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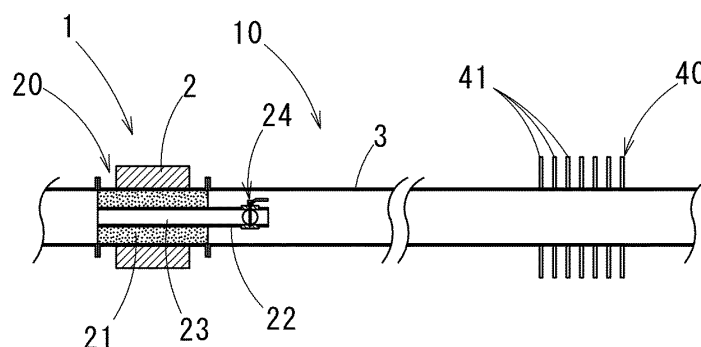
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(54) **HEAT EXCHANGER**

(57) A heat exchanger having an outer tube through which a heating or cooling medium flows, a heat source that heats or cools the outer tube at a middle position at the exterior, and a heat-exchange part which can perform a heat exchange between the heating or cooling medium flows in the outer tube and the heat source; the heat-exchange part is provided with a porous body in a cylindrical

shape being in close contact with an inner peripheral surface of the outer tube, at least one inside channel that is formed inside the porous body, and at least one valve that opens and closes the inside channel; and continuous pores that communicate with both ends of the flow direction of the heating or cooling medium and through which the heating or cooling medium can flow are formed.

FIG. 1



Description

BACKGROUND OF THE INVENTION

5 Technical Field

[0001] The present invention relates to a heat exchanger, concerned with a heat exchanger which can change performance of heat changing by switching flow channels. Priority is claimed on Japanese Patent Application No. 2020-038132, filed March 5, 2020, the content of which is incorporated herein by reference.

10 Background Art

[0002] Patent Literature 1 discloses an air-conditioning system utilizing soil heat, which is provided with one or a plurality of first heat-exchange devices installed under the ground, one or a plurality of second heat-exchange devices installed in a building, a tube system connecting the first heat-exchange devices and the second heat-exchange devices, a liquid medium for heat-exchanging circulated in the tube system, a pump device circulating the liquid medium for heat-exchanging in the tube system, a valve-switching device for switching a circulation path of the liquid medium for heat-exchanging circulated in the tube system, temperature detection system detecting temperature at any part, and a control device for controlling the pump device and the valve-switching device based on temperature data from temperature sensors configuring the temperature detection system.

Citation List

25 Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application, First Publication No. 2003-21360

SUMMARY OF INVENTION

30 Technical Problem

[0004] In the air-conditioning system described in Patent Literature 1, it is necessary to switch the circulation path in accordance with room temperature and the like; however, if the valve is drastically opened and closed when stopping the liquid from flowing into a specific heat-exchange part, water hammering occurs in a tube of the circulation path and it may lead to breakages of the apparatus.

[0005] The present invention is achieved in consideration of the above circumstances, and has an object to provide a heat exchanger which performs heat exchange efficiently and also can prevent occurring of the water hammering when switching the flow channels.

40 Solution to Problem

[0006] A heat exchanger of the present invention has an outer tube through which heating or cooling medium flows, a heat source which heats or cools a middle position of the outer tube from an outside, and a heat-exchange part which can perform heat exchanging between the heat source and the heating or cooling medium flowing through the outer tube. The heat-exchange part is provided with a porous body which is a cylindrical shape adhering to an inner peripheral surface of the outer tube, an inside channel formed inside the porous body, and a valve opens and closes the inside channel; and in the porous body, continuous pores communicating both ends of the heating or cooling medium in a flowing direction of the heating or cooling medium through which the heating or cooling medium can flow are formed.

[0007] In this heat exchanger, since the continuous pores through which the heating or cooling medium can flow are formed in the porous body, when the valve closes the inside channel, the heating or cooling medium flows through the continuous pores of the porous body. Since the heat source is installed on the outside of the outer tube, the heating or cooling medium flowing in the porous body and the heat source exchange heat to heat or cool by the heat source.

The heating or cooling medium which exchanged heat with the heat source flows downstream in the porous body and exchange heat with the outer environment of the outer tube in the downstream position to release heat or absorb heat.

[0008] On the other, when the valve opens in the inside channel of the porous body, since the inside channel has channel resistance smaller than that in the porous body, the heating or cooling medium flowing from the upstream of the porous body flows into the inside channel for the most part and is lead to the downstream. At this time, the heating or cooling medium scarcely flows in the porous body: the heating or cooling medium stays in the porous, or even if it

flows, the amount of flowing is a little.

