7).

Besides, a switching means for enabling and disabling flow of the heat medium may be added to the distribution section 26 or the respective diverging flow channels 271 b-278b, too.

[0085] In the heat exchanger H2, similar to the case of the heat exchanger H, when heat exchange is carried out, the heat medium flows such that flow rate and flow velocity in the flow channel 13 become substantially uniform, and flows along the flow channel 13 of the flow channel member 1 without flowing through the central portion of the flow channel member 1 where the core member 3b is accommodated, such that efficient heat exchange is possible.

That is, the heat exchanger H2, similarly to the heat exchanger H, is capable of raising or lowering the temperature of the flow channel member 1 to a predetermined temperature in short time.

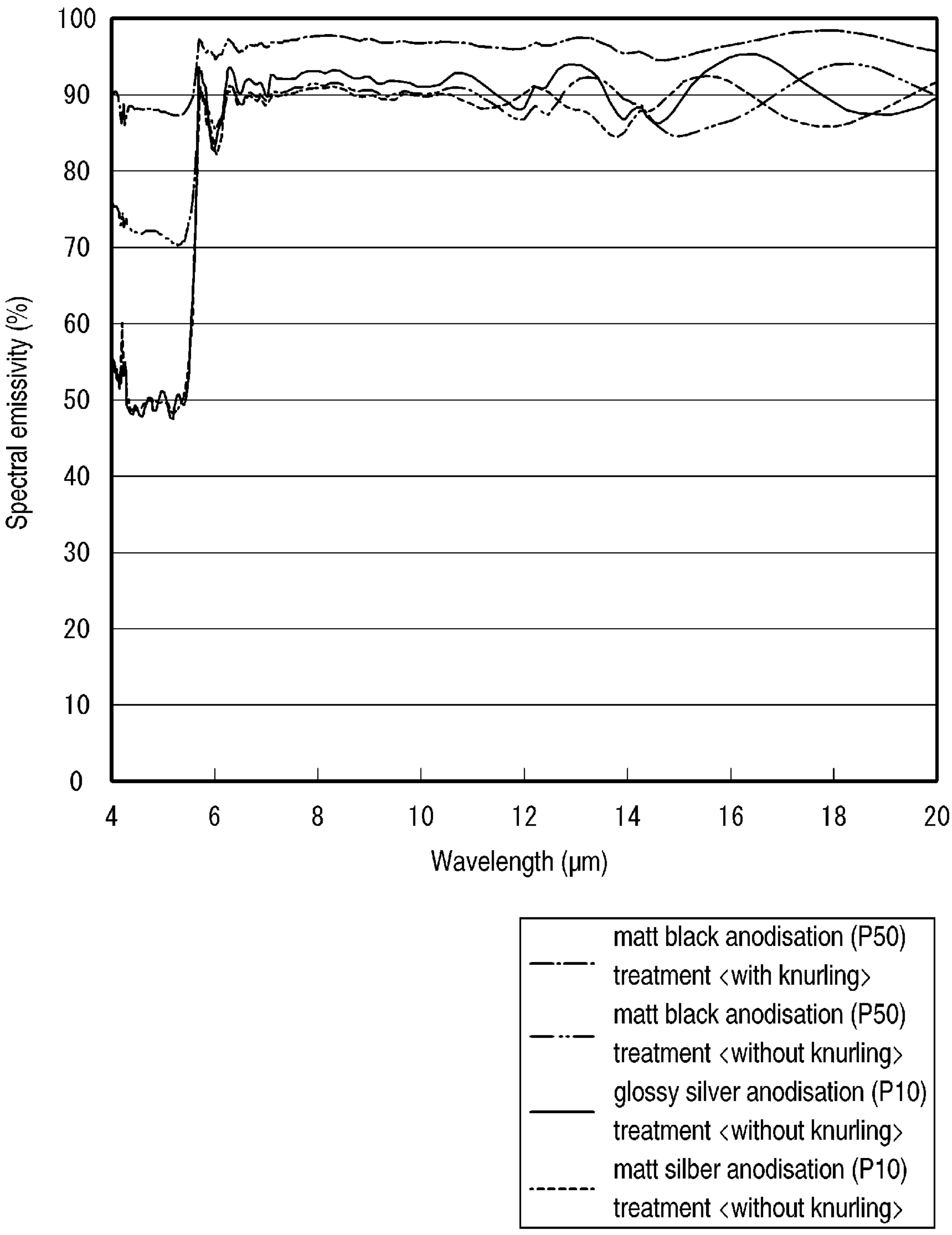
[0086] Also, because in the caps 2b the respective diverging flow channels 271 b-278b are formed directed obliquely forward, and are provided so as to open directly from the discharge sections 281 b-288b into the flow channel 13 (see Figures 6 and 7), the movement of the heat medium is carried out more smoothly.

