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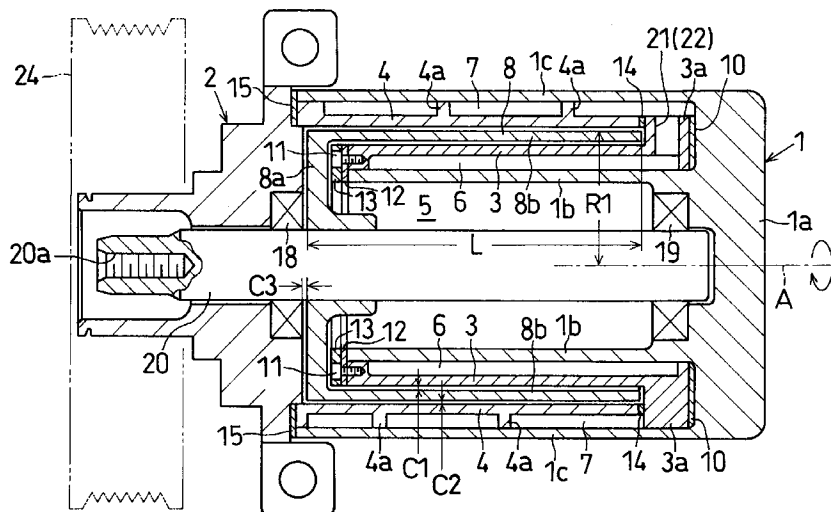
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(54) **DISPOSITIF DE CHAUFFAGE A FLUIDE VISQUEUX**

(54) **VISCOUS HEATER**



(57) Dispositif de chauffage à fluide visqueux comprenant un boîtier, un rotor, une huile de silicone servant de fluide visqueux, une zone de refroidissement, et de l'eau de circulation servant de fluide de circulation. Le rotor est reçu de manière à tourner sur un axe de rotation dans le boîtier et comprend un élément de cisaillement. L'élément de cisaillement est formé de manière à entourer l'axe de rotation et tourne sur un lieu géométrique de rotation lorsque le rotor tourne. La zone de refroidissement est délimitée dans le boîtier et comprend une première chambre de refroidissement et une deuxième. La première et la deuxième chambres de

(57) A viscous heater includes a housing, a rotor, a silicone oil working as a viscous fluid, a radiator region, and circulating water working as a circulating fluid. The rotor is accommodated rotatably about a rotary axis in the housing, and includes a shearing member. The shearing member is formed so as to surround the rotary axis, and rotates along a rotary locus as the rotor rotates. The radiator region is defined in the housing, and includes a first radiator chamber and a second radiator chamber. The first and second radiator chambers are disposed so as to interpose the rotary locus of the shearing member therebetween. The viscous fluid is



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refroidissement sont placées de manière que le lieu géométrique de rotation de l'élément de cisaillement s'interpose entre elles. Le fluide visqueux est reçu dans le boîtier. Le fluide de circulation s'écoule dans la zone de refroidissement. Le fluide visqueux est cisailé par le rotor pour produire de la chaleur. La chaleur produite est transférée au fluide de circulation pour effectuer l'échange de chaleur. Au lieu d'un élément unique et indépendant de cisaillement, le rotor peut comprendre un premier élément de cisaillement et un deuxième; et, au lieu d'une première et d'une deuxième chambres de refroidissement, la zone de refroidissement peut se composer d'une seule chambre de refroidissement indépendante. Non seulement le dispositif de chauffage à fluide visqueux affiche un superbe rendement en matière de production de chaleur, mais il peut également être facilement mis sur un véhicule et peut servir à résoudre les problèmes liés à la modification de la configuration générale (ou des dimensions) de son rotor ou de son boîtier.

accommodated in the housing. The circulating fluid flows in the radiator region. The viscous fluid is sheared by the rotor to generate heat. The resulting heat is transferred to the circulating fluid to carry out heat exchange. Instead of the single and independent shearing member, the rotor can include a first shearing member and a second shearing member, and, instead of the first and second radiator chambers, the radiator region can include a single and independent radiator chamber. Not only the viscous heater exhibits superb heat-generating performance, but also it can be readily boarded on a vehicle and solve the problems associated with altering the general configuration (or the dimensions) of its rotor or its housing.



ABSTRACT OF THE DISCLOSURE

A viscous heater includes a housing, a rotor, a silicone oil working as a viscous fluid, a radiator region, and circulating water working as a circulating fluid. The rotor is accommodated rotatably about a rotary axis in the housing, and includes a shearing member. The shearing member is formed so as to surround the rotary axis, and rotates along a rotary locus as the rotor rotates. The radiator region is defined in the housing, and includes a first radiator chamber and a second radiator chamber. The first and second radiator chambers are disposed so as to interpose the rotary locus of the shearing member therebetween. The viscous fluid is accommodated in the housing. The circulating fluid flows in the radiator region. The viscous fluid is sheared by the rotor to generate heat. The resulting heat is transferred to the circulating fluid to carry out heat exchange. Instead of the single and independent shearing member, the rotor can include a first shearing member and a second shearing member, and, instead of the first and second radiator chambers, the radiator region can include a single and independent radiator chamber. Not only the viscous heater exhibits superb heat-generating performance, but also it can be readily boarded on a vehicle and solve the problems associated with altering the general configuration (or the dimensions) of its rotor or its housing.

VISCOUS HEATER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a viscous heater which comprises a housing, a rotatable rotor accommodated in the housing, a viscous fluid accommodated in the housing, and a radiator chamber defined in the housing. In the viscous heater, the viscous fluid is sheared by the rotor to generate heat, and the resulting heat is transferred to a circulating fluid, which flows in the radiator chamber, to carry out heat exchange.

Description of the Related Art

A viscous heater has been attracting the attention of engineers as an auxiliary thermal source for boarding on a vehicle. The viscous heater utilizes a driving force of a vehicle engine. For instance, Japanese Unexamined Patent Publication (KOKAI) No. 2-246,823 discloses a viscous heater which is built into a heating apparatus for a vehicle.

In this viscous heater, a front housing and a rear housing are disposed so as to face with each other, and are fastened to each other, thereby forming a heat-generating chamber and a water jacket (or a radiator chamber) therein. The water jacket is disposed around an outer region of the heat-generating chamber. In the front housing, a driving shaft is held rotatably by way of a bearing apparatus. At one of the opposite ends of the driving shaft, a rotor is fixed so that it can rotate integrally with the driving shaft in the heat-generating chamber. On front and rear outer walls of the rotor, and on inner walls of the heat-generating chamber facing the front and rear outer walls of the rotor, there are formed concave-convex streaks which agree with each other so as to constitute a labyrinth groove. When the concave-convex

streaks are positioned in close proximity to each other, there is secured a labyrinth-like clearance between the outer walls of the rotor and the inner walls of the heat-generating chamber. In the heat-generating chamber, a viscous fluid, for example, a silicone oil, is sealed in a predetermined amount, and is further developed into the labyrinth-like clearance.

When a driving force of an engine is conveyed to the driving shaft, the rotor rotates together with the driving shaft in the heat-generating chamber. Accordingly, the viscous fluid, disposed between the inner walls of the heat-generating chamber and the outer walls of the rotor, is sheared by the rotor to generate heat which results from fluid friction. The heat thus generated in the heat-generating chamber is transferred to the circulating water, flowing in the water jacket, to carry out heat exchange. The thus heated circulating water is supplied to an external heating circuit, and is used to heat a passenger compartment of a vehicle.

In the conventional viscous heater, the body of the rotor should be formed as a disk-like shape whose axial length is shorter than the radius measured from the center, because the concave-convex streaks should be formed on the front and rear outer walls of the rotor in order to constitute the labyrinth groove. In the rotor, the main shearing surfaces are the surfaces of the concave-convex streaks on the front and rear outer walls of the rotor, and accordingly the concave-convex streaks disposed away from the center of the rotor body exhibit a faster peripheral speed (i.e., a larger shearing rate). As a result, the diameter of the rotor, namely, the outside diameter of the body of the viscous heater should be made larger in order to increase the heat generation of the viscous heater. However, it is generally difficult to securely provide a boarding space in a vehicle, especially in an engine room thereof, for the viscous heater having a large dimension in a radial direction.

