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(54) **AIR CONDITIONING SYSTEM**

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(57) **ABSTRACT**

An air conditioning system includes at least a magnetic disc disposed in parallel along a rotary shaft thereof, permanent magnets installed within rotational radii of the respective magnetic discs, and applying magnetic fields to the magnetic disc rotating within a predetermined section, a heat exchanger for heating installed on a side of the permanent magnets, and having at least a heat radiation fin, and a heat exchanger for cooling installed on a side opposite the permanent magnets, and having at least a heat absorption fin. The air conditioning system has a simple structure, is safe from the fear of environmental pollution, and is suitable for a next-generation air conditioning system to be applied to a hybrid or electric automobile because it does not use engine heat or a refrigerant

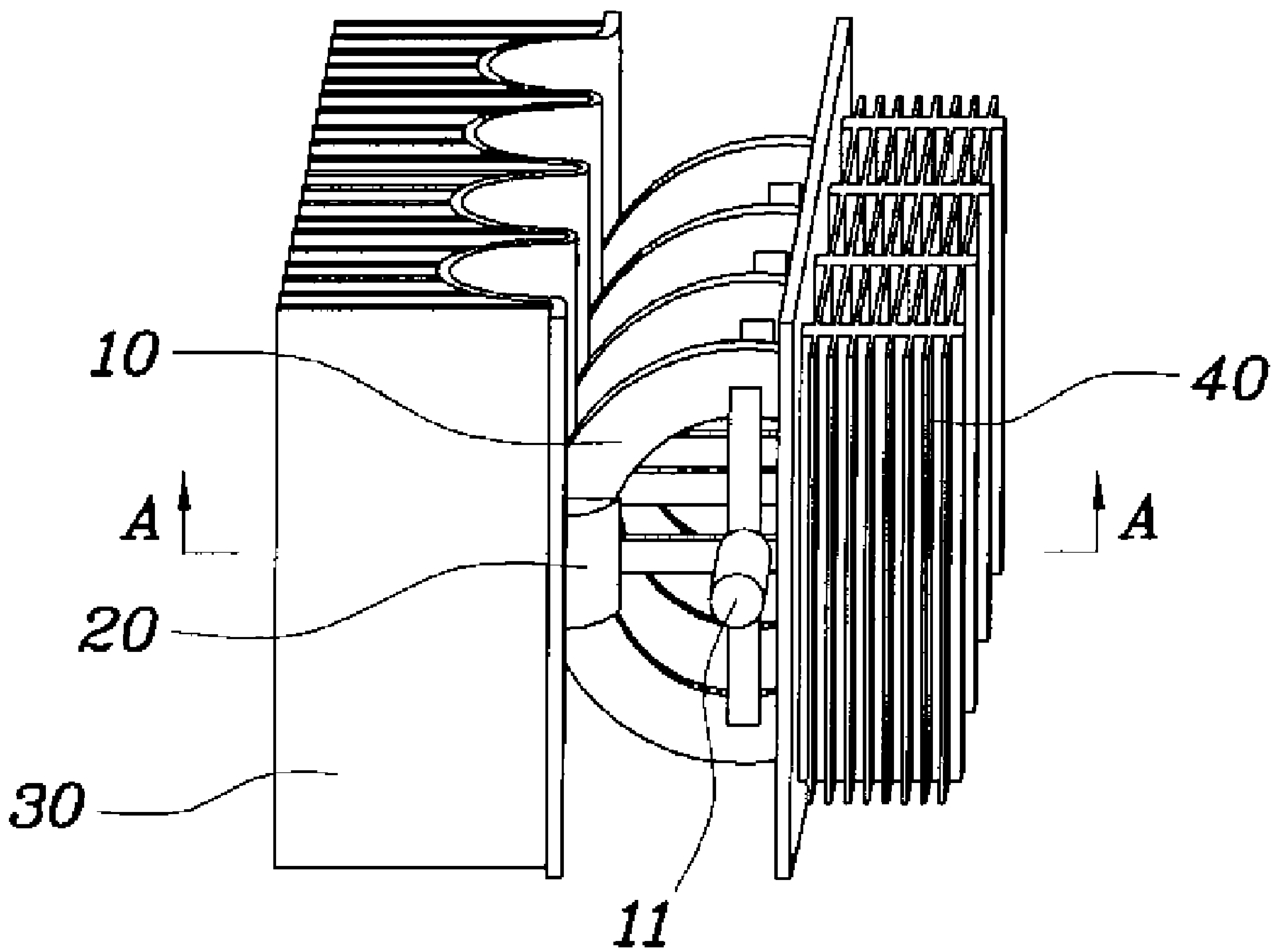


FIG. 1

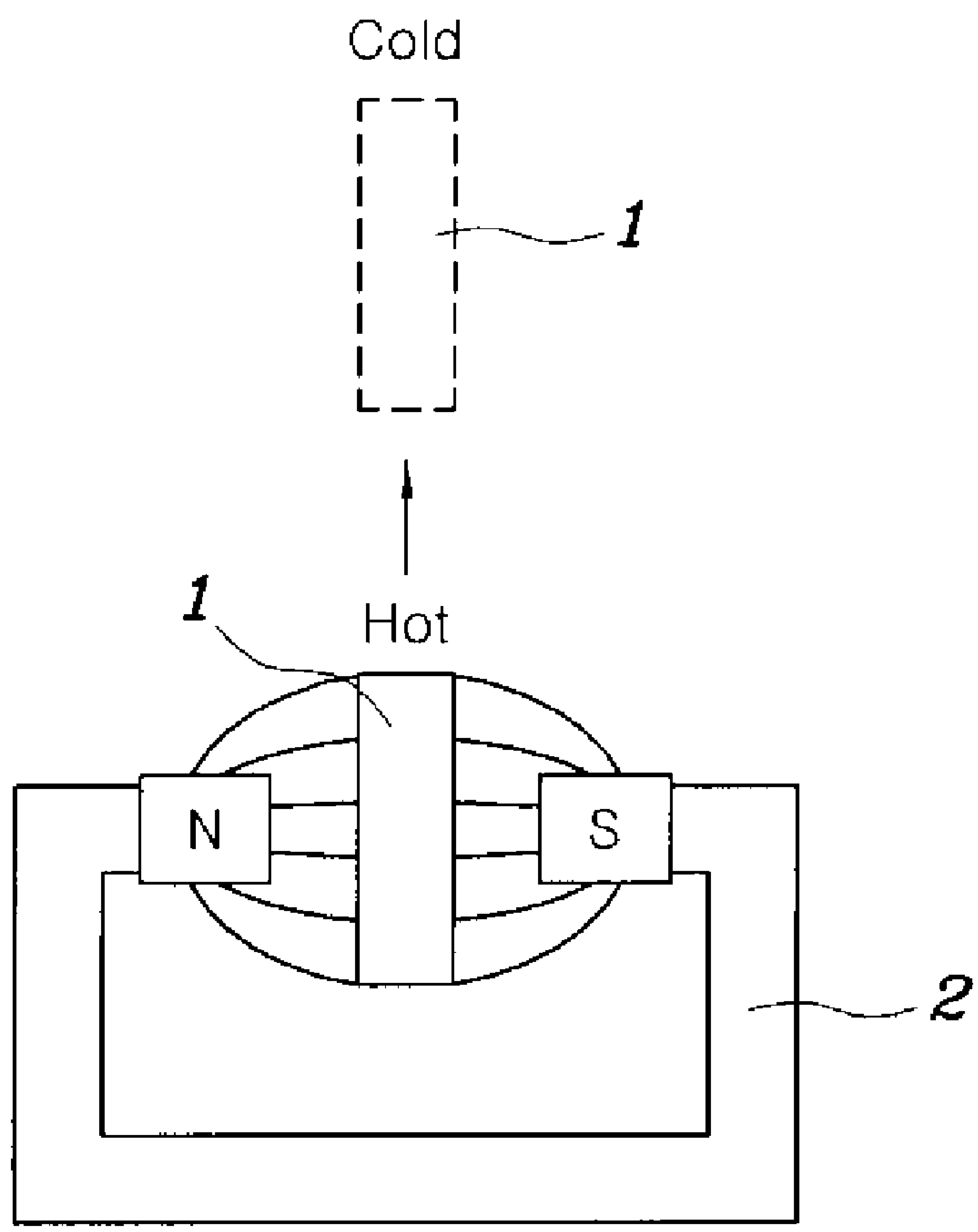