[0009] Accordingly, when the heat from the heat source outside the outer tube is transferred to the inside channel going through the porous body and the heating or cooling medium inside the porous body, the energy thereof is expended on heating or cooling the porous body and the heating or cooling medium inside the porous body; and furthermore, since the heating or cooling medium mostly stays in the porous body, the heat transferring is intercepted and the heat amount transferred from the inner surface of the inside channel to the heating or cooling medium is reduced.

[0010] Moreover, the amount is little even if it flows in the porous body, the heat transfer from the porous body to the downstream is also small. Furthermore, since the pressure drop by the inside channel is small on the heating or cooling medium flowing inside, it flows at relatively a large amount of flowing. Since the heat amount transferred from the inner surface of the inside channel is small to the amount of flowing, the heat amount carried by the heating or cooling medium in the inside channel is also small. Accordingly, the heat exchange is restrained between the heat source and the heating or cooling medium in a state in which the valve of the inside channel is open.

[0011] As described above, by opening and closing the valve of the inside channel, the amount of the heat exchange between the heat source and the heating or cooling medium can be switched. At this time, since the heating or cooling medium flows from the upstream to the downstream of the heat-exchange part not only in the inside channel but also in the porous body, sudden changes of the inner pressure of the outer tube are unlikely to occur, so that water hammering can be restrained.

[0012] In this heat exchanger, a porosity of the porous body is preferably 60% or more and 90% or less. If the porosity is less than 60%, the channel resistance of the porous body increases, so that an amount of the heating or cooling medium flowing in the porous body is small when the valve is closed, and a load of a pump feeding the heating or cooling medium increases. If the porosity exceeds 90%, the heating or cooling medium flowing in the porous body quickly flows to the downstream, the heat exchange may be insufficient with the heat source.

[0013] In this heat exchanger, the pressure drop between the upstream position and the downstream position of the porous body when the heating or cooling medium flows in the outer tube is preferably that a pressure drop ratio ($\Delta P2/\Delta P1$) be one or more and three or less where a pressure drop is $\Delta P1$ when a surface of the porous body is closed at the upstream side and only the inside channel of the inner tube is open and a pressure drop is $\Delta P2$ when the valve is closed and it flows only in the porous body.

[0014] If the pressure drop ratio ($\Delta P2/\Delta P1$) exceeds three times, the pressure fluctuation is too large when the valve is closed, water hammering may occur. If it is less than one times, a large amount of the heating or cooling medium flows into not only the inside channel but also the porous body when the valve is open, a thermal insulation effect of the porous body is reduced and an effect of switching the heat exchange is small.

Advantageous Effects of Invention

[0015] According to the present invention, it is possible to perform the heat exchange efficiently and restrain the occurring of the water hammering when the channel is switched.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

[FIG. 1] It is a schematic view of a heating system using a heat exchanger of one embodiment of the present invention.

[FIG. 2] It is an enlarged cross-sectional view showing a state in which a valve is closed in the heat exchanger shown in FIG. 1.

[FIG. 3] It is a cross sectional view showing a state in which the valve is closed in the heat exchanger in FIG. 2.

[FIG. 4] It is a cross sectional view showing a heat exchanger of another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0017] Below, embodiments of the present invention will be explained using drawings. A heat exchanger 1 of a present embodiment is used for a heating system 10 that heats a heating or cooling medium (heat transfer medium) (air) by a heat source 2 and radiates the heat of the heat transfer medium in which temperature is made high in an objective room or the like. FIG. 1 schematically shows the heating system 10, a sign 20 denotes a heat-absorption part (a first heat-exchange part, corresponding to the heat-exchange part of the present invention), and a sign 40 denotes a heat-radiation part (a second heat-exchange part) which radiates the heat of the heat transfer medium in which temperature is made high in the first heat-exchange part.

[0018] The heat exchanger 1 has an outer tube 3 through which the heat transfer medium flows, a heat source 2 which heats a middle position of the outer tube 3 from an outside, and the first heat-exchange part 20 which performs heat

exchange between the heat source 2 and the heat transfer medium flowing through the outer tube 3.

[0019] The first heat-exchange part 20 is provided with a porous body 21 which is a cylindrical shape adhering to an inner peripheral surface of the outer tube 3, an inner tube 22 adhering to an inner peripheral surface of the porous body 21, and a valve 24 opens and closes a channel (an inside channel) 23 in this inner tube 22.

[0020] The porous body 21 is formed by sintering powder, fiber, or mixture of them made of metal with an excellent heat conduction, for example, aluminum, copper or the like, having a metal skeleton, with a set range of 60% or more and 90% or less of a porosity. The pores of the porous body 21 include continuous pores communicating from one end to the other end of the porous body 21; when the heat transfer medium is supplied to the one end of the porous body 21, it can be flowed through the continuous pores out from the other end of the porous body 21.