Moreover, concerning the layout of the other vehicle auxiliary apparatuses, such a viscous heater troubles engineers to design the layout.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a viscous heater which can be readily boarded on a vehicle or the other products without decreasing its own heat-supplying capacity. It is a further object of the present invention to provide a viscous heater which can solve the problems associated with altering the general configuration (or the dimensions) of its rotor or its body so that it can exhibit superb heat-generating performance.

A viscous heater in accordance with one aspect of the present invention comprises:

- a housing;

- a rotor accommodated rotatably about a rotary axis in the housing, and including a shearing member formed so as to surround the rotary axis and rotating along a rotary locus as the rotor rotates;

- a viscous fluid accommodated in the housing;

- a radiator region defined in the housing, and including a first radiator chamber and a second radiator chamber, the first and second radiator chambers disposed so as to interpose the rotary locus of the shearing member therebetween; and

- a circulating fluid flowing in the radiator region;

- whereby shearing the viscous fluid with the rotor to generate heat, and transferring the resulting heat to the circulating fluid to carry out heat exchange.

In the above-described present viscous heater, the viscous fluid is subjected to shearing by the shearing member of the rotor as the rotor rotates, thereby generating heat. The resulting heat is quickly transferred to the circulating fluid,

which flows in the first and second radiator chambers, thereby carrying out heat exchange. Note that the circulating fluid can collect the heat held by the viscous fluid without loss because the first and second radiator chambers are disposed so as to interpose the rotary locus of the shearing member therebetween. Hence, the present viscous heater can efficiently give the heat of its own generation to the circulating fluid, and can efficiently supply a required quantity of heat. Moreover, the generated heat can be transferred quickly from the viscous fluid, which is sheared by the rotor, to the circulating fluid, which flows in the first and second radiator chambers, because the first and second radiator chambers interpose the heat-generating region therebetween. As a result, the viscous fluid can be inhibited from being overheated locally to the utmost, and can be kept from being deteriorated thermally.

In accordance with a further aspect of the present invention, the present viscous heater can further comprise a driving shaft rotated by an external driving source; and

the rotor can further include a base installed to the driving shaft, and a cylindrical member projecting from the base so as to surround the driving shaft and working as the shearing member.

In the thus arranged present viscous heater, the rotor rotates integrally together with the driving shaft. The shearing member projects from the base so as to surround the driving shaft, thereby providing the shearing member. Therefore, it is easy to dispose the first and second radiator chambers so as to interpose the rotary locus of the cylindrical member therebetween. Moreover, it is possible to make the cylindrical member into the shearing member which is interposed between the first and second radiator chambers.

In accordance with a further aspect of the present invention, the present viscous heater can further comprise a first stator disposed in the housing and defining the first radiator chamber, and a second stator disposed in the housing and defining the second radiator chamber; and

the shearing member of the rotor can be disposed between the first stator and the second stator.

In the thus arranged present viscous heater, it is easy to define the first and second radiator chambers, which interpose the shearing member of the rotor therebetween, in the housing by employing the first and second stators, which are disposed independently in the housing.

Moreover, the above-described present viscous heater can be further modified in the following manner: there can be a first clearance between the first stator and the shearing member of the rotor, and a second clearance between the second stator and the shearing member of the rotor; and

the first clearance and the second clearance can have dimensions differing from each other.

In the thus modified present viscous heater, the shearing member of the rotor can exhibit a first shearing heat-generating capacity at one of the shearing surfaces (i.e., the surface facing the first stator), and a second shearing heat-generating capacity at the other one of the shearing surfaces (i.e., the surface facing the second stator), first and second shearing heat-generating capacities which differ from each other. As a result, it is easy to appropriately adjust the heat-generating capacity of the present viscous heater depending on the service circumstances.

The present viscous heater modified as above can be furthermore modified in the following manner:

the first stator can be disposed nearer to the rotary axis of the rotor than the second stator; and

the dimension of the first clearance can be larger than that the second clearance.

The thus modified present viscous heater can be adjusted in terms of the characteristics as follows. The shearing heat-generating capacity is increased in a region between the second stator and the shearing member of the rotor where a relatively small clearance is provided. Whilst, the shearing heat-generating capacity is kept from enlarging in another region between the first stator and the shearing member of the rotor where a relatively large clearance is provided. Accordingly, in the region where the shearing heat-generating capacity is kept from enlarging, a higher weight is given to the radiator capacity than to the heat-generating capacity caused by shearing. Consequently, the viscous fluid is inhibited from being overheated. As a result, the longevity of the viscous fluid can be extended.

In accordance with a further aspect of the present invention, the present viscous heater can further comprise an accommodation chamber disposed in the housing to accommodate the rotor and the viscous fluid therein; and

the accommodation chamber can be divided functionally into a heat-generating region and a reservoir region, the heat-generating region disposed between the first stator and the shearing member of the rotor and between the second stator and the shearing member of the rotor, the reservoir region storing the viscous fluid to be exchanged between itself and the heat-generating region.

In the thus arranged present viscous heater, the viscous fluid can be exchanged between the heat-generating region and the reservoir region, which are disposed in the accommodation chamber, when the rotor rotates. Specifically, the

viscous fluid, which has been held in the reservoir region, is supplied to the heat-generating region. On the other hand, the viscous fluid, which has been sheared by the rotor in the heat-generating region, is returned to the reservoir region.

Accordingly, a specific portion of the viscous fluid can be inhibited from being always present in the heat-generating chamber and from being continuously subjected to the shearing action. Consequently, the specific portion of the viscous fluid can be kept from deteriorating rapidly. Moreover, the viscous fluid can recover its own viscosity in the reservoir region, and it can be re-supplied to the heat-generating region therefrom, because it can rest in the reservoir region by a predetermined cycle. As a result, when the present viscous heater is operated continuously, the viscous fluid can be sheared by the rotor without decreasing its own shearing efficiency as time passes. Thus, the viscous heater can stably maintain the heat-generating performance.

The above-described present viscous heater can be modified in the following manner:

the first radiator chamber and the second radiator chamber can be communicated with each other; and

the housing can be provided with a first port, a second port and a continuous flow passage, the continuous flow passage formed in the first and second radiator chambers so as to continuously extend from the first port to the second port.

In the thus modified present viscous heater, even when the first radiator chamber and the second radiator chamber are disposed separately while interposing the rotary locus of the shearing member of the rotor therebetween, the circulating fluid, which has been supplied through the first port, can reach the second port after it circulates the entire radiator region by way of the independent continuous flow

passage. Therefore, with the simple arrangement, the circulating fluid can flow smoothly in the radiator region.

A viscous heater in accordance with another aspect of the present invention comprises:

a housing;

a rotor accommodated rotatably about a rotary axis in the housing, and including a first shearing member and a second shearing member, the first and second shearing members formed so as to surround the rotary axis and rotating along a rotary locus respectively as the rotor rotates;

a viscous fluid accommodated in the housing;

a radiator region defined in the housing, and including a radiator chamber, the radiator chamber disposed between the rotary loci of the first and second shearing members; and

a circulating fluid flowing in the radiator region;

whereby shearing the viscous fluid with the rotor to generate heat, and transferring the resulting heat to the circulating fluid to carry out heat exchange.

In the above-described present viscous heater, the viscous fluid is subjected to shearing by the first and second shearing members of the rotor as the rotor rotates, thereby generating heat. The resulting heat is quickly transferred to the circulating fluid, which flows in the radiator chamber disposed between the first and second shearing members, thereby carrying out heat exchange. Note that a much larger quantity of heat is given to the circulating fluid because the radiator chamber receives the heat from the viscous fluid which is sheared by the first and second shearing members interposing the radiator chamber therebetween. Hence, the present viscous heater can generate a great quantity of heat so that the circulating

fluid can be heated constantly. As a result, even when the body of the present viscous heater is downsized, the resulting downsized present viscous heater can still supply a sufficient quantity of heat.