[0087] With regard to the central member fit-in portions 4 fitted into the core member 3a, similarly to the case of the fit-in portions 23b, the inner peripheral surface of the core member 3a and the the outer peripheral surface of the central member fit-in portions 4 are in close contact such that the heat medium flowing in the flow channel 13 is sealed from leaking in, and generate a frictional force so that the central member fit-in portions 4 (and consequently the caps 2b) are unlikely to come off.

[0088] It is noted that while the caps 2, 2b in each of the first embodiment and the second embodiment are formed of polyoxymethylene, the caps may also be formed of materials deficient in elasticity, semi-rigidity or rigidity to a degree that allows the caps to be compressed in the central axis direction (metals such as stainless steel, aluminium and copper, ceramic materials or the like). Also in this case, the grooves or strip-shaped recesses formed in a portion along the longitudinal direction or the entirety of the outside surface of the flow channel member 1 cause expansion and contraction locally within regions of elastic deformation, by which action forces striving to expand or contract the flow channel member 1 in the diametral direction are dispersed and the pipe diameter of the flow channel member 1 is kept constant. As a result, even if the caps are made of a material deficient in elasticity, semi-rigidity or rigidity to a degree that allows the caps to be compressed in the central axis direction, an accurately tightening action is effective wherever the caps and the flow channel member 1 are in contact, such that quality instabilities arising from machining errors are eliminated.

[0089]

[Table 1]



[0090] Table 1 shows experimental results for the far-infrared spectral emissivity of respective samples of

(1) anodised black matt (with grooves in surface),
(2) anodised black matt (without grooves in surface),
(3) anodised silver glossy (without grooves in surface), and
(4) anodised silver without gloss (without grooves in surface).

The experiments were performed using the FT-IR technique for far-infrared spectral emissivity as the experimental method, under experimental conditions of an integrated measurement wavelength range of 4 to 20 μm, and a measurement temperature of 40 °C.

[0091] As a result, the integrated spectral emissivity (%) was

(1) anodised black matt (with grooves in surface) ... 96.4,
(2) anodised black matt (without grooves in surface) ... 89.1,
(3) anodised silver glossy (without grooves in surface) ... 89.5, and
(4) anodised silver without gloss (without grooves in surface) ... 87.6,

wherein the sample of anodised black matt (with grooves in surface) exhibited the highest numerical value.

[0092] As already mentioned, on the outside surface 11 of the flow channel member 1 a large number of grooves extending over the length in the longitudinal direction is formed, covering the outside surface 11 by the grooves (no reference sign); from the above experimental result, the same effect (The heat radiation efficacy is high because a larger surface area can be provided than by a tube of the same diameter with an unmodified surface, enabling to carry out heating or cooling to the outside quickly.) as in the case of anodised black matt (with grooves in surface) is presumed for the flow channel member 1 as well.

[0093] Expressions and terms used in this description and in the claims are merely explanatory and therefore not limiting in any way. There is no intention to exclude expressions and terms equivalent to the features described in this description and in the claims or to a part thereof. Also, it goes without saying that within the scope of the technical idea of the present invention, various modifications are possible.