[0021] A specific surface area (per unit volume) of the porous body 21 is preferably $1000 \text{ m}^2/\text{m}^3$ or more and $15000 \text{ m}^2/\text{m}^3$ or less. If the porosity of the porous body 21 is less than 60%, a channel resistance of the porous body 21 is large (for example, 3 kPa), an amount of the heat transfer medium flowing in the porous body is small when the valve is closed and a load of a pump feeding the heat transfer medium is large. If the porosity exceeds 90%, the heat transfer medium flowing in the porous body 21 flows quickly to the downstream, and there is a possibility that the heat is not sufficiently changed between the heat source 2.

[0022] For such porous body 21, for example, it can be applied that is made by sintering a cluster of many metal powders, by sintering a cluster of many metal fibers, or mixing and sintering these metal fibers and the metal powders. In addition, it may be a foamed metal having a three-dimensional mesh structure made by a continuous metal skeleton in which a plurality of pores are communicated by adding foaming agent and sintering.

[0023] The porous body 21 is installed closely on the inner peripheral surface of the outer tube 3. In the drawings, a short tube 35 which is relatively short is formed on a middle of the outer tube 3 in order to be combined by flanges 31 to 34, and the porous body 21 is provided in the short tube 35. In this case, metal powder or metal fiber are compacted into a cylindrical shape to form an aggregate in the short tube 35, and the metal powder and the metal fiber are bonded to the inner peripheral surface of the short tube 35 by sintering in the short tube 35.

[0024] The inner tube 22 are provided coaxially with the short tube 35 in a state of being in close contact with the inner peripheral surface of the porous body 21. In this case, metal powder or metal fiber are compacted into a cylindrical shape to form an aggregate on an outer peripheral surface of the inner tube 22, and the metal powder and the metal fiber are bonded to the outer peripheral surface of the inner tube 22 by sintering on the outer peripheral surface of the inner tube 22.

[0025] Specifically, the short tube 35 and the inner tube 22 are coaxially disposed, the metal powder and the metal fiber are filled between them and compacted in the cylindrical shape, and the short tube 35, the inner tube 22, and the metal powder and the like are placed in a furnace and heated, so that the inner peripheral surface of the porous body 21 and the outer peripheral surface of the inner tube 22 are bonded, and it is made into a state in which the outer peripheral surface of the porous body 21 and the inner peripheral surface of the short tube 35 are bonded.

[0026] The outer tube 3 and the inner tube 22 may be formed of the same kind of metal as that of the porous body 21 or formed of a different kind of metal if they can be bonded, such as a combination of aluminum and copper, and the like.

[0027] The inner tube 22 is longer than the length of the porous body 21 and protrude toward the downstream from one end part (an end part at the downstream side) of the porous body. On a protruded end part of the inner tube 22, a valve 24 which opens and closes the inner channel 23 is provided.

[0028] For the valve 24, a butterfly valve is exemplified to open and close the channel by rotating a valve body 24a at 90° in the drawings; however, it is possible to apply a ball valve, a gate valve or the like if it can open and close the channel.

[0029] On the other end part (an end part at the upstream side) of the porous body 21, a tip end of the inner tube 22 is arranged in the same manner as the end surface of the porous body 21.

[0030] A pressure drop ratio ($\Delta P_2/\Delta P_1$) is one or more and three or less, where ΔP_1 is a pressure drop when the surface at the upstream side of the porous body 21 is closed and only the inside channel 23 is open to flow the heat transfer medium only through the inside channel 23; and ΔP_2 is a pressure drop (it is equal to a pressure drop in a state of closing the valve 24) when the heat transfer medium flows only through the porous body 21.

[0031] If the pressure drop ratio ($\Delta P_2/\Delta P_1$) between the inside channel 23 and the porous body 21 is less than one, a large amount of the heat transfer medium flows not only into the inside channel 23 but also into the porous body 21 when the valve 24 is open; as a result, the thermal insulation effect in the porous body 21 is decreased and the effect of switching the heat exchange is small. If the pressure drop ratio ($\Delta P_2/\Delta P_1$) exceeds three, the pressure fluctuation is large when the valve 24 is closed and water hammering may occur. The pressure drop ratio ($\Delta P_2/\Delta P_1$) between the inside channel 23 and the porous body 21 is more preferably 1.5 or more and 2 or less.

[0032] Where ΔP_3 is a pressure drop of a whole channel when the valve 24 is open (in a full-open state) and a ΔP_2 is a pressure drop of the whole channel when the valve 24 is closed (in a full-closed state), a pressure drop ratio ($\Delta P_2/\Delta P_3$) is preferably 1.2 or more and 15 or less.