FIG. 2

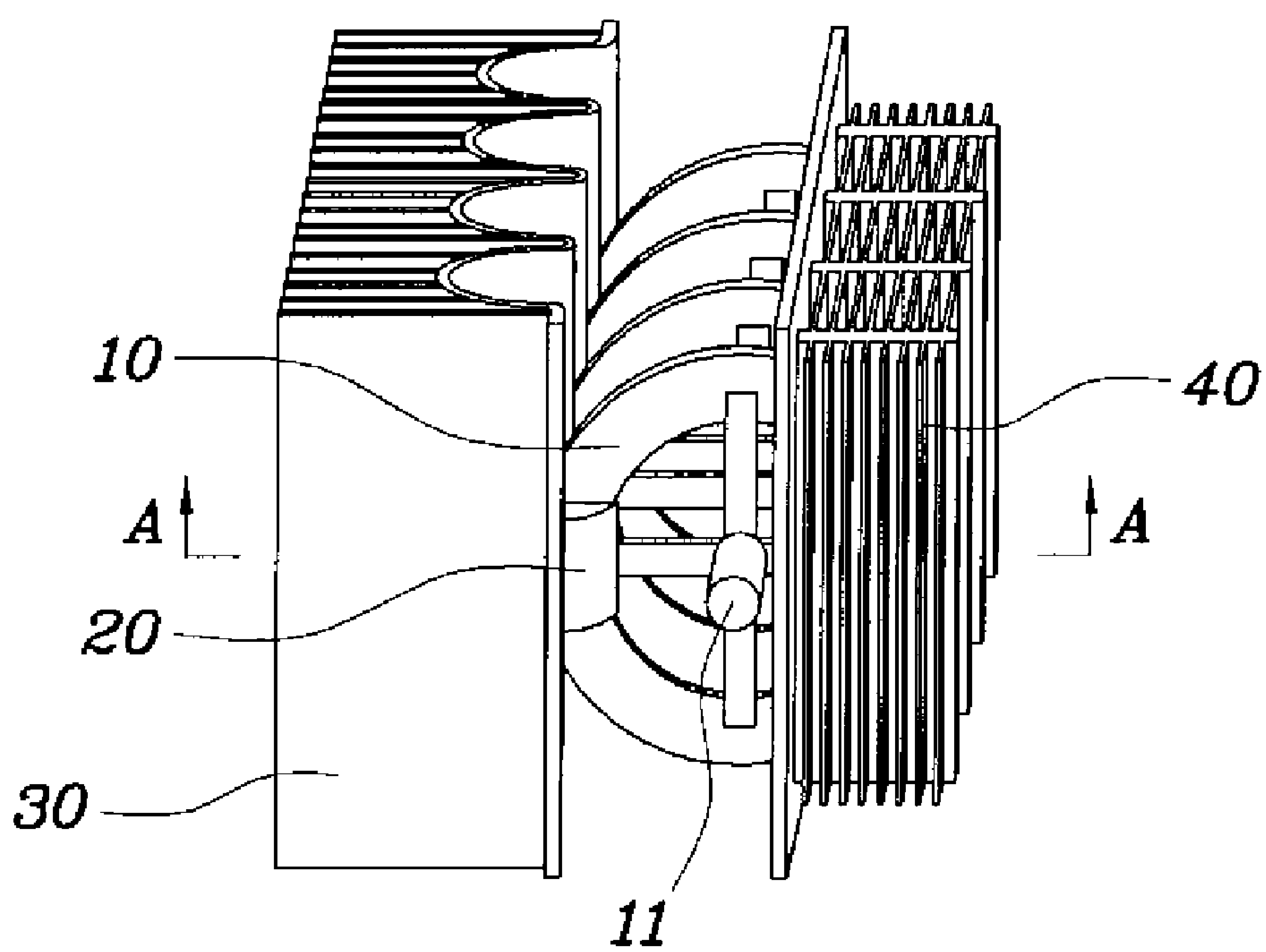


FIG. 3

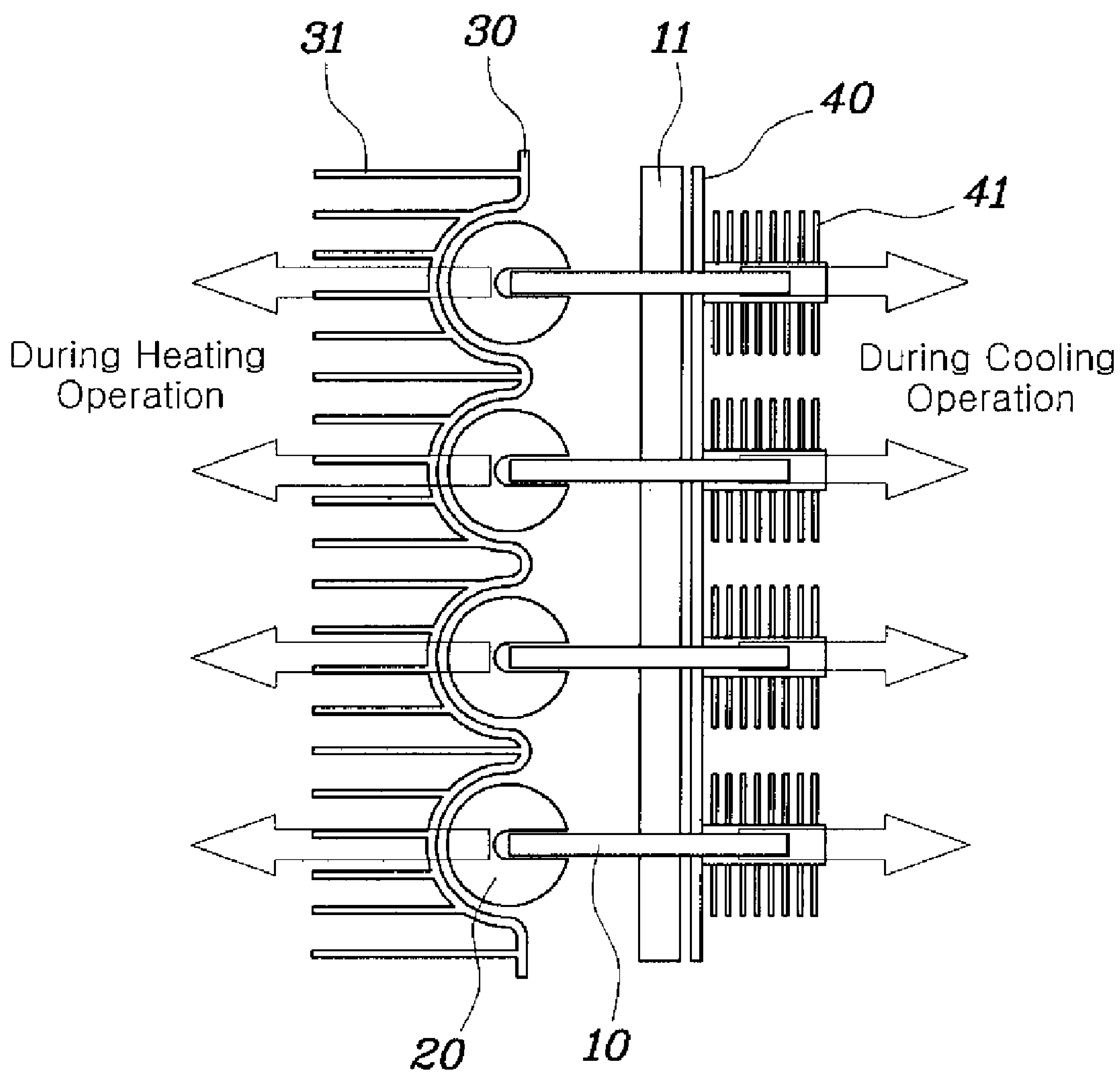

31
30
11
40
41
During Heating Operation
During Cooling Operation
20
10

FIG. 4

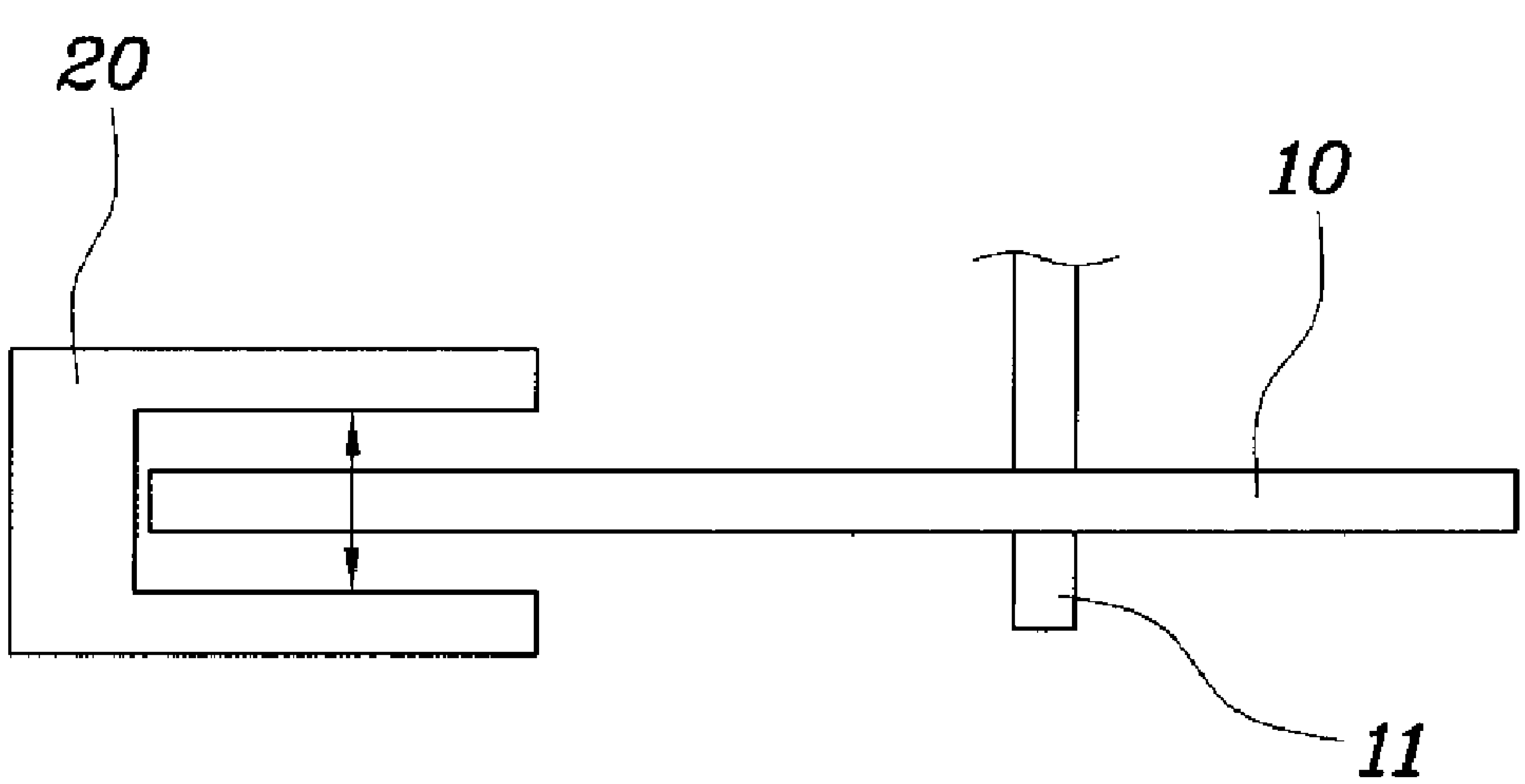

20
10
11

FIG. 5