Explanation of the reference signs

[0094]

H, H2 heat exchanger

1 flow channel member

11 outside surface, 12 inner peripheral surface, 13 flow channel, 14 open space portion

2, 2b cap

21 end stop portion, 22 connexion member, 222 flow passage route, 224 threaded portion, 23, 23b fit-in portion, 241, 242, 243 sealing portion, 251, 252 recessed groove, 26, 26b distribution section, 271, 272, 273, 274, 275, 276, 277, 278 diverging flow channel

271 b, 272b, 273b, 274b, 275b, 276b, 277b, 278b diverging flow channel

281, 282, 283, 284, 285, 286, 287, 288 discharge section

281 b, 282b, 283b, 284b, 285b, 286b, 287b, 288b discharge section

291, 292 convex sealing portion

3 core member

4 central member fit-in portion

410 recessed groove, 412, 414 sealing portion, 420 inclined portion

Industrial applicability

[0095]

(1) A sealing structure for a heat exchanger and a heat exchanger can be provided wherein, in the attachment operation for the caps, the quality of the product is stable because quality fluctuations resulting from the level of skill of the operating personnel are hard to occur, leakage is unlikely and the operation is facilitated by a reduction in work processes.
(2) A heat exchanger can be provided wherein the cap mounting operation is simple, and a sealing structure of the heat exchanger works in combination with a flow channel member that impedes deformation to make gaps between the flow channel member and the attached caps unlikely to occur, thereby preventing leakage.

Claims

1. A heat-exchanger sealing structure for sealing an end portion of a heat exchanger (H, H2) having a tubular flow channel member (1) with a cap (2, 2b) attached by press-fitting to an opening portion at either end of the flow channel member (1),
wherein the cap (2, 2b) comprises a fit-in portion (23, 23b) for being fitted into an opening end portion of the heat exchanger (H, H2), and a flow passage route (222, 271-278, 271b-278b) formed to guide a heat medium from outside the flow channel member to inside the flow channel member or to emit the heat medium from inside the flow channel member to outside the flow channel member,
wherein the fit-in portion (23, 23b) of the cap is larger in diameter than an inner diameter of the flow channel member (1), and at least one recessed groove (251, 252) in a longitudinal direction of an outer peripheral surface of the fit-in portion (23, 23b) is formed around an entire circumference of the fit-in portion (23, 23b), and
wherein the outer peripheral surface of the fit-in portion (23, 23b) closely contacts an inner wall (12) of the flow channel member (1), an open space portion (14) being formed between the recessed groove (251, 252) and the inner wall (12) of the flow channel member.

2. The heat-exchanger sealing structure according to claim 1, wherein the tubular flow channel member (1) of the heat exchanger (H, H2) is provided with a coating on its entire inner wall (12) or on a part of the inner wall (12) that contacts the outside surface of the fit-in portion (23, 23b).

3. A heat exchanger comprising the heat-exchanger sealing structure according to claim 1 or 2.

4. A heat exchanger comprising the heat-exchanger sealing structure according to claim 1 or 2, wherein at an outside surface (11) of the flow channel member (1) constituting the heat exchanger (H, H2) a plurality of grooves or strip-shaped recesses is formed along a portion or the entirety of a longitudinal direction of the surface (11).