[0033] If the pressure drop ratio ($\Delta P_2/\Delta P_3$) exceeds 15 when opening or closing the valve 24, the pressure fluctuation of a whole system of the heat exchanger 1 is too much and a design is complicated. If it is less than 1.2, a great volume of the heat transfer medium flows into the porous body 21 not only into the inside channel 23 when the valve 24 opens

(in other words, a volume of the heat transfer medium flows in the inside channel 23 is small), so that the thermal insulation effect of the porous body 21 is reduced and the effect of switching the heat exchanging is small. The pressure drop ratio ($\Delta P_2/\Delta P_3$) by opening and closing the valve 24 is more preferably three or more and 10 or less.

[0034] It is not always limited but where a cross-sectional area of the inside channel 23 is A_1 mm² and a cross-sectional area of the porous body 21 is A_2 mm², a cross-sectional area ratio (A_2/A_1) is preferably three or more and 12 or less. If the cross-sectional ratio (A_2/A_1) is less than three, the water hammering easily occurs since a difference of flow rates between closing and opening the valve 24 is large; and if it exceeds 12, the heat exchanging efficiency is reduced since a total flow rate is small.

[0035] In the first heat-exchange part 20, it is preferable to cover the heat source 2 and the outer tube 3 with heat insulation material.

[0036] The second heat-exchange part 40 in this embodiment is installed in a room in which a heater is necessary; a plurality of fins 41 are formed integrally on an outer peripheral surface of the outer tube 3 to advance heat radiation.

[0037] In such heating system 10 structured as above, the heat source 2 disposed outside the first heat-exchange part 20 is made hot and the valve 24 is closed to flow the heat transfer medium (the air) from the upstream of the first heat-exchange part 20, the heat transfer medium does not flow into the inside tube 22 but flows through the porous body 21 in the first heat-exchange part 20.

[0038] Since the porous body 21 has continuous pores as described above, the heat transfer medium flows through the porous body 21 and flows out from the other end of the porous body 21 toward the downstream. The outer peripheral surface of the porous body 21 is closely in contact with the inner peripheral surface of the outer tube 3; and the heat source 2 in a heating state is provided on the outside of the outer tube 3. Accordingly, the heat of the heat source 2 is immediately transmitted to the porous body 21 via a wall of the outer tube 3 and transmitted to the heat transfer medium flowing in the pores of the porous body 21 to heat the heat transfer medium before it is transmitted to the inner tube 22 via the metal skeleton in the porous body 21.

[0039] Since a specific surface area of the porous body 21 is large, the heat is efficiently transmitted to the heat transfer medium from the metal skeleton of the porous body 21. The heat transfer medium which has been made high temperature in the porous body 21 and flowed to the downstream of the porous body 21 transmits the heat to the fins 41 in the second heat-exchange part 40, and the fins 41 radiate heat to warm environment around the second heat-exchange part 40.

[0040] On the other, opening the valve 24 (FIG. 3), the heat transfer medium supplied from the first heat-exchange part 20 flows into the inner tube 22 as priority since the pressure drop in the porous body 21 is larger than that in the inner tube 22. Accordingly, most of the heat transfer medium flows through the inside channel 23 to the downstream; so that the heat transfer medium does not almost flow in the porous body 21 or stays in the pores without flowing.

[0041] As a result, the porous body 21 works as a heat insulator, so that the heat transmission from the heat source 2 to the inner tube 22 is restrained. Accordingly, the heat transfer medium flowed through the inside channel 23 is introduced to the downstream without temperature changing.

[0042] As described above, in a state in which the valve 24 is closed (FIG. 2), the heat of the heat source 2 is transmitted to the heat transfer medium flowing through the porous body 21, the heated heat transfer medium flows to the downstream; on the other, in a state in which the valve 24 is open, the heat is not transmitted to the heat transfer medium flowing through the inside channel 23 and it flows to the downstream in a state in which the temperature at the upstream of the first heat-exchange part 20 is substantially maintained. Accordingly, by opening and closing the valve 24, it is possible to transmit or cut off the heat of the heat source 2.

[0043] By adjusting the opening of the valve 24, the heat transfer medium can flow both the porous body 21 and the inner tube 22 to appropriately control the temperature of the heat transfer medium passing through the first heat-exchange part 20. That is to say, although there is a large different between the pressure drop in the porous body 21 and the pressure drop in the inner tube 22, a part of the heat transfer medium can be flowed in the porous body 21 and the rest can be flowed in the inner tube 22 by appropriately controlling the opening of the valve 24.

