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• **Sakamoto, Takenori**

Isesaki-shi Gunma, 372-8502 (JP)

• **Iino, Yusuke**

Isesaki-shi Gunma, 372-8502 (JP)

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(71) Applicant: **Sanden Corporation**

Isesaki-shi, Gunma 372-8502 (JP)

(74) Representative: **Haley, Stephen**

Gill Jennings & Every,

Broadgate House,

7 Eldon Street

London EC2M 7LH (GB)

(72) Inventors:

• **Wada, Kenichi**

Isesaki-shi Gunma, 372-8502 (JP)

(54) **Heat exchangers and air conditioning systems including such heat exchangers**

(57) A heat exchanger (1) including a pair of header pipes (2,3) and a plurality of heat transfer tubes (4) extending between and placing the header pipes (2,3) in communication and extending in parallel to each other to form a parallel-flow type heat exchanger core (13). The heat exchanger core (13) is bent, so that relative to a center portion of the core, at least one header pipe (3)

is offset in the direction of air flow across the heat exchanger (1). The offset disposition of a larger header pipe may be achieved without increasing a tube insertion length into the header pipe or the reduction or elimination of liquid storing and moisture reducing unit contained in the header pipe.

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Description

[0001] The present invention relates to heat exchangers, in particular, parallel-flow type heat exchangers, in which heat transfer tubes are disposed between a pair of header pipes in parallel to each other. More specifically, the invention relates to heat exchangers which are suitable for use as condensers of an air conditioning systems for vehicles, particularly, as a subcooling-type condensers.

[0002] Parallel-flow type heat exchangers, in which heat transfer tubes are disposed between a pair of header pipes in parallel to each other, are known. In such heat exchangers, at least one header pipe requires a relatively large capacity, and a cross-sectional area of the header pipes is required to be greater than a width of each of heat transfer tube extending in parallel, *i.e.*, a width of a heat transfer tube in a direction of air flow across a heat exchanger. For example, in a condenser of an air conditioning system for vehicles, in particular, in a subcooling-type condenser, one header pipe has a cross-sectional area greater than that of the other header pipe and requires a liquid storing function.

[0003] Such a subcooling-type condenser is constructed, for example, as depicted in **Fig. 1**. Elements of the structure depicted in **Fig. 1** are common to the structure of the present invention described later. In **Fig. 1**, a heat exchanger 1 includes a pair of header pipes 2 and 3, a plurality of flat-type heat transfer tubes 4 extending between and placing the pair of header pipes 2 and 3 in communication and extending in parallel to each other, and a plurality of corrugated fins 5 provided between adjacent heat transfer tubes 4 and on outermost portions of the outermost tubes 4. An inlet 6 and an outlet 7 for refrigerant are provided on header pipe 2, and a partition 8 is provided in header pipe 2. Header pipe 3 performs a liquid storing function and a moisture removing function. Header pipe 3, for example, includes a unit 11, which has a desiccant unit 9 at its upper portion holding a bag containing desiccant for removing moisture from the refrigerant and has a strainer 10 at its lower portion for removing foreign materials from the refrigerant, and unit 11 is detachably retained in header pipe 3 by a holding plate 12 having a communication portion at its central position. As a whole, a core portion 13 of heat exchanger 1 is divided into a first portion located above the position of partition 8, which is formed as a refrigerant condensation core portion 14 for condensing refrigerant, and a second portion located below the position of partition 8, which is formed as a subcooling core portion 15 for supercooling refrigerant condensed by refrigerant condensation core portion 14. In such heat exchangers 1 having first and second core portions 14 and 15 respectively, separated from each other, refrigerant flows through inlet 6 into the upper portion of header pipe 2 above partition 8 flows through and is condensed in first or refrigerant condensation core portion 14. Moisture and foreign materials are removed from the refrigerant flowing into header pipe 3, liquefied refrigerant is temporarily stored in the lower portion of header pipe 3, particularly, temporarily stored in a lower portion 3a in header pipe 3, which functions as a liquid storing portion. After flowing therefrom the refrigerant then is introduced into second or subcooling core portion 15 and supercooled therein, the refrigerant is discharged through a discharge portion 2a of header pipe 2 below partition 8 and through outlet 7. In such a subcooling-type condenser, a receiver drier may be formed integrally with a condenser without providing other components, and a compact and efficient structure of a drier, *e.g.*, unit 11 including desiccant unit 9, interchangeably positioned in header pipe 3 may be achieved.