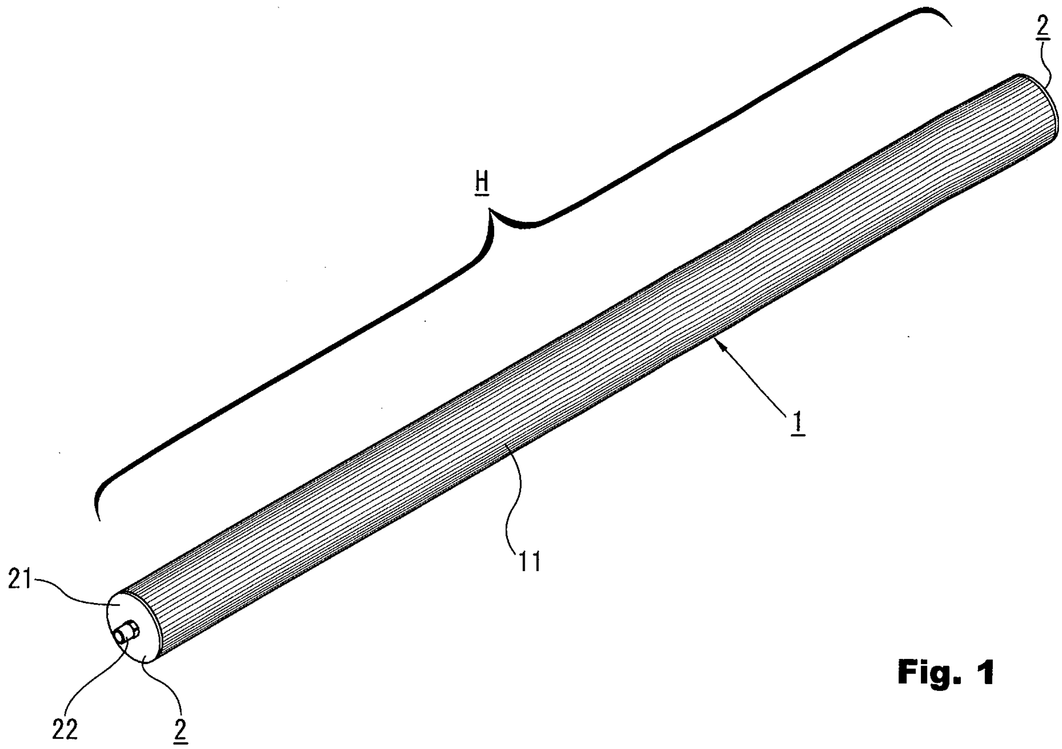


Fig. 1

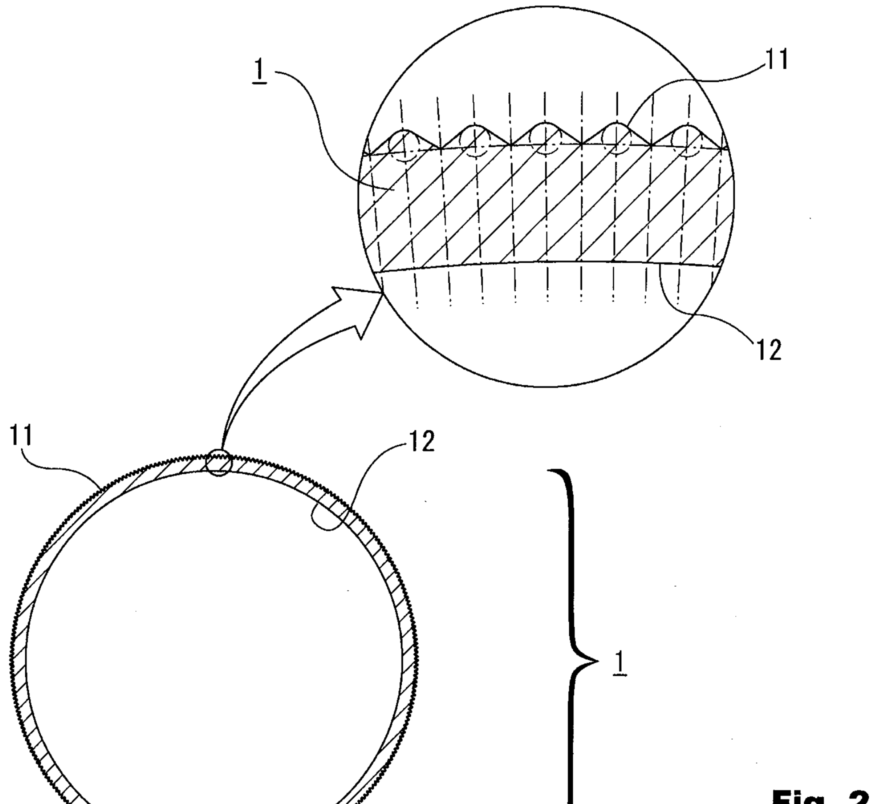


Fig. 2

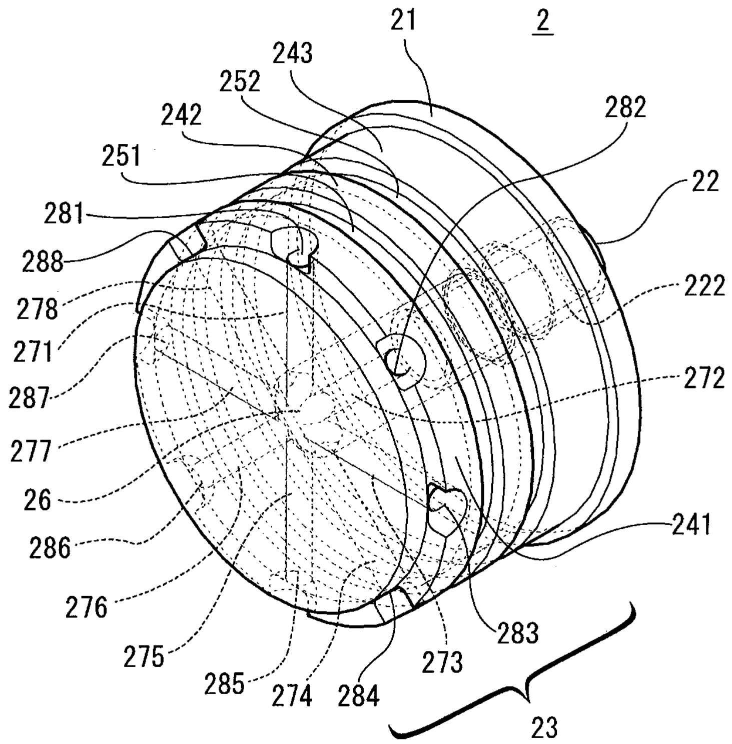

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Fig. 3

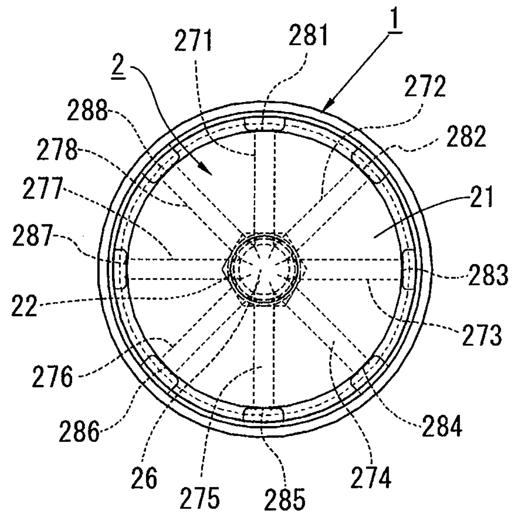
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Fig. 4