In accordance with a further aspect of the present invention, the present viscous heater can further comprise a driving shaft rotated by an external driving source; and

the rotor can further include a base installed to the driving shaft, and two concentrically-disposed cylindrical members projecting from the base so as to surround the driving shaft and working as the first and second shearing members.

In the thus arranged present viscous heater, the rotor rotates integrally together with the driving shaft. The first and second shearing members are formed as the two concentrically-disposed cylindrical members which project from the base so as to surround the driving shaft. Therefore, it is easy to dispose the radiator chamber between the rotary loci of the first and second cylindrical members. Moreover, it is possible to make the first and second cylindrical members into the first and second shearing members which interpose an independent radiator chamber therebetween.

In accordance with a further aspect of the present invention, the present viscous heater can further comprise a stator disposed in the housing and defining the radiator chamber.

In the thus arranged present viscous heater, it is easy to define the radiator chamber, which is disposed between the first and second shearing members of the rotor, in the housing by employing the stator, which is disposed in the housing.

In accordance with a further aspect of the present invention, the above-described present viscous heater can furthermore comprise an accommodation

chamber disposed in the housing to accommodate the rotor and the viscous fluid therein; and

the accommodation chamber can be divided functionally into a heat-generating region and a reservoir region, the heat-generating region disposed between the stator and at least one of the first shearing member of the rotor and the second shearing member thereof, the reservoir region storing the viscous fluid to be exchanged between itself and the heat-generating region.

In the thus arranged present viscous heater, the viscous fluid can be exchanged between the heat-generating region and the reservoir region, which are disposed in the accommodation chamber, when the rotor rotates. Specifically, the viscous fluid, which has been held in the reservoir region, is supplied to the heat-generating region. On the other hand, the viscous fluid, which has been sheared by the rotor in the heat-generating region, is returned to the reservoir region. Accordingly, a specific portion of the viscous fluid can be inhibited from being always present in the heat-generating chamber and from being continuously subjected to the shearing action. Consequently, the specific portion of the viscous fluid can be kept from deteriorating rapidly. Moreover, the viscous fluid can recover its own viscosity in the reservoir region, and it can be re-supplied to the heat-generating region therefrom, because it can rest in the reservoir region by a predetermined cycle. As a result, when the present viscous heater is operated continuously, the viscous fluid can be sheared by the rotor without decreasing its own shearing efficiency as time passes. Thus, the viscous heater can stably maintain the heat-generating performance.

The above-described present viscous heater can be modified in the following manner:

the housing can be provided with a first port, a second port and a continuous flow passage, the continuous flow passage formed in the radiator chamber so as to continuously extend from the first port to the second port.

In the thus modified present viscous heater, the circulating fluid, which has been supplied through the first port, can reach the second port after it circulates the entire radiator region (or the radiator chamber) by way of the independent continuous flow passage. Therefore, with the simple arrangement, the circulating fluid can flow smoothly in the radiator region.

As having described so far, the above-described present viscous heater can produce the following advantages: namely; the present viscous heater can be readily boarded on a vehicle or the other products without decreasing its own heat-supplying capacity; and simultaneously it can solve the problems associated with altering the general configuration (or the dimensions) of its rotor or its body so that it can exhibit superb heat-generating performance.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the present invention and many of its advantages will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings and detailed specification, all of which forms a part of the disclosure:

Fig. 1 is a vertical cross-sectional view of a viscous heater according to a First Preferred Embodiment of the present invention;

Fig. 2 is a diagram illustrating an outer peripheral side wall of the viscous heater illustrated in Fig. 1;

Fig. 3 is a development schematically illustrating an exemplified arrangement

of an inner radiator chamber in a viscous heater of the present invention;

Fig. 4 is a vertical cross-sectional view of a viscous heater according to a Second Preferred Embodiment of the present invention;

Fig. 5 is a development schematically illustrating another exemplified arrangement of an inner radiator chamber of a viscous heater according to the present invention;

Fig. 6 is an enlarged cross-sectional view on major portions of a modified version of the present viscous heater; and

Fig. 7 is a schematic block diagram on major portions of another modified version of the present viscous heater.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Having generally described the present invention, a further understanding can be obtained by reference to the specific preferred embodiments which are provided herein for the purpose of illustration only and not intended to limit the scope of the appended claims.

While referring to the accompanying drawings, the present invention will be hereinafter described with respect to First and Second Preferred Embodiments, which embody the present viscous heater to be built into a vehicle heating apparatus.

First Preferred Embodiment

As illustrated in Figs. 1 and 2, a viscous heater according to a First Preferred Embodiment of the present invention is provided with a housing body 1 and a housing lid 2. The housing body 1 has an opened end. The housing lid 2 is installed to the opened end of the housing body 1.

The housing body 1 includes a base end 1a, a first cylindrical wall 1b, and a second cylindrical wall 1c. The base 1a constitutes a rear end of the viscous heater.

The first and second cylindrical walls 1b and 1c project forward (i.e., to the left-hand side in Fig. 1), and are disposed concentrically. The first cylindrical wall 1b has an inside diameter which is smaller than that of the second cylindrical wall 1c, and is disposed inside the second cylindrical wall 1c. The second cylindrical wall 1c constitutes an outer peripheral wall of the housing body 1 (i.e., a contour thereof).

On an outside of the first cylindrical wall 1b, a first stator 3 is fitted around the first cylindrical wall 1b. A major portion of the first stator 3 is formed as a cylinder shape substantially, and a base end thereof is formed as flange 3a having a heavy thickness. A ring-shaped gasket 10 is held between the flange 3a and an inner wall surface of the base end 1a of the housing body 1. Moreover, the leading end of the first stator 3 is formed as a disk shape on the front side. At the disk-shaped leading end of the first stator 3, a ring-shaped retainer plate 13 is installed by a plurality of screws 11 while interposing a ring-shaped gasket 12 between the retainer plate 13 and the leading end of the first stator 3.

On an inside of the second cylindrical wall 1c, a second stator 4 is fitted into the second cylindrical wall 1c. The second stator 4 is formed as a cylinder shape substantially, and is provided with a streak of rib 4a on an outer peripheral surface. The rib 4a projects from the outer peripheral surface, and extends helically thereon. The rear end of the substantially cylinder-shaped second stator 4 contacts with the flange 3a of the first stator 1 by way of a ring-shaped gasket 14. An overall length of the second stator 4 is determined so that the front end of the second stator 4 agrees with the leading end of the second cylindrical wall 1c when the second stator 4 is fitted into the second cylindrical wall 1c. Moreover, a ring-shaped gasket 15 is held between the front end of the second stator 4 and the housing lid 2, and between the leading end of the second cylindrical wall 1c and the housing lid 2.

The housing lid 2 is installed on an opened-end side of the housing body 1 into which the first and second stators 3 and 4 are fitted. The first and second stators 3 and 4 work as a radiator-chamber defining member in the housing body 1, respectively. Thereafter, the housing body 1 and the housing lid 2 are fastened by a plurality of through bolts (not shown) which are disposed in a direction along the axis of the housing body 1. Accordingly, the first and second stators 3 and 4 are positioned unmovably in the housing 1 in such a manner that they are pressed against with each other. Thus, in the housing body 1, an accommodation chamber 5 is defined by part of the housing body 1, the housing lid 2 and the first and second stators 3 and 4.