[0004] Such heat exchangers 1, because of their compact structure, are suitable as condensers of an air conditioning system for vehicles, for which an installation space is limited. In such heat exchangers 1, however, because the cross-sectional area of at least one header pipe, *i.e.*, header pipe 3 including unit 11 with the above-described structure, must be enlarged, the following problems may occur. For example, if a header pipe 21 having a circular cross-section, as depicted in **Fig. 2**, is employed as the above-described header pipe 3, header pipe 21, which becomes an exit portion of refrigerant condensation core portion 14 and an entrance portion of subcooling core portion 15, projects significantly forward and backward relative to the width of heat transfer tube 4 in the direction of air flow across heat exchanger 1. Therefore, as depicted in **Fig. 3**, if a mounting layout of a vehicle is employed, so that the condenser, *e.g.*, heat exchanger 1, and a radiator 30 are disposed on a front-to-rear axis, the heat radiation portions of heat transfer tubes 4 and radiator 30 are separated significantly from each other. The thickness of the condenser plus that of radiator 30 in this disposition becomes significant, and, therefore, it is a disadvantageous mounting layout for a vehicle. Because an amount of air passing through the condenser may decrease due to air leakage between the condenser and radiator 30, the performance of the condenser may decrease.

[0005] With respect to such problems, a structure of a condenser, as depicted in **Fig. 4**, may be employed wherein a center position of a header pipe having a larger cross-section is disposed to be offset to one side in the direction of air flow across the heat exchanger, relative to the position of the center of the heat exchanger in the direction of air flow, namely, relative to the position of the center of heat transfer tube 4 in the direction of air flow (Arrow A) across the heat exchanger or, as depicted in **Fig. 3**, in a direction away from radiator 30. In this case, however, a length 42 of tube 4, to which tube 4 is inserted into a header pipe 41, increases significantly, and a diameter of a contained unit 43 must be decreased in order to avoid the interference between the end of the tube 4 and contained unit 43.

[0006] As means for preventing such interference, a

header pipe 51 may be formed with a cross-section having a partially flat surface 55 as depicted in **Fig. 5**. For example, as depicted in **Fig. 6**, insertion holes for heat transfer tubes 4 are formed through the portion of a flat surface 55 of header pipe 51, and the position of the center of the cross-section of header pipe 51 is offset to one side in the direction of air flow (Arrow A) across the heat exchanger. Such a structure is described in Japanese Patent Application Publication No. JP-A-2003-185296. In such a structure, however, because the cross-sectional shape of the interior of header pipe 51 is not circular, when the inner header pressure increases, deformation occurs, particularly in the portion forming the above-described flat surface 55 and a portion forming an adjacent flat surface. Thus, the pressure resistance of header pipe 51 may decrease.

[0007] In response to such problems, a structure of a condenser, as depicted in **Figs. 7 and 8**, may be employed wherein the outer surface of a portion of header pipe 52, which is adapted to receive the heat transfer tubes, is formed as a flat surface 56, and the cross-sectional shape of the interior of header pipe 52 is circular. Such a structure is described in Japanese Patent Application Publication No. JP-A-2005-83719. In such a structure, however, as depicted in **Fig. 9**, because the size of a thickened portion 53 increases, the weight and the cost of header pipe 52 may increase. Further, although header pipe 52 usually is formed by extrusion, because of the presence of thickened portion 53, a more strict dimensional accuracy is required at the time of molding as compared with tubes having a circular cross-section. Consequently, productivity may decrease.

[0008] Accordingly, it would be desirable to provide a parallel-flow type heat exchanger, in which a cross-sectional area of at least one header pipe is increased, which may employ an offset disposition of the header pipe in a direction of air flow across the heat exchanger without increasing the tube insertion length into the header pipe or a reduction of a diameter of a unit to be contained in the header pipe, or both. It is an advantage of such heat exchangers that a decrease of a pressure resistance of the header pipe may be reduced or eliminated. Further, a lighter weight and lower cost heat exchanger may be achieved while increasing the productivity heat exchanger manufacturing methods.

[0009] In an embodiment of this invention, a heat exchanger comprises a pair of header pipes, and a plurality of heat transfer tubes extending between and placing the pair of header pipes in communication and extending in parallel to each other to form a parallel-flow type heat exchanger core. The heat exchanger core is bent, e.g., formed in segments and the segments are set at an angle with respect to each other, so that relative to a center portion of the core, at least one of the pair of header pipes is offset in a direction of air flow across the heat exchanger.