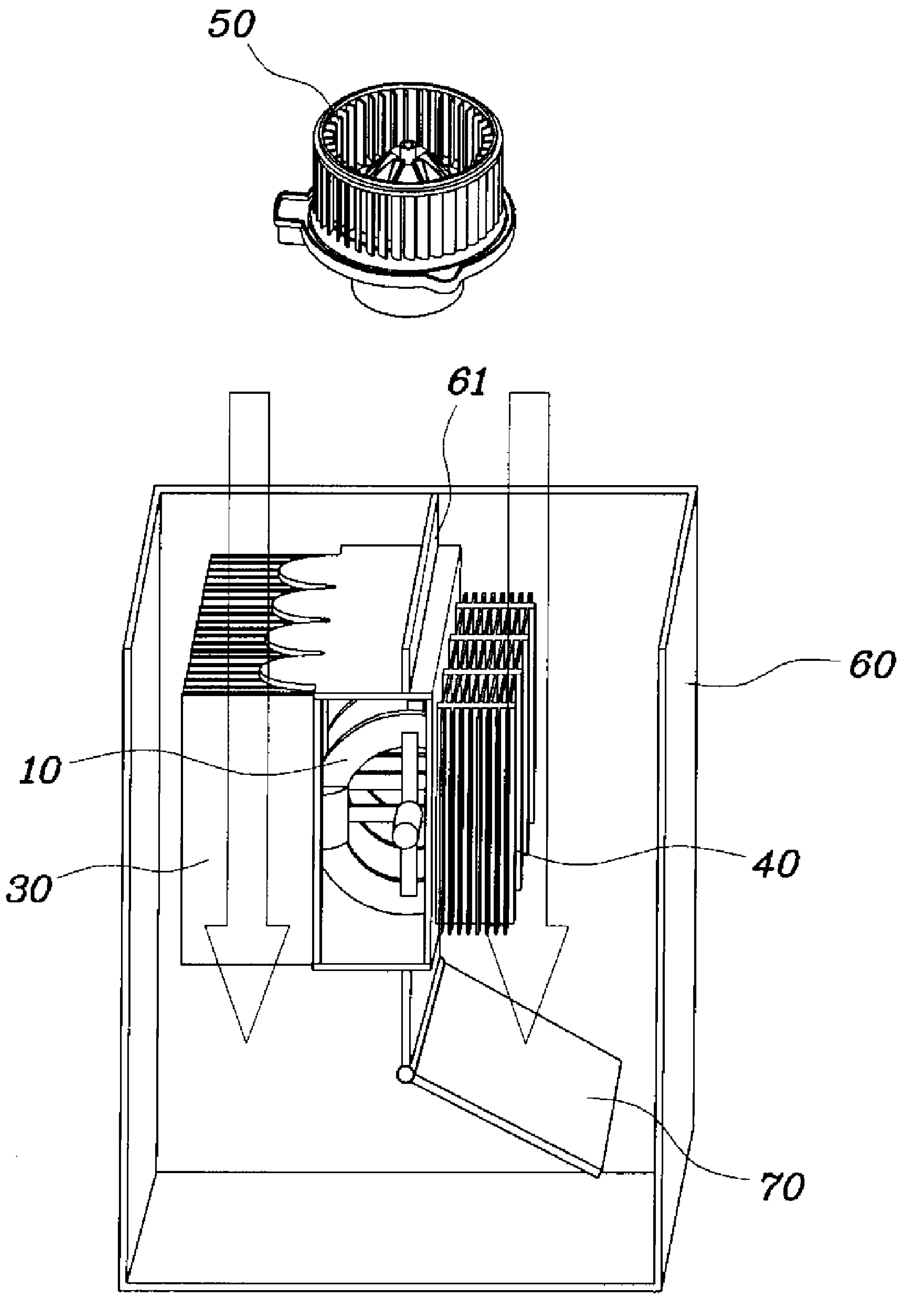


FIG. 6

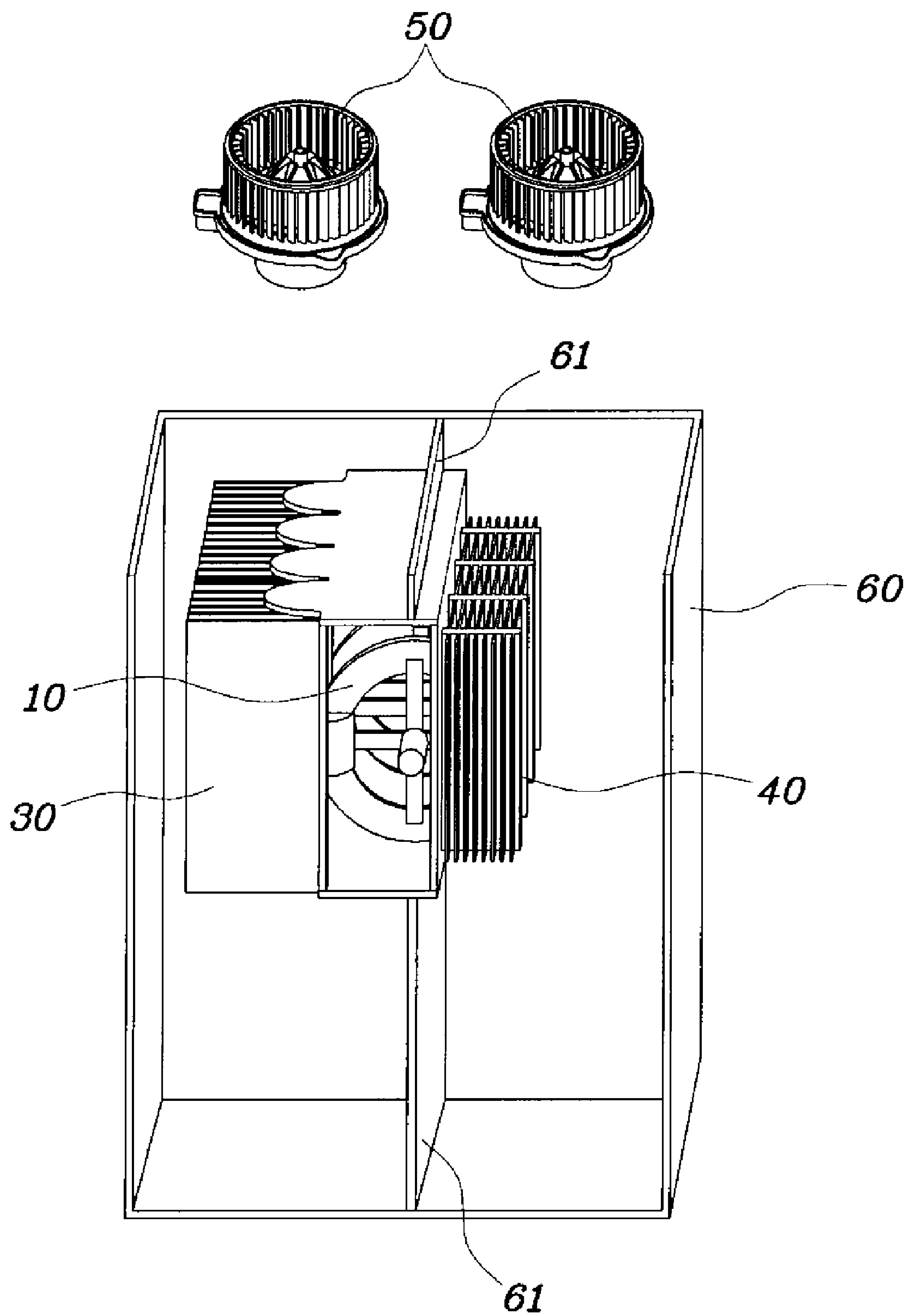


FIG. 7

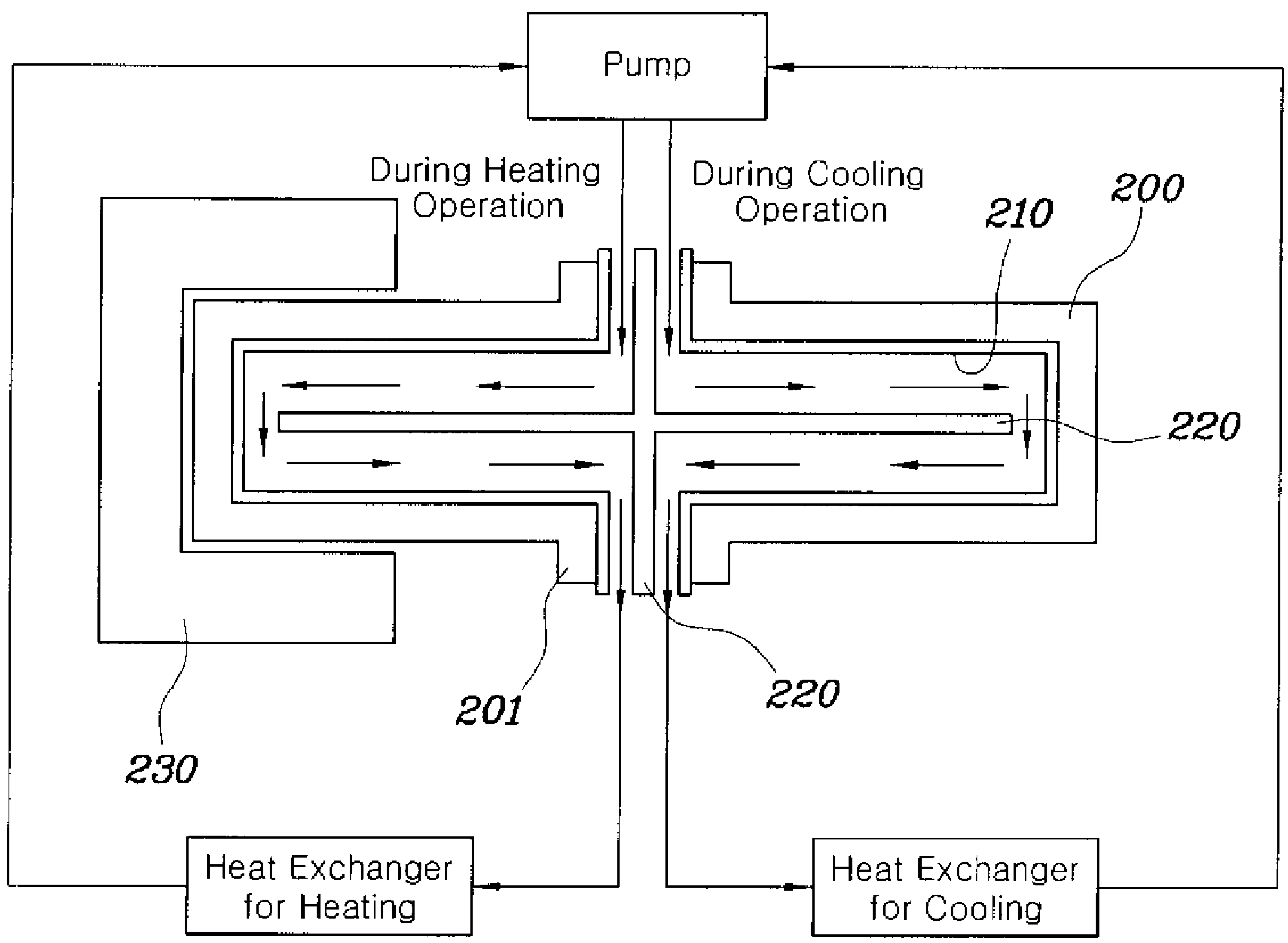

Pump
During Heating Operation
During Cooling Operation
200
210
220
220
201
230
Heat Exchanger for Heating
Heat Exchanger for Cooling