As illustrated in Figs. 1 and 2, when the first stator 3 is fitted around the first cylindrical wall 1b, an inner water jacket 6 is defined between the first stator 3 and the first cylindrical wall 1b. The inner water jacket 6 works as the first radiator chamber. Moreover, when the second stator 4 is fitted into the second cylindrical wall 1c, an outer water jacket 7 is defined between the second stator 4 and the second cylindrical wall 1c. The outer water jacket 7 works as the second radiator chamber. When the second stator 4 is press-fitted into the housing body 1, the helical rib 4a of the second stator 4 contacts closely with an inner peripheral surface of the second cylindrical wall 1c of the housing body 1, and accordingly sets up a helical flow passage "P1" (shown in Fig. 2) in the outer water jacket 7. Thus, in the outer water jacket 7, the rib 4a functions as means for setting up a circulating passage for a circulating fluid, and for guiding the circulating fluid.

Fig. 3 is a development schematically illustrating the first stator 3. In the drawing, the first stator 3 is cut and opened along a side which extends in the longitudinal direction. As illustrated in Fig. 3, a plurality of projection streaks 3b are

disposed on an inner peripheral side of the first stator 3. The projection streaks 3b extend in a longitudinal direction of the first stator 3 (i.e., in the axial direction thereof). At the same time, the projection streaks 3b contact closely with an outer peripheral surface of the first cylindrical wall 1b when the first stator 3 is fitted around the first cylindrical wall 1b. Thus, the projection streaks 3b set up a zigzagging flow passage "P2" in the inner water jacket 6. The flow passage "P2" goes around the first cylindrical wall 1b while zigzagging in the inner water jacket 6. Hence, in the inner water jacket 6, the projection streaks 3b function as means for setting up a circulating passage for a circulating fluid, and for guiding the circulating fluid.

Moreover, as illustrated in Figs. 1 and 3, two communication holes 21 and 22 are drilled through the flange 3a of the first stator 3. The inlet-side communication hole 21 and the outlet-side communication hole 22 are disposed at positions which correspond to the starting point and terminating point of the zigzagging flow passage "P2". The communication holes 21 and 22 extend in a radial direction of the housing body 1, respectively, and communicate the inner water jacket 6 with the outer water jacket 7.

As illustrate in Fig. 2, the outer periphery of the housing body 1 is provided with an inlet port 16 (i.e., the first port) and an outlet port 17 (i.e., the second port). The inlet port 16 takes in circulating water (e.g., an engine coolant) into the outer water jacket 7 from a vehicle heating circuit (not shown). The circulating water works as the circulating fluid. The outlet port 17 delivers the circulating water out from the outer water jacket 7 to the heating circuit. Accordingly, the circulating water, which is taken in through the inlet port 16 from the heating circuit, arrives at the outlet port 17 by way of the helical flow passage "P1", which is set up in the outer

water jacket 7, and returns again to the heating circuit. In addition, the circulating water, which is taken in into the outer water jacket 7, is also introduced into the inner water jacket 6 through the inlet-side communication hole 21. Then, the circulating water goes substantially around the entire periphery of the first stator 3 by way of the zigzagging flow passage "P2", and thereafter arrives at the outlet-side communication hole 22. Finally, the circulating water returns again to the helical flow passage "P1" through the outlet-side communication hole 22. Thus, the circulating water is supplied from the outside, and flows smoothly in the inner and outer water jackets 6 and 7.

As illustrated in Fig. 1, the driving shaft 20 is held rotatably in the housing body 1 and the housing lid 2 by way of bearing apparatuses 18 and 19. At the front end (or the outer end) of the driving shaft 20, there is formed a threaded hole 20a. Into the threaded hole 20a, a bolt (not shown) is screwed so that a pulley 24 is fastened to the driving shaft 20. In the drawing, the pulley 24 is schematically illustrated with the alternate long and two dashes line. Thus, the pulley 24 is driven by and connected with a vehicle engine via a power transmission belt (not shown). The vehicle engine works an external power source. The power transmission belt is put around an outer periphery of the pulley 24. Consequently, the driving shaft 20 is rotated by a driving force of the engine via the pulley 24.

The bearing apparatuses 18 and 19 are sealed bearings which have a sealing function as well. Accordingly, when the central major portion of the driving shaft 20 is accommodated in the accommodation chamber 5, the bearing apparatuses 18 and 19 make the accommodation chamber 5 into a liquid-filled inner space. In the accommodation chamber 5, a rotor 8 is fastened onto the driving shaft 20, and is rotated integrally together with the driving shaft 20 by the driving force of the

engine.

The rotor 8 is made of a light metal, such as an aluminum-based alloy, etc. The rotor 8 is provided with a base end 8a and a cylindrical member 8b. The base end 8a is installed to the driving shaft 20. The cylindrical member 8b is projected from the base end 8a rearward (i.e., to the right-hand side in Fig. 1). The base end 8a is formed substantially as a disk shape, and is flat on the forward-end surface. The flat forward-end surface of the base end 8a faces the rear-end surface of the housing lid 2. A fine clearance "C3" is thus formed between the forward-end surface of the base end 8a and the rear-end surface of the housing lid 2. The cylindrical member 8b is formed as a cylinder shape which surrounds a rotary axis "A" of the driving shaft 20. Positions on the outer peripheral surface of the cylindrical member 8b are separated away from the rotary axis "A" by a distance of a radius "R1". The cylindrical member 8b has a length "L" in the direction of the rotary axis "A" of the driving shaft 20. The length "L" is designed to be longer than the radius "R1".

An inner peripheral surface of the cylindrical member 8b faces an outer peripheral surface of the first stator 3. A fine clearance "C1" is thus formed between the inner peripheral surface of the cylindrical member 8b and the outer peripheral surface of the first stator 3. Moreover, an outer peripheral surface of the cylindrical member 8b faces an inner peripheral surface of the second stator 4. A fine clearance "C2" is thus formed between the outer peripheral surface of the cylindrical member 8b and the inner peripheral surface of the second stator 4. Thus, the cylindrical member 8b is disposed between the first stator 3 and the second stator 4, and is rotated so as to draw a rotary locus about the rotary axis "A" as the rotor 8 rotates. Note that the first stator 3 defines the inner water jacket 6, and that the second stator 4 defines the outer water jacket 7. In the First Preferred Embodiment, the

clearances "C1", "C2" and "C3" are designed to exhibit an identical interval (or distance). However, the clearances "C1", "C2" and "C3" can exhibit intervals which differ from each other.

A silicone oil (not shown) is held in the accommodation chamber 5 in a predetermined amount. The silicone oil works as the viscous fluid. The accommodation chamber 5 works as the liquid-filled inner space. A charging amount V_f of the silicone oil is determined so that an ordinary-temperature volumetric charging ratio of the silicone oil falls in a range of from 50 to 80% with respect to a residual space volume V_r . The residual space volume V_r herein means a volumetric difference which is obtained by subtracting the volumes of the accommodated objects (e.g., the rotor 8 and the driving shaft 20) from the theoretical inner volume of the accommodation chamber 5. Considering the volumetric expansion of the silicone oil during the heat generation, the charging ratio of the silicone oil is not set at 100%. Specifically, an empty space, where no silicone oil exists, works as a buffer space. The buffer space enables the silicone oil to expand its volume during the heat generation, and prevents the inner pressure of the accommodation chamber 5 from increasing.

As the driving shaft 20 and the rotor 8 rotate integrally, the inner and outer peripheral surfaces of the cylindrical member 8b of the rotor 8, and the forward-end surface of the disk-shaped base end 8a thereof shear the silicone oil, which is present in the fine clearances "C1", "C2" and "C3". In particular, the cylindrical member 8b contributes to the shearing much more than the disk-shaped base end 8a, because of the dimensions of the surface area, and because of the high peripheral speed during the rotation. Therefore, in the rotor 8, the cylindrical member 8b plays a role of a major member for shearing the viscous fluid. The silicone oil is subjected to the

shearing actions of the shearing surfaces in the rotor 8 (i.e., the inner and outer peripheral surfaces of the cylindrical member 8b of the rotor 8, and the forward-end surface of the disk-shaped base end 8a thereof). As a result, the silicone oil generates heat which results from the fluid friction. The thus generated heat is transferred to the circulating water by way of the first and second stators 3 and 4 to carry out heat exchange. The circulating water flows in the inner and outer water jackets 6 and 7 to work as the circulating fluid. Then, the circulating fluid, heated in the inner and outer water jackets 6 and 7, is delivered to the heating circuit, and is eventually used to heat a passenger compartment of a vehicle.