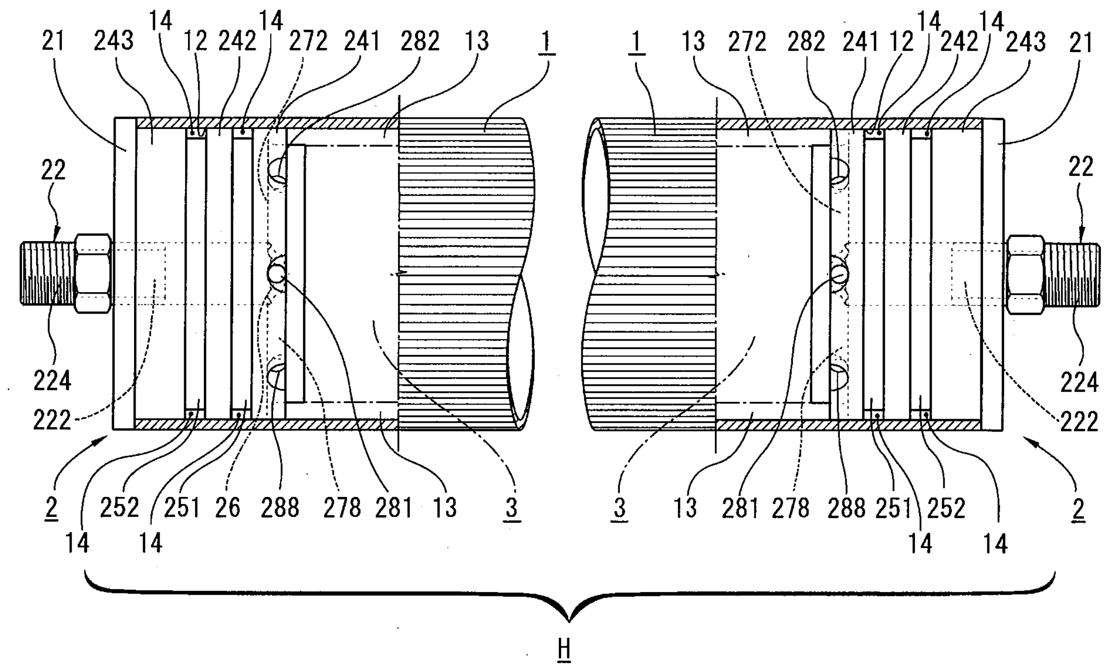
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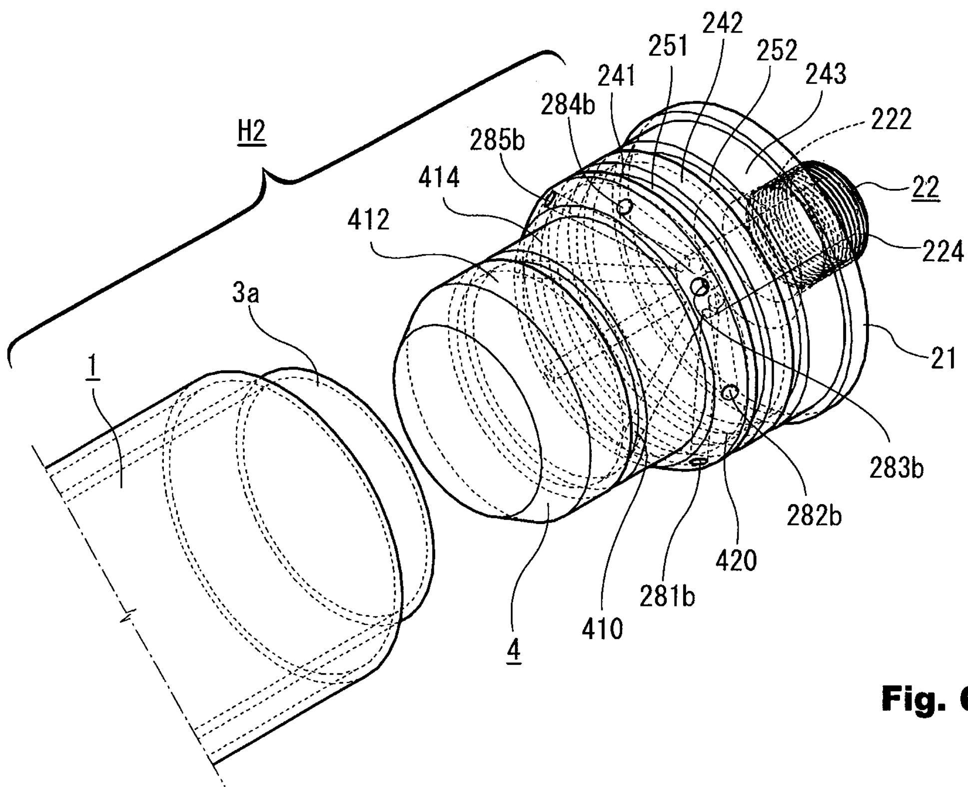
Fig. 5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281b
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