FIG. 8

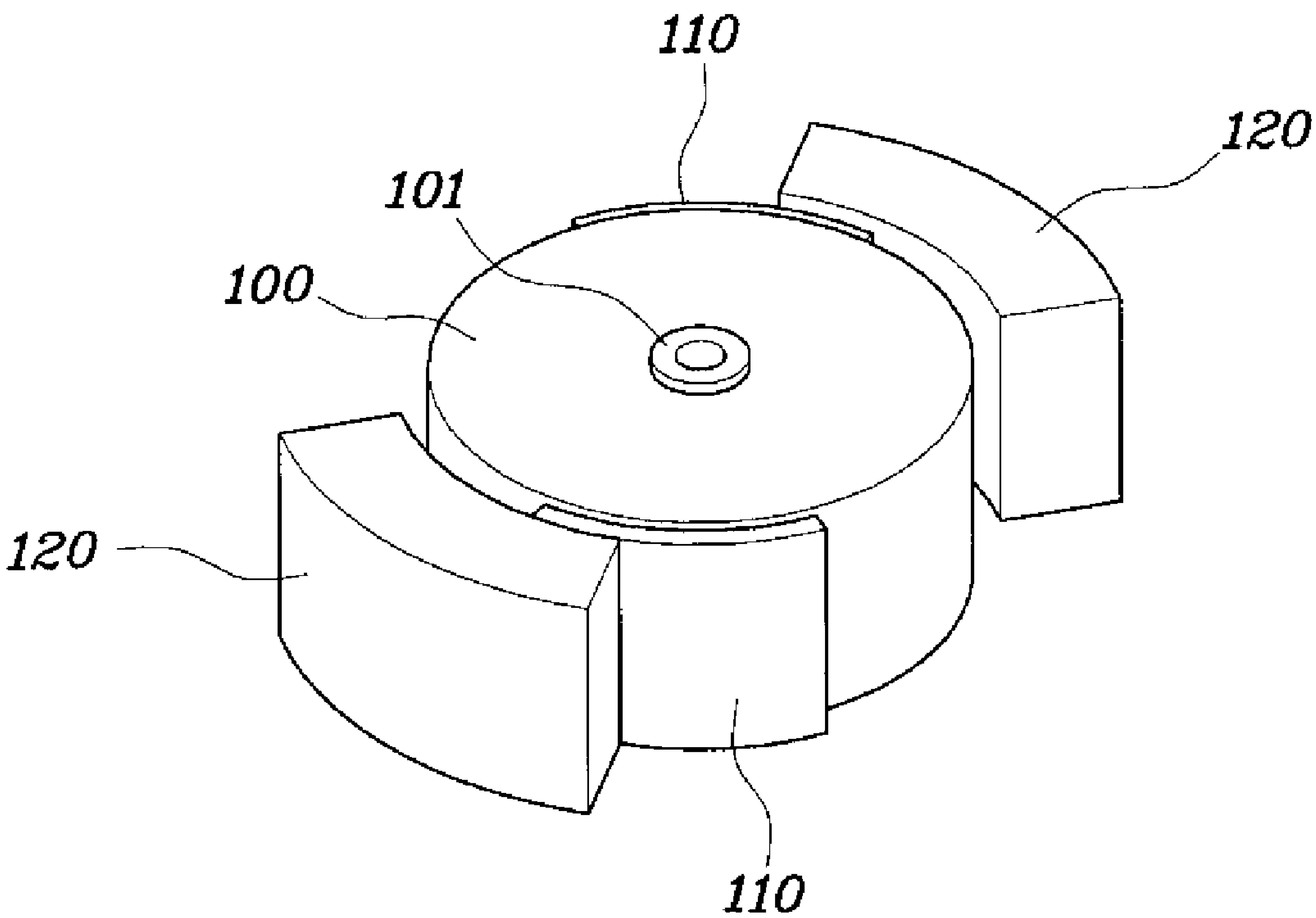
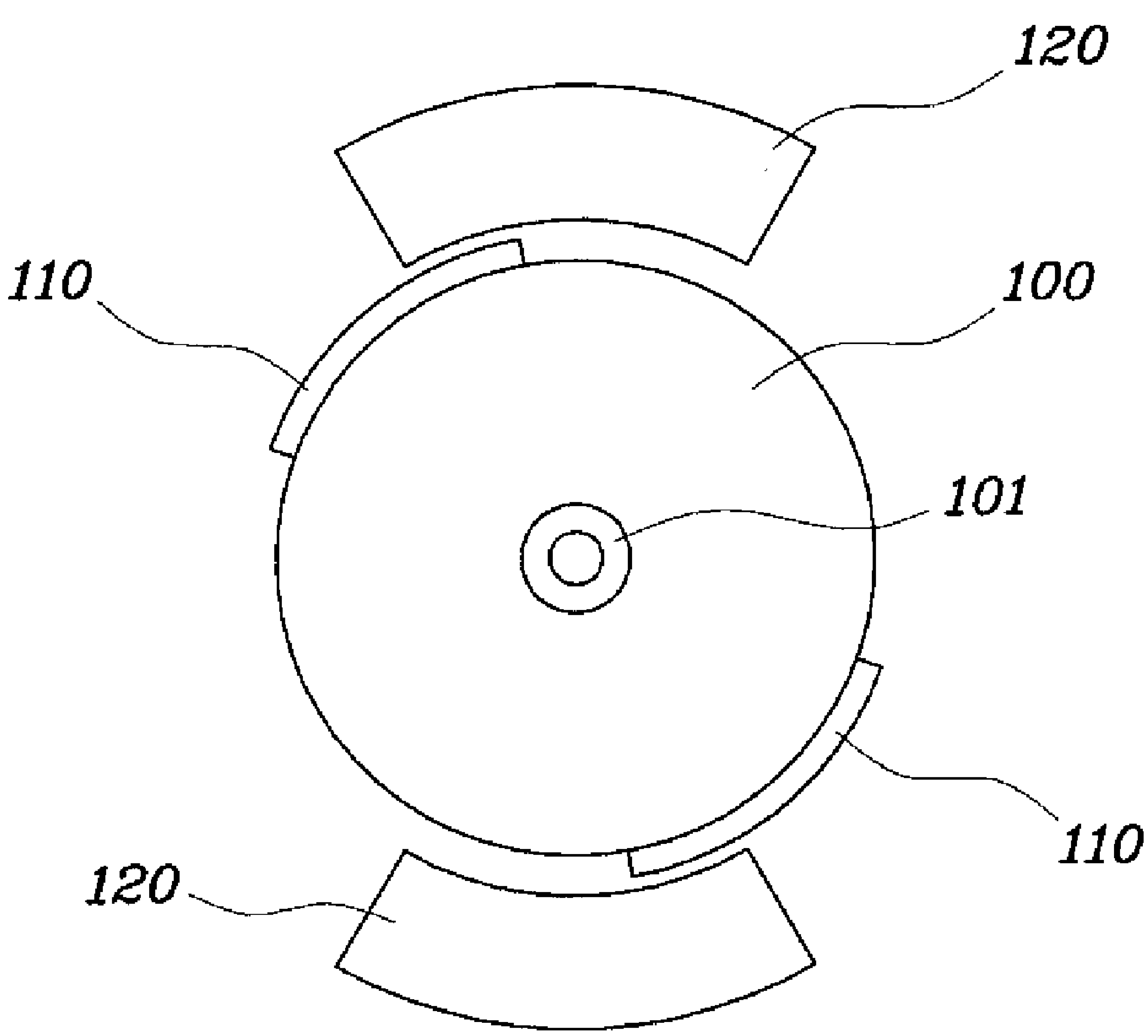


FIG. 9



AIR CONDITIONING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Korean Application No. 10-2008-0056262, filed on Jun. 16, 2008, the entire contents of which is incorporated herein by this reference for all purposes.