As described above, the inner space of the accommodation chamber 5 is functionally divided into the heat-generating region and the other region (i.e., the reservoir region). In the heat-generating region, the viscous fluid is subjected to the shearing to generate heat. Specifically, the heat-generating region is constituted by the clearances "C1", "C2" and "C3". The clearance "C1" is present between the inner peripheral surface of the cylindrical member 8b and the outer peripheral surface of the first stator 3. The clearance "C2" is present between the outer peripheral surface of the cylindrical member 8b and the inner peripheral surface of the second stator 3. The clearance "C3" is present between the forward-end surface of the disk-shaped base end 8a and the rear-end surface of the housing lid 2. The inner and outer water jackets 6 and 7 work as the first and second radiator chambers, respectively, and are considered the radiator region. The radiator region facilitates the transfer or radiation of the heat, which is possessed by the viscous fluid disposed in the heat-generating region, to the circulating fluid.

Moreover, in the accommodation chamber 5, the region, excepting the heat-generating region, plays a role of the reservoir chamber for the viscous fluid. The

reservoir region is mainly constituted by the inside region with respect to the first cylindrical wall 1b which surrounds the driving shaft 20 disposed in the accommodation chamber 5. In addition to the heat-generating region, the reservoir region accommodates the viscous fluid therein as well, and works as a supply source of the viscous fluid which is exchanged between the reservoir region and the heat-generating chamber.

Note that the heat-generation by shearing the viscous fluid is not hindered because the charging ratio of the silicone oil is set at 80% or less with respect to the residual space volume V_r . This phenomenon results from the expansive viscosity of the viscous fluid. Namely, when the driving shaft 20 and the rotor 8 rotate integrally, the silicone oil develops by its own expansive viscosity evenly all over the fine clearances which are formed between the outer surfaces of the rotor 8 and the inner surfaces of the accommodation chamber 5.

The operations and advantages of the viscous heater according to the First Preferred Embodiment are listed below.

a) The outer and inner peripheral surfaces of the cylindrical member 8b of the rotor 8 work as the major shearing member, and shear the viscous fluid, held in the heat-generating region, to generate heat. Accordingly, even when the dimensions of the rotor 8 are reduced, it is possible to generate a required quantity of heat with the resulting small rotor 8. Moreover, the inner and outer jackets 6 and 7 are disposed so as to interpose the cylindrical member 8b of the rotor 8 therebetween, and are disposed in proximity to the inner and outer peripheral surfaces of the cylindrical member 8b as close as possible. Consequently, the heat generated in the clearances "C1" and "C2" can be efficiently transferred to the circulating water to carry out heat exchange. Therefore, in the viscous heater, the

body of the viscous heater can be readily downsized while securing an ample heat-generating ability.

b) The first and second stators 3 and 4 are disposed concentrically so as to interpose the cylindrical member 8b of the rotor 8 therebetween. Accordingly, there arises a relative difference between the peripheral speed of the first stator 3 and that of the second stator 4. Under the circumstance, a secondary flow occurs in a fluid which is disposed between peripheral surfaces facing to each other, like the peripheral surfaces of the cylindrical member 8b and the first and second stators 3 and 4. The secondary flow is called the Taylor vortex, and is caused by the destabilizing effects resulting from the centrifugal force. Specifically, in each of the regions of the clearances "C1" and "C2", a plurality of ring-shaped vortexes generate. The ring-shaped vortexes neighbor in the direction of the rotary axis "A", and produce a relative flow in the direction of the peripheral direction as a whole. However, the relative flow assumes a helical flow which is produced by intertwining the 3-way vectors, for instance, the vectors extending in the direction of the rotary axis "A", the vectors extending in the peripheral directions and the vectors extending in the radial directions, complicatedly. When the ring-shaped vortexes are observed in a vertical cross-section which is taken along the rotary axis "A", the rotary directions of the ring-shaped vortexes are inverted to each other.

Hence, the silicone oil circulates helically in the clearances "C1" and "C2", because the secondary flow (i.e., the Taylor vortex) generates in the each of the regions of the clearances "C1" and "C2". Consequently, the temperature distribution of the silicone oil can be equalized in the radial directions. As a result, it is possible to inhibit the portions of the silicone oil, which are present adjacent to the inner and outer peripheral surfaces of the cylindrical member 8b of the rotor 8 (i.e., the

extremely thin boundary-layer regions), from being overheated locally, and to avoid the drawback stemming from the local deterioration of the silicone oil.

c) As described above, the inner space of the accommodation chamber 5 can be functionally divided into the heat-generating region and the reservoir region without loss. As a result, it is possible to effectively utilize the inside of the accommodation chamber 5. Thus, the arrangement is extremely advantageous to downsizing the body of the viscous heater.

d) The reservoir region of the accommodation chamber 5 additionally holds the viscous fluid (e.g., the silicone oil), excepting the viscous fluid which is sheared directly by the rotor 8, therein. As a result, a large amount of the viscous fluid can be secured in the accommodation chamber 5, and the viscous fluid can be subjected to the shearing intermittently while it is exchanged between the heat-generating region and the reservoir region, and while it takes a rest. Thus, it is possible to delay the deterioration timing of the viscous fluid, and to prolong the longevity of the viscous heater as a whole.

Second Preferred Embodiment

Fundamentally, a viscous heater according to a Second Preferred Embodiment of the present invention has the same arrangements as those of the viscous heater according to the First Preferred Embodiment. However, the viscous heater according to the Second Preferred Embodiment comprises a rotor whose configuration differs partly from the rotor 8 of the viscous heater according to the First Preferred Embodiment. Therefore, in Fig. 4 illustrating the viscous heater according to the Second Preferred Embodiment specifically, the component parts or members, which have the counterparts in the viscous heater according to the First Preferred Embodiment, are designated at the same reference numerals with those of

the viscous heater according to the First Preferred Embodiment. Accordingly, in order to avoid presenting the same descriptions repeatedly, the viscous heater according to the Second Preferred Embodiment will be hereinafter described primarily with respect to the arrangements which differ from those of the viscous heater according to the First Preferred Embodiment.

As illustrated in Fig. 4, in an accommodation chamber 5, a rotor 8 is fastened onto a driving shaft 20. In addition to a base end 8a and a first cylindrical member 8b, the rotor 8 is further provided with a second cylindrical member 8c. The first cylindrical member 8b and the second cylindrical member 8c are formed as cylinder shapes which are disposed concentrically with respect to the rotary axis "A" of the driving shaft 20. Thus, the outer peripheral surfaces of the first cylindrical member 8b and the second cylindrical member 8c draw rotary loci, which have a radius of "R1" and "R2", respectively, about the rotary axis "A" as the rotor 8 rotates. A clearance "C4" is thus formed between an outer peripheral surface of the second cylindrical member 8c and an inner peripheral surface of a first cylindrical wall 1b of a housing body 1, because the rotor 8 is provided with the second cylindrical member 8c. The clearance "C4" forms a part of a heat-generating region in the viscous heater according to the Second Preferred Embodiment. Note that the clearance "C4" is designed to exhibit an identical interval (or distance) with that of a clearance "C2" which is formed between an outer peripheral surface of the first cylindrical member 8b and an inner peripheral surface of a second stator 4.

In the viscous heater according to the Second Preferred Embodiment, the first cylindrical member 8b and the second cylindrical member 8c of the rotor 8 correspond to the first shearing member and the second shearing member, respectively. Further, an inner water jacket 6 corresponds to the radiator chamber

which is disposed between the rotary loci of the first and second shearing members. The overall surface area of the surfaces for shearing the viscous heater is increased because the second cylindrical member 8c is formed additionally to the rotor 8. As a result, even when the viscous heater according to the Second Preferred Embodiment has the same outside dimensions as those of the viscous heater according to the First Preferred Embodiment, the viscous heater according to the Second Preferred Embodiment can generate a greater quantity of heat than the viscous heater according to the First Preferred Embodiment does.