[0044] The heat transfer medium which is made high temperature receiving the heat of the heat source 2 flows to the downstream in the porous body 21; in the inner tube 22, the heat transfer medium flows to the downstream with substantially maintaining the temperature at the upstream. Then, both meet the downstream position of the first heat-exchange part 20 and flow as a fluid mixture of them. The temperature of the fluid mixture is set based on a combination of temperature and a flow rate of the heat transfer medium going through the porous body 21 and temperature and a flow rate of the heat transfer medium going through the inside channel.

[0045] By adjusting the opening of the valve 24, the pressure drop difference between the porous body 21 and the inner tube 22 is controlled to adjust a ratio of the flow rate between the porous body 21 and the inner tube 22, so the temperature of the heat transfer medium at the downstream of the porous body 21 can be optionally set.

[0046] As described above, by adjusting the opening of the valve 24, the temperature around the second heat-exchange part 40 can be appropriately controlled. In this case, since the temperature can be adjusted only by opening and closing the valve 24 (adjusting the opening) and the pressure of the heat transfer medium does not radically fluctuated, the water hammering can be also prevented.

[0047] The present invention is not limited to the above-described embodiments and various modification may be made without departing from the scope of the present invention.

[0048] For example, in the example shown in FIG. 1 to FIG. 3, one inner tube 22 is provided; however, two or more inner channels 23 equipped with a plurality of inner tubes 22 having valves 24 respectively may be formed, as in a heat exchanger 11 shown in FIG. 4.

[0049] In this case, the pressure drop $\Delta P1$ of the inside channels 23 is a pressure drop when it flows through all the inside channels 23 of the plurality of the inner tubes 22; the pressure drop ratio ($\Delta P2/\Delta P3$) when the valves 24 are opened and closed is a pressure drop ratio when the all of the inside channels 23 are opened and closed. A cross-sectional area $A1 \text{ mm}^2$ of the inside channels 23 is a sum of cross-sectional areas of all the inside channels 23.

[0050] In the heat exchanger 11 shown in FIG. 4, since the valves 24 are respectively installed in a plurality of the inner tubes 22, it is possible to set the most suitable temperature by adjusting the openings for the valves 24 respectively, not by setting the same opening for the every valve 24.

[0051] Moreover, the porous body 21 is bonded to the inner peripheral surface of the outer tube 3 and the outer peripheral surface of the inner tube 22 when it is formed by sintering; however, it is not necessary to be bonded if it fills between the outer tube and the inner tube 22 in a close-contact state.

<Examples>

[0052] As Nos. 1 to 9, porous bodies were made by filling mixtures of powder and fiber of aluminum between an outer tube made of aluminum or aluminum alloy with an inner diameter 15 mm to 30 mm and a thickness 1 mm and an inner tube similarly made of aluminum or aluminum alloy with an inner diameter 8 mm and an outer diameter 10 mm and sintering it. A length of the inner tube was 150 mm; the porous body had a length (50 mm, 100 mm, 150 mm, and 300 mm) and a porosity (60% to 95%) shown in Table 1.

[0053] Air was used as the heat transfer medium; a difference between the upstream and the downstream of the porous body was measured in a state in which the valve is open and a state in which it is closed, respectively.

[0054] The heat source (heater) is closely in contact with the outer peripheral surface of the outer tube at a middle position in the length of the porous body in a range of 30 mm length, and the air as the heat transfer medium at normal temperature (25°C) was flowed. The circumference of the heat source and the outer tube were surrounded with a heat-insulation material.

[0055] A pressure at the upstream position and a pressure at the downstream position of the porous body were measured when the porous body was closed to flow only in the inside channel, and the differential pressure $\Delta P1$ (pressure drop) was obtained.

[0056] A pressure at the upstream position and a pressure at the downstream position of the porous body were measured when the valve was closed to flow only through the inside channel, and the differential pressure $\Delta P2$ (pressure drop) was obtained; and a ratio of the differential pressures $P1$ and $P2$ (pressure drop ratio) ($\Delta P2/\Delta P1$) was calculated.

[0057] Without closing the porous body, in a state in which the valve was open, the pressure at the upstream position and the pressure at the downstream position of the porous body were measured, and a differential pressure $\Delta P3$ (pressure drop) was also obtained.

[0058] Measuring temperature at between the heat source and the outer tube in a state in which the valve is closed by a thermocouple, controlling temperature of the heat transfer medium so that the thermocouple records 60°C, and measuring the temperature after five minutes of opening the valve by the thermocouple, a heat change ΔT (K) was obtained.

[0059] A sample (No. 10) in which the porous body was not provided between the outer tube and the inner tube was also made for comparison. These results are shown in Tables 1 and 2.