[0010] In such heat exchangers, because the heat exchanger core, e.g., the heat exchanger core through all

heat transfer tubes, is bent, so that relative to the center portion of the heat exchanger core, at least one of the pair of header pipes is offset in the direction of air flow across the heat exchanger. For example, when an adjacent component, e.g., a radiator, is present on a downstream side in the air flow direction, and if it is desirable to prevent contact between that component and an enlarged header pipe, the heat exchanger core may be bent toward an upstream side in the air flow direction, i.e., away from the adjacent component. Alternatively, when an adjacent component e.g., a radiator, is present on an upstream side in the air flow direction, the heat exchanger core may be bent toward a downstream side in the air flow direction, i.e., towards the adjacent component. Therefore, in a parallel-flow type heat exchanger for which it is desirable to increase a cross-sectional area of at least one header pipe, a gap between an adjacent component, e.g., a radiator, and the heat transfer tubes of the heat exchanger core may be reduced. Namely, an offset disposition of the header pipe in the direction of air flow across the heat exchanger may be achieved, without increasing the length of tube insertion into the header pipe and without decreasing the diameter of a unit, e.g., a unit comprising a desiccant, contained in the header pipe.

[0011] Further, in this heat exchanger, the above-described at least one header pipe may be formed from a pipe having a circular cross-section. Thus, the header pipes' inner cross-sectional shape may be circular. Therefore, an internal pressure is received uniformly by an inner surface of the header pipe, and even if a large internal pressure is applied, deformation of the header pipe may be reduced or eliminated, and a reduction of the pressure resistance of the header pipe may be reduced or eliminated. Moreover, because a thickened portion of the header pipe is not necessary, the productivity of methods for manufacturing such heat exchangers may be increased, and a lighter weight and lower cost heat exchanger may be achieved than known heat exchangers.

[0012] Such heat exchangers according to the present invention are suitable as subcooling-type heat exchangers. Namely, they are suitable as subcooling-type heat exchangers whose heat exchanger cores comprise a refrigerant condensation core portion for condensing refrigerant and a subcooling core portion for supercooling refrigerant condensed by the refrigerant condensation core portion. In this case, it is preferred that at least a lower portion of one header pipe with a circular, interior cross-sectional shape has a liquid storing function. As a result, liquid refrigerant may flow into the subcooling core portion from the header pipe portion having the liquid storing function.

[0013] Further, heat exchangers according to the present invention are suitable, particularly as a condenser, for use in an air conditioning systems for vehicles, for which there is limited installation space.

[0014] Thus, in heat exchangers according to the

present invention, a structure may be employed, in which the header pipe is offset to one side of the direction of air flow across the heat exchanger without decreasing the pressure resistance of the header pipe and without increasing the insertion length of heat transfer tubes or decreasing the diameter of a unit contained in the header pipe, or both. Such heat exchangers have an outer shape permitting an efficient layout while achieving a desirable performance. Therefore, even if components, such as a radiator, are disposed adjacent to the heat exchanger, as described above, the heat radiation portions of the radiator and the heat transfer tubes need not be greatly separated from each other. Thus, the thickness of the heat exchanger, e.g., the condenser, and another component, e.g., the radiator need not increase; and an amount of air passing through the heat exchanger and another adjacent component need not decrease due to air leakage between the heat exchanger and the other component.

[0015] Further objects, features, and advantages of the present invention will be understood from the following detailed description of preferred embodiments of the present invention with reference to the accompanying figures.

[0016] Embodiments of the invention now are described with reference to the accompanying figures, which are given by way of example only, and are not intended to limit the present invention.

Fig. 1 is an front, partially cut-away view of a heat exchanger showing a known subcooling-type condenser.

Fig. 2 is a cross-sectional view of one header pipe of a known subcooling-type condenser.

Fig. 3 is a top, partially cut-away view of a radiator and a condenser including the header pipe depicted in **Fig. 2**, showing an example of the installation thereof.

Fig. 4 is a partially cut-away plan view of a condenser including the header pipe depicted in **Fig. 3**, showing an offset disposition of the header pipe.

Fig. 5 is a cross-sectional view of another embodiment of header pipe of another known subcooling-type condenser.

Fig. 6 is a top, partially cut-away view of a radiator and a condenser including the header pipe depicted in **Fig. 5**, showing another example of the installation thereof.

Fig. 7 is a cross-sectional view of yet another embodiment of header pipe of yet another known heat exchanger.

Fig. 8 is a partially cut-away view of a condenser including the header pipe depicted in **Fig. 7**.

Fig. 9 is a cross-sectional view of the header pipe depicted in **Fig. 7**, showing a thickened portion.

Fig. 10 is a top, partially cut-away view of a condenser according to an embodiment of the present invention.

Fig. 11 is a top, partially cut-away view of a radiator and the condenser depicted in **Fig. 10**, showing an example of the installation thereof.

Fig. 12 is a top, partially cut-away view of a radiator and a condenser according to another embodiment of the present invention, showing an example of the installation thereof.