In the viscous heater according to the Second Preferred Embodiment, the major shearing member of the rotor 8 is constituted by the two concentrically-disposed cylinder elements 8b and 8c. Note that, however, the concentrically-disposed cylinder elements can be provided in a quantity of three or more. With this arrangement, it is possible to furthermore increase the quantity of heat produced by the viscous heater, and to utilize the inner space furthermore effectively. In this instance, it is preferable to additionally provide an extra radiator chamber, which operates in the same manner as the inner water jacket 6, between the second cylindrical member and the third and extra cylindrical member, and so on.

The above-described First and Second Preferred Embodiments do not at all limit how the present invention is embodied. For example, it is possible to modify the First and Second Preferred Embodiments in the following manner.

First Modified Version

In the First and Second Preferred Embodiments, the clearance "C1" and the clearance "C2" are designed to exhibit the same dimension (i.e., interval or distance) with each other. The clearance "C1" is formed between the inner peripheral surface of the cylindrical member 8b of the rotor 8 and the outer peripheral surface of the

first stator 3. The clearance "C2" is formed between the outer peripheral surface of the cylindrical member 8b of the rotor 8 and the inner peripheral surface of the second stator 4.

However, the inside clearance "C1" with respect to the cylindrical member 8b of the rotor 8 can be larger than the outside clearance "C2" with respect thereto (i.e., "C1" > "C2"). When the clearances "C1" and "C2" are thus designed, the shearing heat-generating capacity can be enhanced in the outside clearance "C2" while the shearing heat-generating capacity can be suppressed to the utmost in the inside clearance "C1". In this instance, in the inside clearance "C1", the radiating capability for radiating heat to the inner water jacket 6 is increased relatively with respect to the heat-generating capability resulting from shearing. Consequently, it is possible to keep the silicone oil, which is present in the heat-generating region, from being overheated. All in all, it is possible to inhibit the silicone oil from being overheated and degraded locally in the heat-generating region, and to eventually prolong the longevity of the silicone oil.

Second Modified Version

In the First and Second Preferred Embodiments, the fine clearance "C3" is designed to be made up of the space between the rear-end surface of the housing lid 2 and the front-end surface of the disk-shaped base end 8a of the rotor 8, and works as part of the heat-generating region.

However, the clearance "C3" can be enlarged so that no heat is generated in the region of the clearance "C3". If such is the case, the overall heat-supplying capacity is little affected adversely, because a considerably large amount of heat can be generated in the regions of the clearances "C1", "C2" and "C4".

Third Modified Version

Instead of the zigzagging flow passage "P2" (shown in Fig. 3) employed by the First and Second Preferred Embodiments, a flow passage "P3" as illustrated in Fig. 5 can be formed in an inner water jacket 6 which operates as the first radiator chamber. Specifically, as shown in Fig. 5, a plurality of projection streaks 31 are disposed on an inner-peripheral-surface side of the first stator 3. The projection streaks 31 extend in a peripheral direction, and contact closely with an outer peripheral surface of the first cylindrical wall 1b of the housing body 1. Thus, the projection streaks 31 form a zigzagging flow passage "P3" which goes back and forth in a peripheral direction. With the thus arranged flow passage "P3", it is possible to discharge the circulating water, which is introduced into the inner water jacket 6 by way of an inlet-side communication hole 21, through an outlet-side communication hole 22 after circulating the circulating water smoothly all over the regions in the inner water jacket 6.

Fourth Modified Version

In the First and Second Preferred Embodiments, the helically-shaped rib 4a is protruded from the outer periphery of the second stator 4. As illustrated in Fig. 6, instead of the rib 4a, a plurality of radiator fins 4b can be formed substantially entirely on an outer periphery of a second stator 4. The radiator fins 4b are designed to have a leading end which is kept from contacting with an inner peripheral surface of a second cylindrical wall 1c of a housing body 1. With the thus arranged radiator fins 4b, it is possible to avoid the undesirable heat transfer to the housing body 1, and accordingly to efficiently carry out heat exchange between a viscous fluid and circulating water.

Fifth Modified Version

In the viscous heaters according to the First and Second Preferred

Embodiments illustrated in Figs. 1 and 4, respectively, an electromagnetic clutch mechanism 26 can be further disposed between the pulley 24 and the driving shaft 20, and can be controlled by a controller 28 as illustrated in Fig. 7. Consequently, the driving force of the vehicle engine (i.e., the external power source) can be selectively transmitted to the driving shaft 20 on demand. When no shearing heat-generation is demanded, the electromagnetic clutch mechanism 26 is shut down. As a result, with this arrangement, it is possible to inhibit the viscous fluid from being sheared unnecessarily.

In the present specification, the term, "viscous fluid", means all media which generate heat when they are subjected to the shearing action of a rotor. The thus generated heat results from fluid friction. Hence, the viscous fluid is not limited to liquids of high viscosity, semi-fluidic substances, etc. Thus, it is needless to say that the viscous fluid is not at all limited to the silicone oil.

Having now fully described the present invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit or scope of the present invention as set forth herein including the appended claims.

The entire disclosure of Japanese Patent Application No. 9-042,314 filed on February 26, 1997, including the specification, claims, drawings and summary, is incorporated herein by reference in its entirety.

What is claimed is:

1. A viscous heater, comprising:
 - a housing;
 - a rotor accommodated rotatably about a rotary axis in said housing, and including a shearing member formed so as to surround the rotary axis and rotating along a rotary locus as the rotor rotates;
 - a viscous fluid accommodated in said housing;
 - a radiator region defined in said housing, and including a first radiator chamber and a second radiator chamber, the first and second radiator chambers disposed so as to interpose the rotary locus of the shearing member therebetween; and
 - a circulating fluid flowing in said radiator region;
 - whereby shearing said viscous fluid with said rotor to generate heat, and transferring the resulting heat to said circulating fluid to carry out heat exchange.
2. The viscous heater according to Claim 1, wherein:
 - said viscous heater further comprises a driving shaft rotated by an external driving source; and
 - said rotor further includes a base installed to the driving shaft, and a cylindrical member projecting from the base so as to surround the driving shaft and working as the shearing member.
3. The viscous heater according to Claim 1 or 2, wherein:
 - said viscous heater further comprises a first stator disposed in said housing and defining the first radiator chamber, and a second stator disposed in said housing and defining the second radiator chamber; and
 - the shearing member of said rotor is disposed between the first stator and the second stator.

4. The viscous heater according to Claim 3, wherein:
there are a first clearance between the first stator and the shearing member of said rotor, and a second clearance between the second stator and the shearing member of said rotor; and
the first clearance and the second clearance have dimensions differing from each other.
5. The viscous heater according to Claim 4, wherein:
the first stator is disposed nearer to the rotary axis of said rotor than the second stator; and
the dimension of the first clearance is larger than that of the second clearance.
6. The viscous heater according to Claim 3, 4 or 5 wherein:
said viscous heater further comprises an accommodation chamber disposed in said housing to accommodate said rotor and said viscous fluid therein; and
the accommodation chamber is divided functionally into a heat-generating region and a reservoir region, the heat-generating region disposed between the first stator and the shearing member of said rotor and between the second stator and the shearing member of said rotor, the reservoir region storing said viscous fluid to be exchanged between itself and the heat-generating region.
7. The viscous heater according to Claim 1, 2, 3, 4, 5 or 6 wherein:
the first radiator chamber and the second radiator chamber are communicated with each other; and
said housing is provided with a first port, a second port and a continuous flow passage, the continuous flow passage formed in the first and second radiator chambers so as to continuously extend from the first port to the second port.
8. A viscous heater, comprising:

a housing;

a rotor accommodated rotatably about a rotary axis in said housing, and including a first shearing member and a second shearing member, the first and second shearing members formed so as to surround the rotary axis and rotating along a rotary locus respectively as the rotor rotates;

a viscous fluid accommodated in said housing;

a radiator region defined in said housing, and including a radiator chamber, the radiator chamber disposed between the rotary loci of the first and second shearing members; and

a circulating fluid flowing in said radiator region;

whereby shearing said viscous fluid with said rotor to generate heat, and transferring the resulting heat to said circulating fluid to carry out heat exchange.