[Table 1]

No.	POROUS BODY		OUTER TUBE	CROSS SECTIONAL AREA (mm ²)		AREA RATIO
	POROSITY (%)	FILLING LENGTH (mm)	INNER DIAMETER (mm)	POROUS BODY A2	INNER CHANNEL A1	A2/A1
1	85	100	24	373.8	50.3	7.4
2	85	150	24	373.8	50.3	7.4
3	90	300	24	373.8	50.3	7.4
4	70	50	24	373.8	50.3	7.4

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(continued)

No.	POROUS BODY		OUTER TUBE	CROSS SECTIONAL AREA (mm ²)		AREA RATIO
	POROSITY (%)	FILLING LENGTH (mm)	INNER DIAMETER (mm)	POROUS BODY A2	INNER CHANNEL A1	A2/A1
5	85	150	27	494.0	50.3	9.8
6	85	100	20	235.6	50.3	4.7
7	85	100	18	175.9	50.3	3.5
8	60	30	24	373.8	50.3	7.4
9	95	50	24	373.8	50.3	7.4
10	NO POROUS BODY		24	373.8	50.3	7.4

[Table 2]

No.	DIFFERENTIAL PRESSURE (kPa)			PRESSURE DROP RATIO	HEAT CHANGE ΔT
	$\Delta P1$	$\Delta P2$	$\Delta P3$	$\Delta P2/\Delta P1$	K
1	0.87	0.90	0.20	1.0	7.2
2	0.86	1.35	0.24	1.6	7.7
3	0.86	1.22	0.21	1.4	6.1
4	0.89	1.80	0.28	2.0	8.1
5	0.85	0.95	0.19	1.1	7.3
6	0.88	1.44	0.25	1.6	7.5
7	0.87	1.96	0.28	2.3	6.9
8	0.86	2.03	0.31	2.4	7.4
9	0.85	0.18	0.10	0.2	4.1
10	0.86	0.12	0.09	0.1	3.4

[0060] As clear from the results shown in Tables 1 and 2, it is known that prescribed heat change can be obtained in Nos. 1 to 9 in which the porous body is provided between the outer tube and the inner tube by switching the channels between the porous body and the inside channel of the inner tube. As in Nos. 1 to 8, if the porosity of the porous body is 60% or more and 90% or less and the pressure drop ratio ($\Delta P2/\Delta P1$) between the porous body and the inside channel is one or more and three times or less, the heat change ΔT is large and the heat is sufficiently exchanged.

[0061] On the other hand, in No. 10 in which the porous body is not provided, the pressure drop ratio ($\Delta P2/\Delta P1$) and the heat change ΔT are small, and sufficient heat exchange is not obtained.

Industrial Applicability

[0062] Efficient heat exchange can be performed, and generation of water hammering when switching the flow channels can be suppressed.

Reference Signs List

[0063]

- 1, 11 Heat exchanger
- 2 Heat source
- 3 Outer tube

10	Heating system
20	First heat-exchange part
21	Porous body
22	Inner tube
5 23	Inside channel
24	Valve
40	Second heat-exchange part
41	Fin

Claims

1. A heat exchanger comprising

an outer tube through which a heating or cooling medium flows,
 a heat source which heats or cools a middle position of the outer tube from an outside, and
 a heat-exchange part which can perform heat exchanging between the heat source and the heating or cooling
 medium flowing through the outer tube, wherein
 the heat-exchange part is provided with a porous body which is a cylindrical shape adhering to an inner peripheral
 surface of the outer tube, at least one inside channel formed inside the porous body, and at least one valve
 opens and closes the inside channel, and
 in the porous body, continuous pores communicating both ends of the heating or cooling medium in a flowing
 direction of the heating or cooling medium through which the heating or cooling medium can flow are formed.

2. The heat exchanger according to claim 1, wherein a porosity of the porous body is 60% or more and 90% or less.

3. The heat exchanger according to claim 1, wherein a pressure drop between an upstream position and a downstream
 position of the porous body when the heating or cooling medium flows in the outer tube is that a pressure drop ratio
 ($\Delta P_2/\Delta P_1$) is one or more and three or less, where a pressure drop is ΔP_1 when a surface of the porous body is
 closed at the upstream side and only the inside channel is open and a pressure drop is ΔP_2 when the valve is closed
 and it flows only in the porous body.

4. The heat exchanger according to claim 2, wherein a pressure drop between an upstream position and a downstream
 position of the porous body when the heating or cooling medium flows in the outer tube is that a pressure drop ratio
 ($\Delta P_2/\Delta P_1$) is one or more and three or less, where a pressure drop is ΔP_1 when a surface of the porous body is
 closed at the upstream side and only the inside channel is open and a pressure drop is ΔP_2 when the valve is closed
 and it flows only in the porous body.