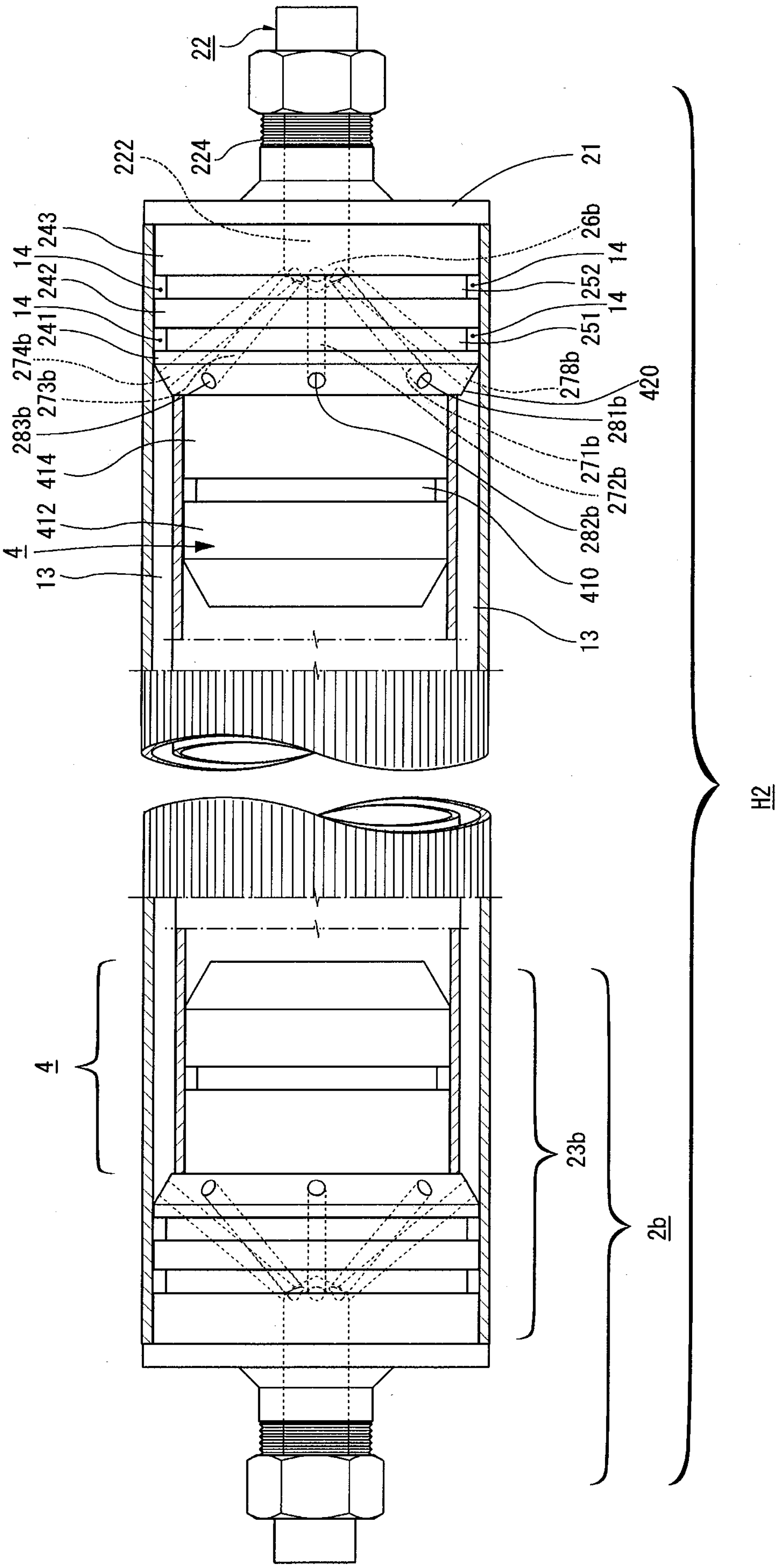
Fig. 6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272b
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23b
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H2