[0017] Referring to **Figs. 10** and **11**, a heat exchanger according to an embodiment of the present invention is depicted. Heat exchangers according to the present invention are suitable for use as condensers in air conditioning systems for vehicles, in particular, as subcooling-type condensers. A known subcooling-type condenser is depicted in **Fig. 1**. Namely, a heat exchanger, such as subcooling-type condenser 1, comprises two header pipes: a smaller diameter header pipe 2 and a larger diameter header pipe 3, a plurality of flat-type heat transfer tubes 4 disposed between header pipes 2 and 3 and extending in parallel to each other, and a plurality of corrugated fins 5 provided between adjacent heat transfer tubes 4 and on the outermost transfer tubes. Inlet 6 and outlet 7 for refrigerant are provided on header pipe 2, and partition 8 is provided in the header pipe 2.

[0018] Header pipe 3 is formed as a header pipe having a larger diameter and having an larger interior capacity. In header pipe 3, unit 11 includes desiccant unit 9 at its upper portion holding a bag of desiccant for removing moisture and has strainer 10 at its lower portion for removing foreign materials. Further, unit 11 is held detachably in header pipe 3 by holding plate 12 having a communication opening at its central position.

[0019] With respect to core 13 of subcooling-type condenser 1, a portion of core 13 located above partition 8 is formed as a first or refrigerant condensation core portion 14 for condensing refrigerant, and a portion of core 13 located below partition 8 is formed as subcooling core portion 15 for supercooling refrigerant condensed by refrigerant condensation core portion 14. Refrigerant having passed through refrigerant condensation core portion 14 and having been condensed therein flows into header pipe 3. Moisture and foreign materials are removed from the refrigerant flowing into header pipe 3, liquefied refrigerant is stored temporarily in the lower portion of header pipe 3, particularly, in lower portion 3a in header pipe 3, and therefrom the refrigerant flows into subcooling core portion 15 and is supercooled therein. Consequently, a structure for subcooling-type condenser 1 is achieved, wherein a drier of a refrigeration or air conditioning system is formed integrally within a condenser, without providing other components.

[0020] In subcooling-type condenser 1 thus constructed according to the present invention, heat exchanger core 13, as whole, is bent, as depicted in **Fig. 10**, so that relative to the center portion of the core, at least one header pipe 3 is offset in the direction of air flow across heat exchanger 1. For example, as depicted in **Fig. 11**, a radiator 30 is disposed on a downstream

side of the air flow as an adjacent component. By bending heat exchanger core 13, as a whole, toward an upstream side of the air flow, *i.e.*, away from radiator 30, the tip side portion or the portion of heat exchanger core including header pipe 3 side beyond a bend or an angled portion 16 is offset from radiator 30. Therefore, interference between header pipe 3 and radiator 30 may be prevented, the gap between header pipe 3 and radiator 30 may be reduced, and the amount of air which does not pass through condenser 1 due to air leakage between condenser 1 and radiator 30 may be reduced or eliminated. Namely, without increasing of the tube insertion length into header pipe 3 or reducing the diameter of unit 11 contained in header pipe 3, or both, the offset disposition of header pipe 3 in the direction of air flow across condenser 1 may be achieved.

[0021] Further, in such heat exchangers, because header pipe 3 may be made from a pipe having a circular cross-section, the shape of the interior cross-section also may be circular. Therefore, an internal pressure is applied uniformly to the inner surface of header pipe 3, and even if a significant internal pressure is applied thereto, deformation of header pipe 3 may be reduced or eliminated, and a reduction in the pressure resistance of header pipe 3 may be reduced or eliminated. Moreover, because a thickened portion is no longer necessary, the productivity of molding such components by extrusion may be increased, and lighter weight and lower cost heat exchangers may be achieved.

[0022] Fig. 12 depicts a subcooling-type condenser according to another embodiment of the present invention. Although heat exchanger core 13, as a whole, is bent in an upstream direction of the air flow, opposite to that depicted in Fig. 11, if contact between header pipe 3 with an adjacent component disposed on an upstream side of the air flow is to be avoided, rather than with radiator 30; exchanger core 13, as a whole, may be bent, as depicted in Fig. 12, in a downstream direction of the air flow, *i.e.*, toward the side of radiator 30. In addition, interference between header pipe 3 and the adjacent component disposed on the upstream side of the air flow may be prevented, and an enhanced performance and a lighter weight condenser may be obtained by manufacturing methods achieving increased productivity and at a lower cost.

[0023] Structure according to the present invention may be applied to any parallel-flow type heat exchanger requiring a diameter of at least one header pipe to be larger than the other header pipe. Specifically, a condenser of an air conditioning system for vehicles, and in particular, a subcooling-type condenser, may be manufactured to include this structure.

Claims

1. A heat exchanger comprising a pair of header pipes and a plurality of heat transfer tubes extending be-

tween and placing said pair of header pipes in communication and extending in parallel to each other to form a parallel-flow type heat exchanger core wherein said heat exchanger core bent, so that relative to a center portion of said core, at least one of said pair of header pipes is offset in a direction of air flow across said heat exchanger.