5. The heat exchanger according to claim 1, wherein a plurality of the inside channels are provided and have the valve
 respectively.

6. The heat exchanger according to claim 1, wherein the valve is enabled to control opening individually.

FIG. 1

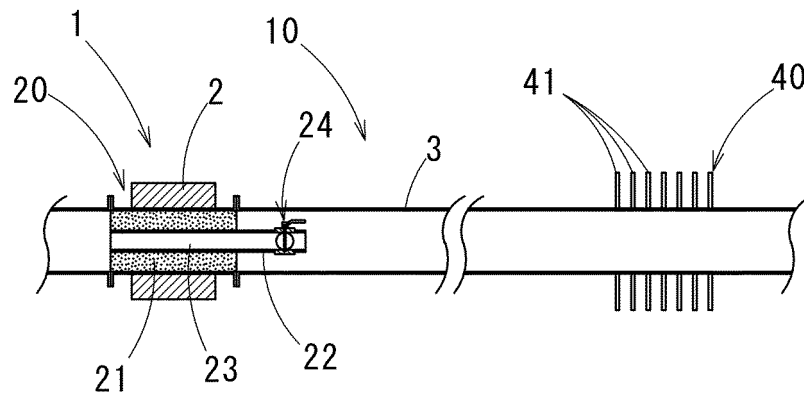


FIG. 2

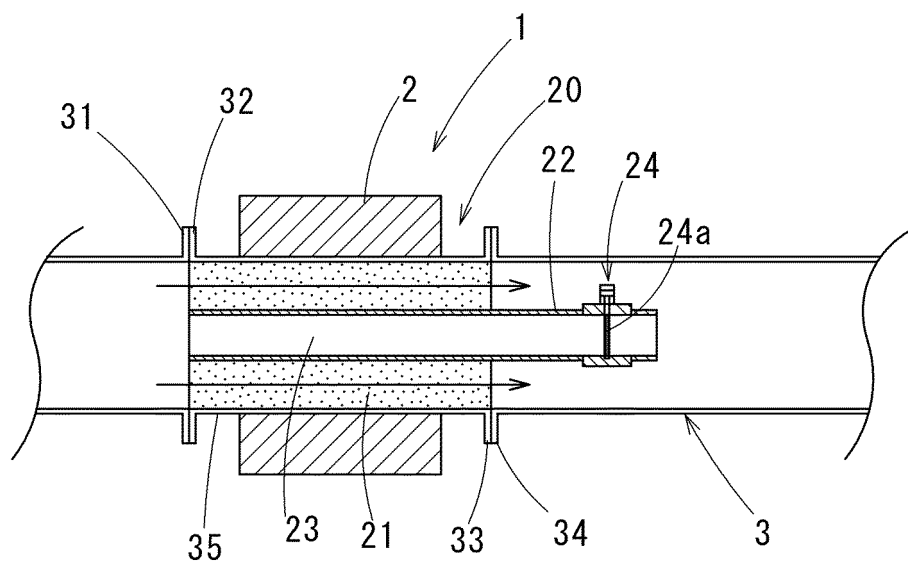


FIG. 3

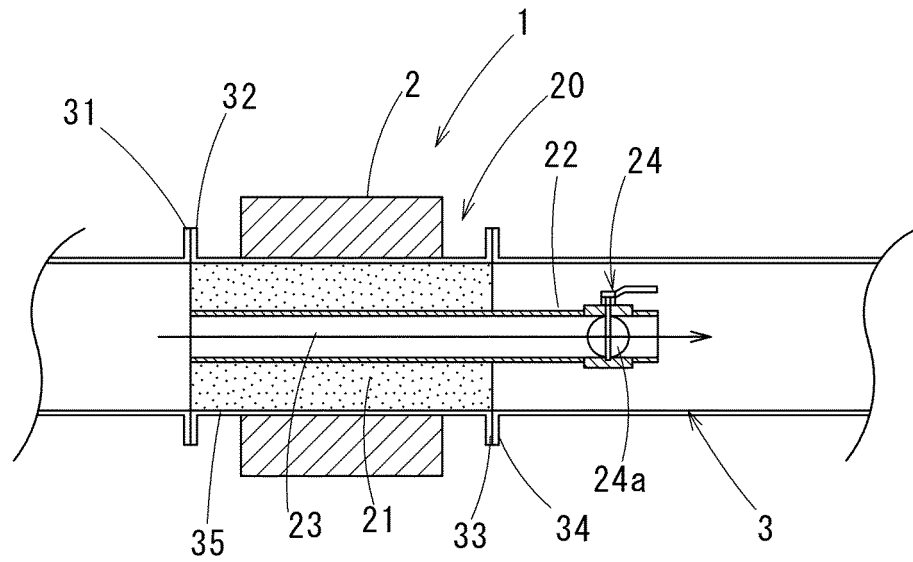
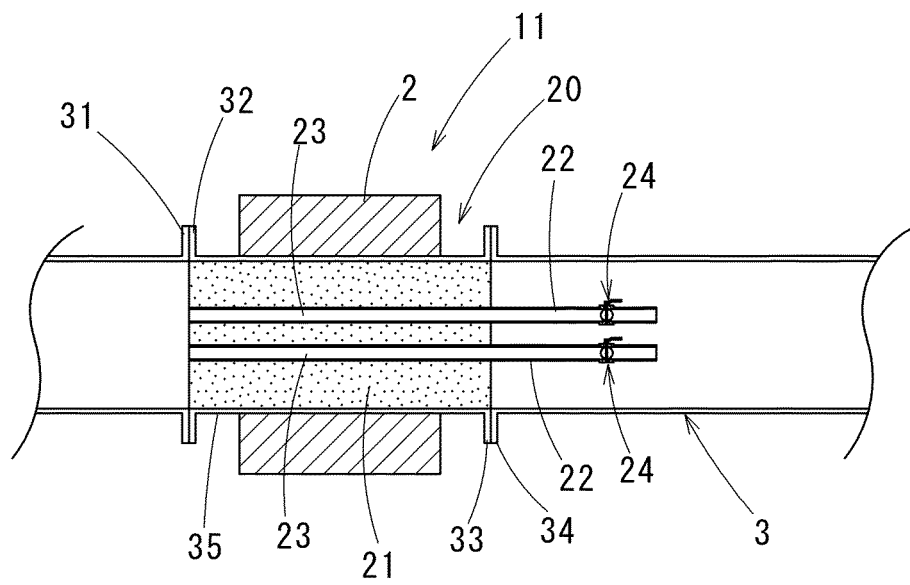


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/004924

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F24H9/00(2006.01)i, F28D1/04(2006.01)i, F28F1/40(2006.01)i,
F16L55/00(2006.01)i, F24H1/14(2006.01)i
FI: F28D1/04, F28F1/40R, F24H9/00A, F24H1/14Z, F16L55/00L, F16L55/00M
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)

Int.Cl. F24H9/00, F28D1/04, F28F1/40, F16L55/00, F24H1/14

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 47624/1985 (Laid-open No. 36366/1987) (OSAKA PREFECTURE) 04 March 1987 (1987-03-04), page 5, line 15 to page 10, line 7, fig. 1-5	1-2, 5-6 3-4
Y	WO 2017/038380 A1 (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 09 March 2017 (2017-03-09), paragraphs [0020]-[0065], fig. 1-9	1-2, 5-6
Y	JP 2018-40530 A (HITACHI CHEMICAL COMPANY, LTD.) 15 March 2018 (2018-03-15), paragraphs [0009]-[0048], fig. 1-5	2

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

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search