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/073662

A. CLASSIFICATION OF SUBJECT MATTER
F28F11/02(2006.01)i, *F28F1/40*(2006.01)i, *F28F13/12*(2006.01)i

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)
F28F11/02, F28F1/40, F28F13/12

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-106974 A (Yugen Kaisha Locus), 08 May 2008 (08.05.2008), entire text; all drawings (Family: none)	1-4
A	WO 2005/010451 A1 (Chikara TAKEHARA), 03 February 2005 (03.02.2005), entire text; all drawings & JP 2005-48995 A & KR 10-2006-0055510 A & CN 1833154 A	1-4
A	JP 1-310298 A (Toshiba Corp.), 14 December 1989 (14.12.1989), entire text; all drawings (Family: none)	1-4

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search 21 November, 2011 (21.11.11)	Date of mailing of the international search report 06 December, 2011 (06.12.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/073662

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 79121/1989(Laid-open No. 21689/1991) (Mitsubishi Heavy Industries, Ltd.), 05 March 1991 (05.03.1991), entire text; all drawings (Family: none)	1-4
A	JP 11-132683 A (Hitachi, Ltd.), 21 May 1999 (21.05.1999), entire text; all drawings (Family: none)	1-4
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 11440/1987(Laid-open No. 120023/1988) (Toshiba Corp.), 03 August 1988 (03.08.1988), entire text; all drawings (Family: none)	1-4
A	JP 59-230738 A (Sumitomo Light Metal Industries, Ltd.), 25 December 1984 (25.12.1984), entire text; all drawings (Family: none)	1-4
A	JP 2000-205782 A (Hitachi Cable, Ltd.), 28 July 2000 (28.07.2000), entire text; all drawings (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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