2. The heat exchanger according to claim 1, wherein said heat exchanger core is bent toward an upstream side of said air flow direction.
3. The heat exchanger according to claim 1, wherein said heat exchanger core is bent toward a downstream side of said air flow direction.
4. The heat exchanger according to any of claims 1 to 3, wherein a unit comprising a desiccant is contained in said at least one of said pair of header pipes.
5. The heat exchanger according to any of claims 1 to 4, wherein cross-sectional areas of interiors of each of said pair of header pipes are not equal, and at least one of said pair of header pipe has a larger cross-sectional area.
6. The heat exchanger according to any of claims 1 to 5, wherein said heat exchanger is a subcooling-type heat exchanger, and said heat exchanger core comprises a refrigerant condensation core portion for condensing refrigerant and a subcooling core portion for supercooling refrigerant condensed by said refrigerant condensation core portion.
7. An air conditioning system for vehicles comprising said heat exchanger of any of claims 1 to 6.

FIG. 1

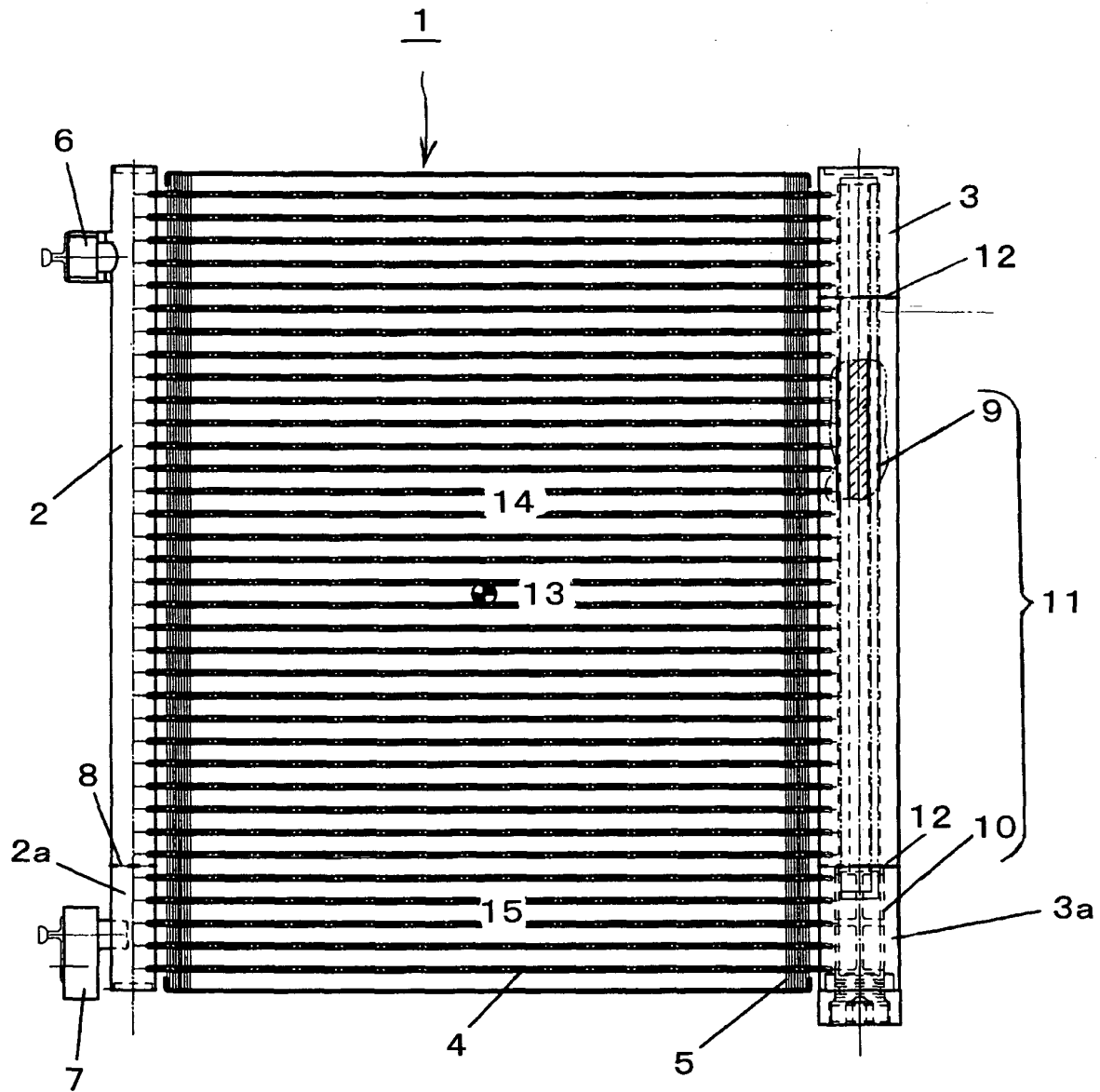


FIG. 2

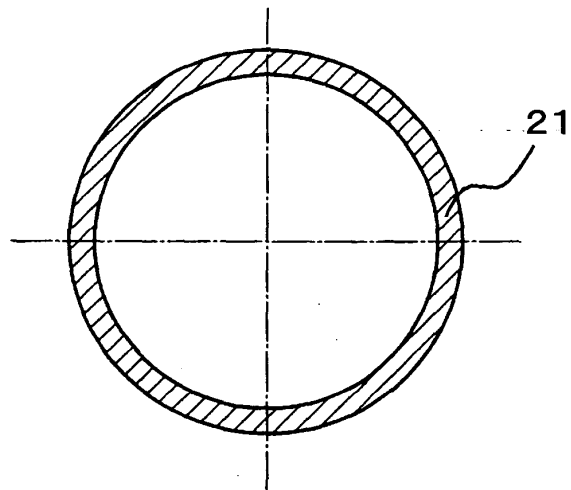


FIG. 3

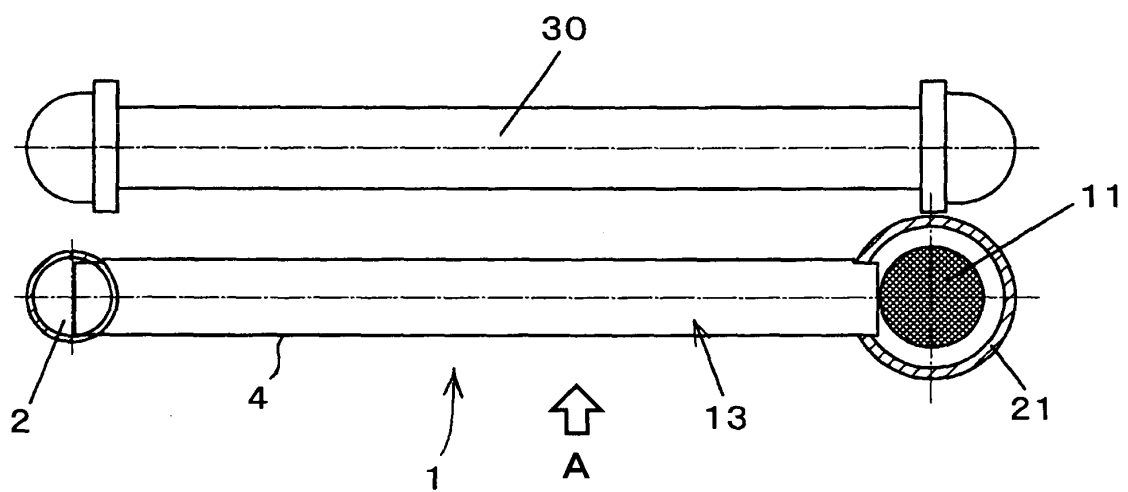