02 March 2021Date of mailing of the international search report
23 March 2021

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/004924

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-508472 A (RENAULT SAS) 21 March 2008 (2008-03-21), entire text, all drawings	1-6
A	JP 2008-249193 A (MITSUBISHI ELECTRIC CORPORATION) 16 October 2008 (2008-10-16), entire text, all drawings	1-6
A	JP 2008-187116 A (TOSHIBA CORPORATION) 14 August 2008 (2008-08-14), entire text, all drawings	1-6
A	JP 5-168847 A (KWW GESELLSCHAFT MIT BESCHRANKTER HAFTUNG) 02 July 1993 (1993-07-02), entire text, all drawings	1-6
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 127837/1990 (Laid-open No. 84994/1992) (YAMATAKE HONEYWELL CO., LTD.) 23 July 1992 (1992-07-23), entire text, all drawings	1-6

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2021/004924

JP 62-36366 U1	04 March 1987	(Family: none)
WO 2017/038380 A1	09 March 2017	JP 2017-44461 A
JP 2018-40530 A	15 March 2018	(Family: none)
JP 2008-508472 A	21 March 2008	US 2007/0209783 A1 WO 2006/021704 A1 FR 2873798 A1
JP 2008-249193 A	16 October 2008	(Family: none)
JP 2008-187116 A	14 August 2008	US 2008/0179046 A1
JP 5-168847 A	02 July 1993	EP 509111 A1 CA 2065176 A1
JP 4-84994 U1	23 July 1992	(Family: none)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2020038132 A [0001]
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