9. The viscous heater according to Claim 8, wherein:

said viscous heater further comprises a driving shaft rotated by an external driving source; and

said rotor further includes a base installed to the driving shaft, and two concentrically-disposed cylindrical members projecting from the base so as to surround the driving shaft and working as the first and second shearing members.

10. The viscous heater according to Claim 8 or 9, wherein:

said viscous heater further comprises a stator disposed in said housing and defining the radiator chamber.

11. The viscous heater according to Claim 10, wherein:

said viscous heater further comprises an accommodation chamber disposed in said housing to accommodate said rotor and said viscous fluid therein; and

the accommodation chamber is divided functionally into a heat-generating

region and a reservoir region, the heat-generating region disposed between the stator and at least one of the first shearing member of said rotor and the second shearing member thereof, the reservoir region storing said viscous fluid to be exchanged between itself and the heat-generating region.

12. The viscous heater according to Claim 8, 9, 10 or 11, wherein:

said housing is provided with a first port, a second port and a continuous flow passage, the continuous flow passage formed in the radiator chamber so as to continuously extend from the first port to the second port.

FIG. 1

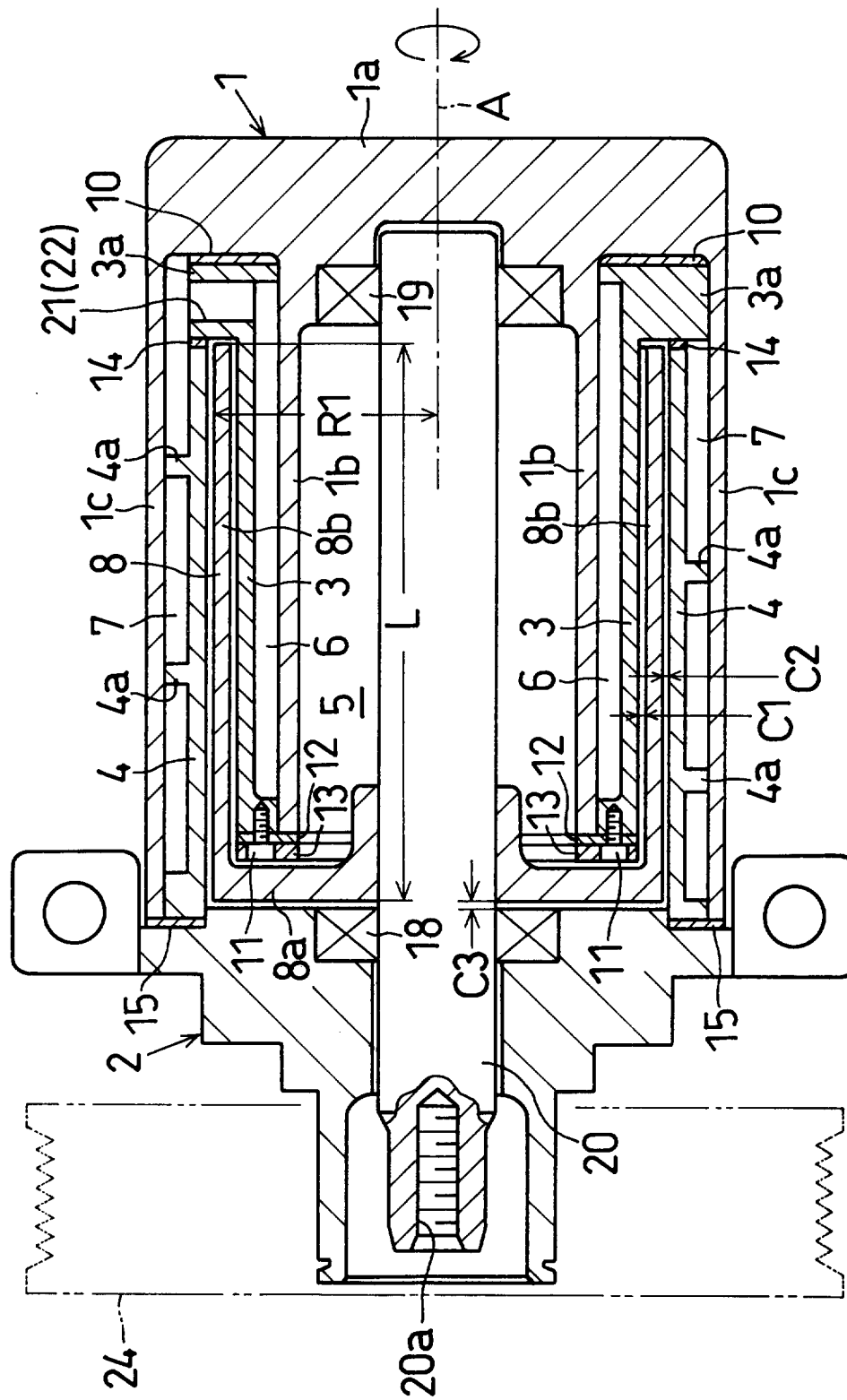


FIG. 2

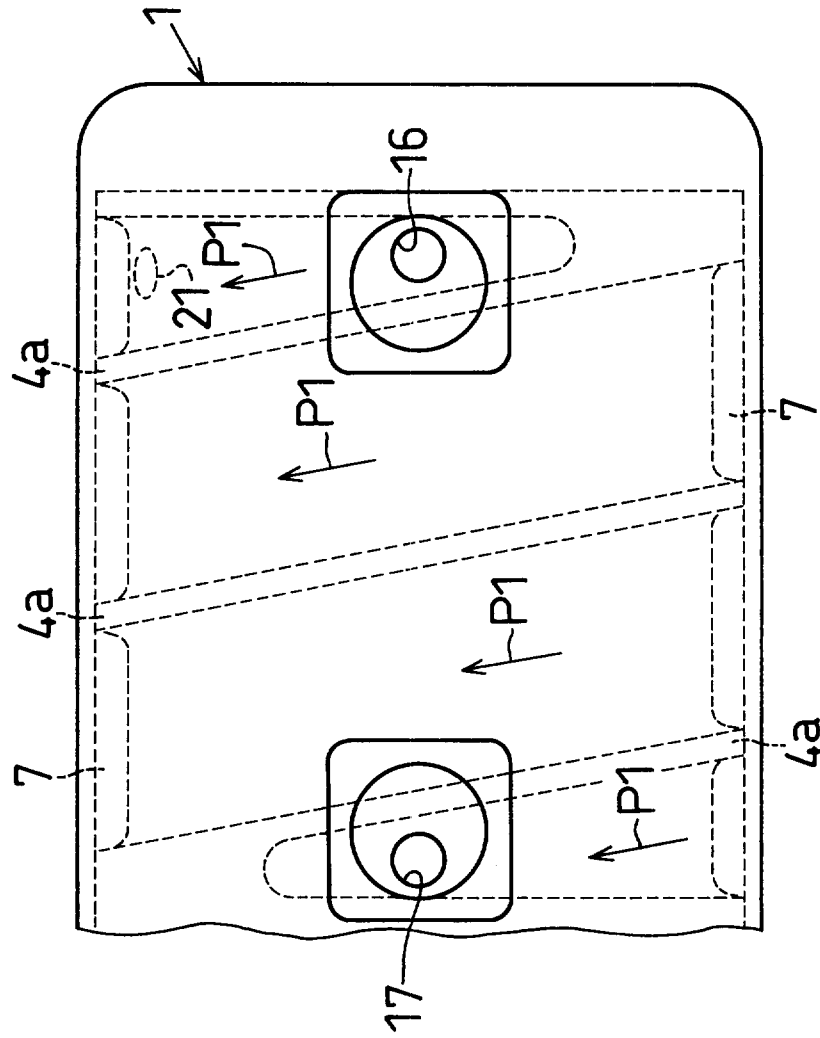


FIG. 3

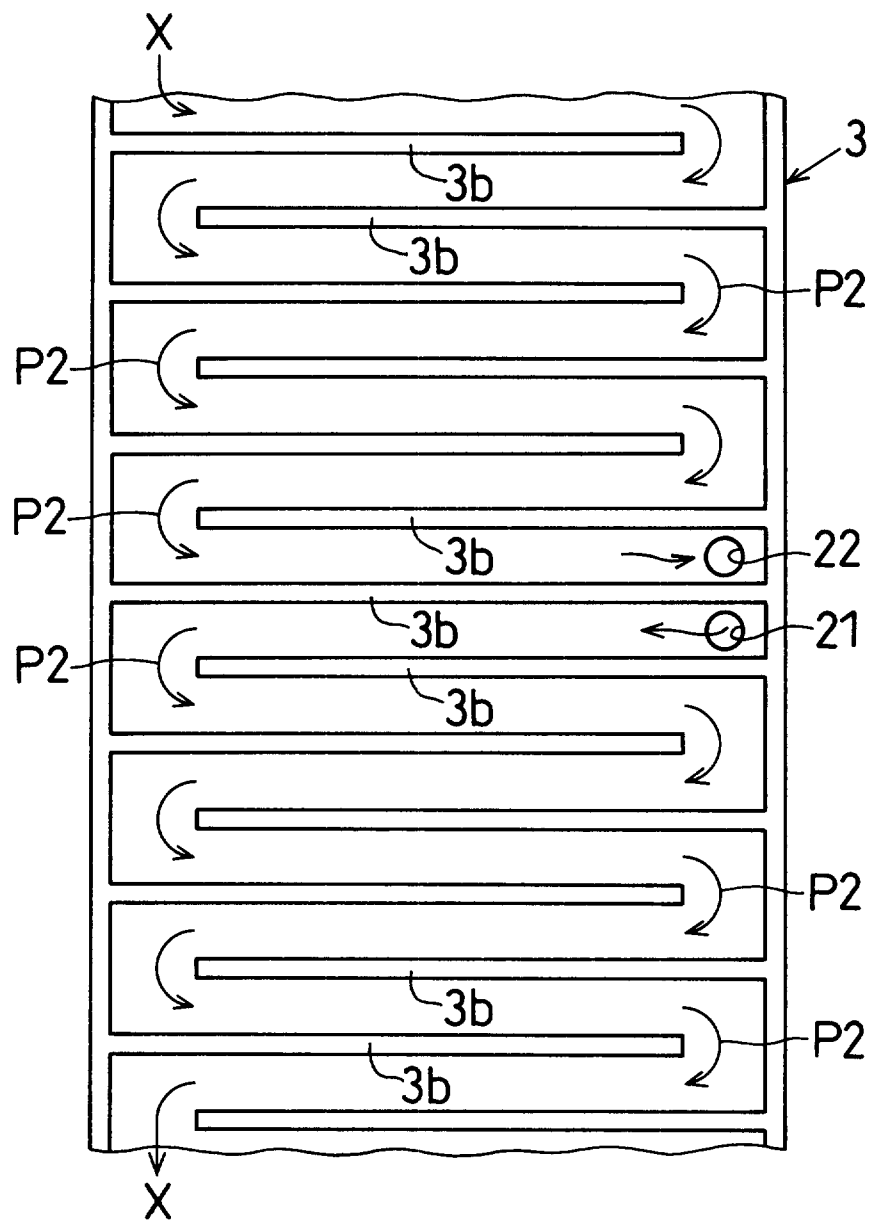


FIG. 5

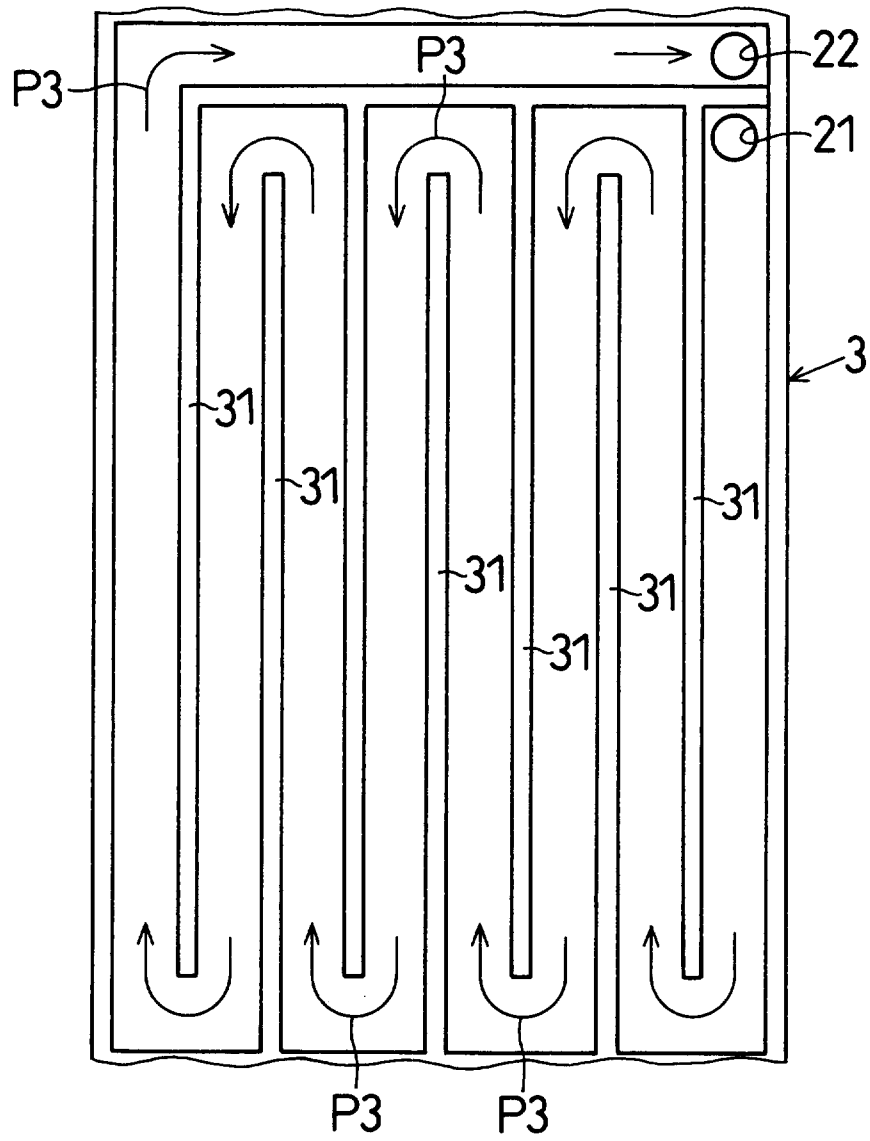


FIG. 6

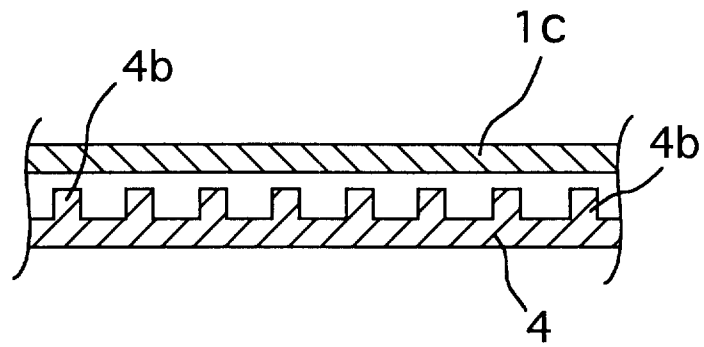


FIG. 7