FIG. 4

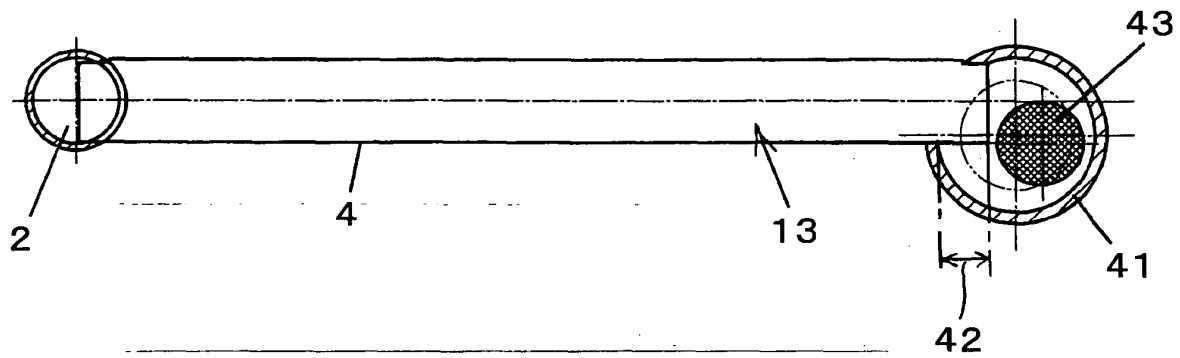


FIG. 5

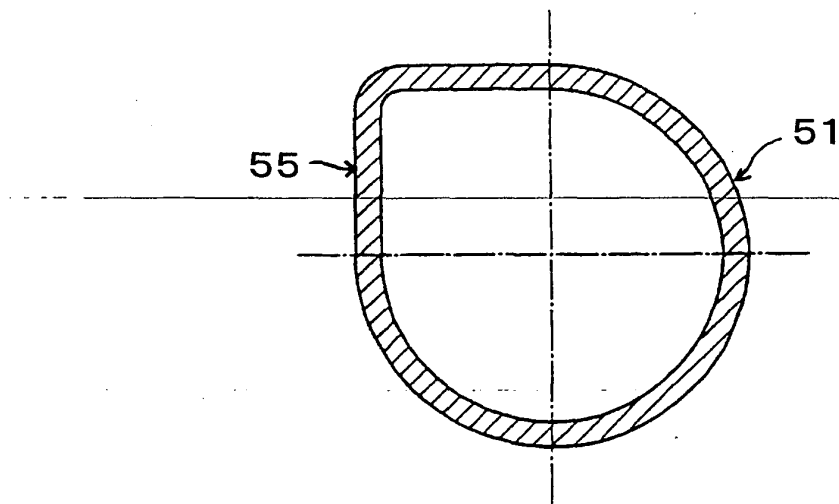


FIG. 6

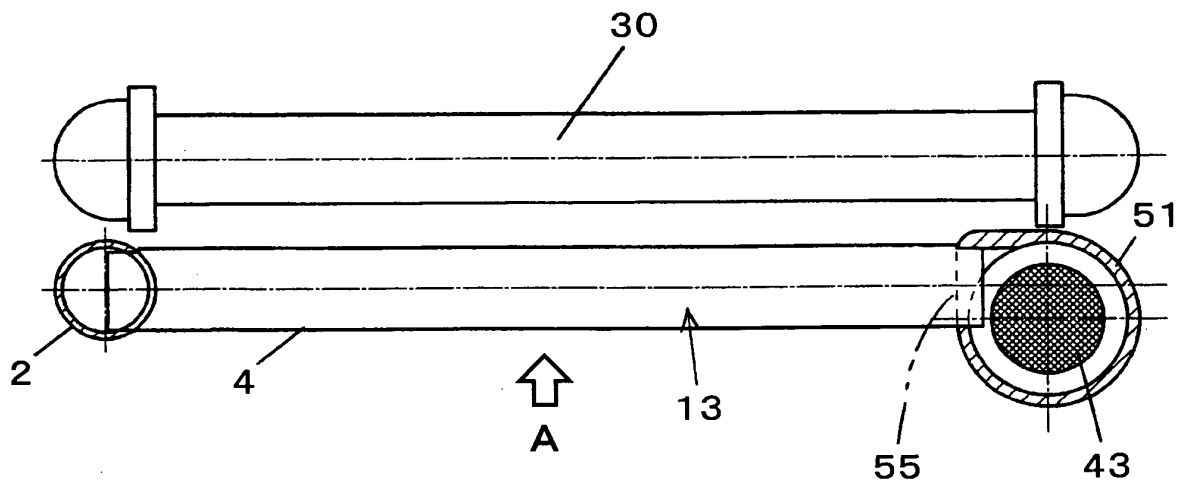


FIG. 7

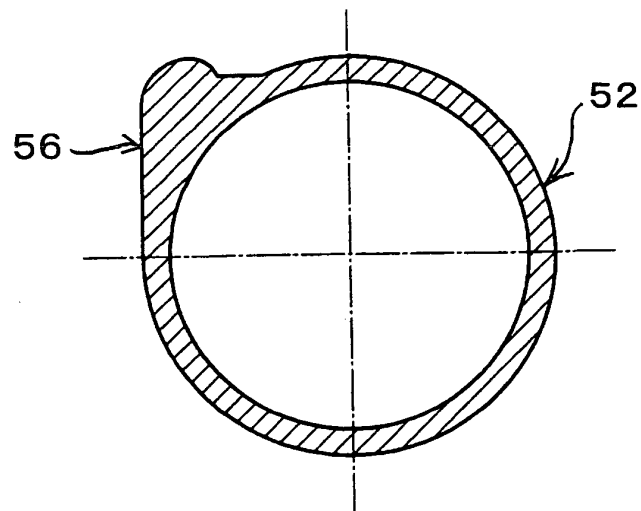


FIG. 8

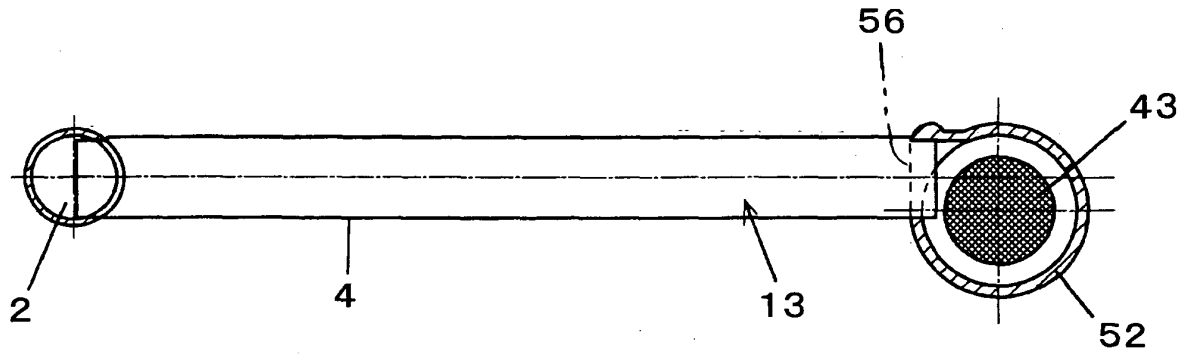


FIG. 9

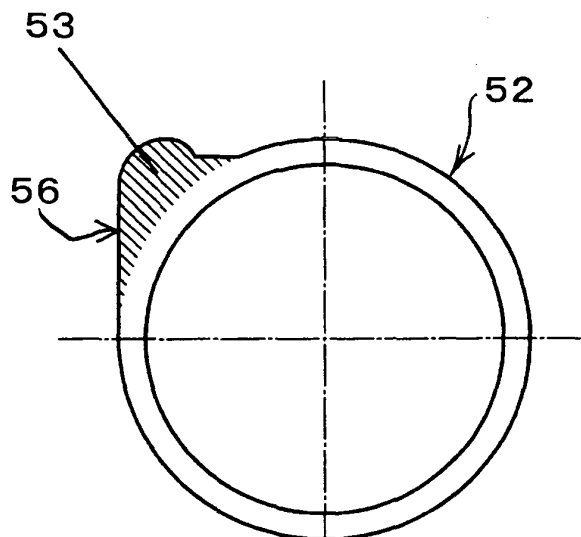


FIG. 10

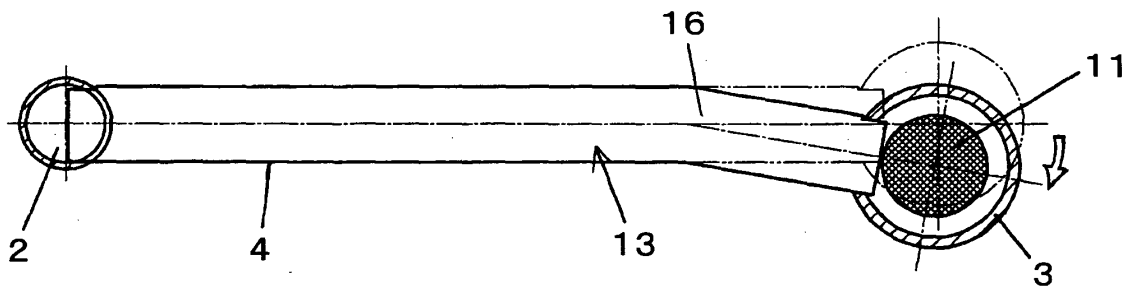


FIG. 11

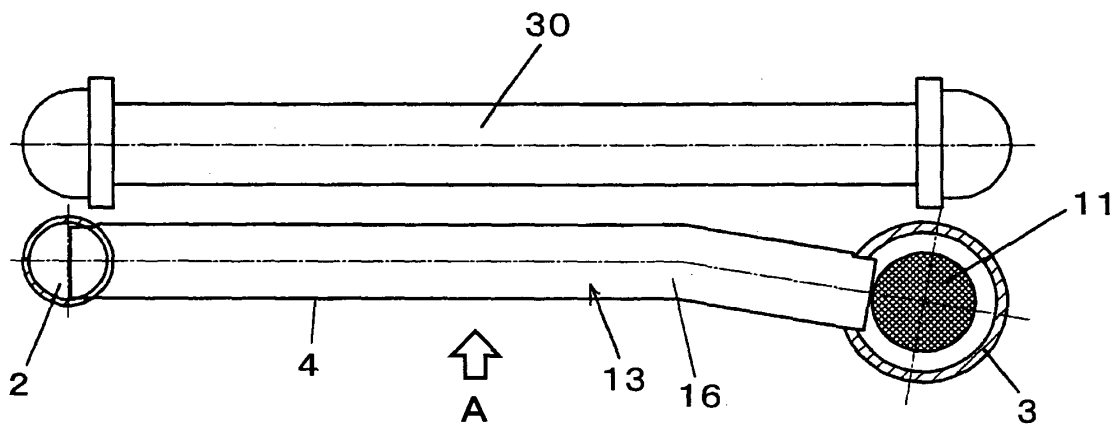


FIG. 12