BACKGROUND OF THE INVENTION

[0002] (1) Field of the Invention

[0003] The present invention relates, in general to an air conditioning system and, more particularly, to an air conditioning system for a motor vehicle using a magnetocaloric effect,

[0004] (2) Description of the Related Art

[0005] A magnetocaloric effect refers to a phenomenon that the temperature of a ferromagnetic material is increased when a strong magnetic field is applied to the ferromagnetic material on the outside, while the temperature of the ferromagnetic material is decreased when the magnetic field is eliminated.

[0006] This magnetocaloric effect results from an entropy conservation law. As illustrated in FIG. **1**, when a ferromagnetic material **1** is magnetized by a magnetic field generated from an external magnetic object **2**, the ferromagnetic material is subjected to spin alignment reduction in magnetic entropy, increase in atomic lattice entropy (increase in vibration of an atomic lattice) according to a total entropy conservation law, and generation of heat. In contrast, when the magnetic field applied to the ferromagnetic material **1** is eliminated, the ferromagnetic material is subjected to reduction in the atomic lattice entropy, and thus the temperature of the ferromagnetic material is decreased.

[0007] Meanwhile, in the case of a current air conditioning system for a motor vehicle, the heat from an engine is used for heating an interior of the motor vehicle. However, due to a fear of oil exhaustion and environmental pollution, many efforts are made to develop a hybrid automobile or an electric automobile in various countries around the world. Thus, there is a practical need to displace the conventional heating system of the motor vehicle using the engine heat with another system. Further, in order to cool the interior of the motor vehicle, an ammonia-based gas called R-134a is mainly used. This refrigerant incurs environmental issues such as disruption of an ozone layer, and requires many additional devices such as a compressor, a condenser, a refrigerant pipe, a heater hose, and so on. As such, it is absolutely need to develop a so-called magnetic air conditioning system using the magnetocaloric effect from the viewpoint of reduction in cost and weight and environmental conservation.

[0008] The information disclosed in this Background of the Invention section is only for enhancement of understanding of the background of the invention and should not be taken as an acknowledgement or any form of suggestion that this information forms the prior art that is already known to a person skilled in the art.

SUMMARY OF THE INVENTION

[0009] Accordingly, various embodiments of the present invention has been made keeping in mind the above problems occurring in the related art and an object of the present invention is to provide a an air conditioning system, particularly for a motor vehicle, using a magnetocaloric effect which has no chance of environmental pollution and does not require additional devices.

[0010] According to one aspect of the present invention, there is provided an air conditioning system, which may comprise: at least a magnetic disc disposed in parallel along a rotary shaft thereof, magnets installed within rotational radii of the respective magnetic discs, and applying magnetic fields to the magnetic disc, wherein the magnet is fixed; a heat exchanger for heating installed on a side of the magnets, and having at least a heat radiation fin; and a heat exchanger for cooling installed on a side opposite the magnets, and having at least a heat absorption fin. The magnet may be a permanent magnet, superconductive magnet or an electromagnet. The magnetic disc may be made of a ferromagnetic material. The rotary shaft may be configured to move in an axial direction thereof and thereby a desired air conditioning temperature can be controlled through adjusting magnetic flux density of the magnet.

[0011] Magnetic object pairs may be installed on the upper and lower circumference of the magnetic disc corresponding to the magnet. The rotary shaft is configured to be rotatable within a predetermined angle and thus an area where the magnetic object pairs face the magnet can be adjusted by rotating the magnetic disc around the rotary shaft.

[0012] According to another aspect of the present invention, at least one magnetic object pair may be installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least one pair of the magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to reciprocate in an axial direction thereof.

[0013] At least one magnetic object pair may be installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least one pair of the magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to rotate around the rotary shaft thereof at a predetermined angle.

[0014] A heating channel and a cooling channel may be partitioned by a partition wherein the heat exchanger for heating is disposed on the heating channel, and the heat exchanger for cooling is disposed on the cooling channel. A common fan may be installed upstream the heat exchangers in order to ventilate both the heating channel and the cooling channel, wherein the partition downstream the heat exchangers includes a temperature door. Fans may be installed upstream the heat exchangers in order to feed air each heat exchanger.

[0015] According to another aspect of the present invention an air conditioning system may comprise at least a hollow magnetic disc configured to rotate; magnets installed within rotational radii of the respective magnetic discs, and applying magnetic fields to the magnetic disc, wherein the magnets are fixed, an adiabatic partition installed in each magnetic disc so as not to be rotated together with each magnetic disc, and partitioning an interior of each magnetic disc into a space of a magnet side and a space opposite the magnet side; a heating channel causing a fluid to be fed into the magnetic discs, to pass through the magnet side, and to exchange heat at a heat exchanger for heating; and a cooling channel causing a fluid to be fed into the magnetic discs, to pass through a side opposite the magnet side, and to exchange heat at a heat exchanger for cooling. The magnet may be a permanent magnet superconductive magnet or an electromagnet. The magnetic disc may be made of a ferromagnetic material.

[0016] At least one magnetic object pair may be installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least a pair of magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to reciprocate in an axial direction thereof. At least one magnetic object pair may be installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least a pair of magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to rotate around the rotary shaft thereof at a predetermined angle.

[0017] According to a further aspect of the present invention an air conditioning system may comprise: a movable cylinder configured to reciprocate in an axial direction thereof; at least one magnetic object pair installed on an outer circumference of the movable cylinder in a diagonal direction; and at least one permanent magnet pair spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined section, wherein an area where the magnetic object pair faces the permanent magnet pair is adjusted by rotating the movable cylinder around a shaft thereof at a predetermined angle.

[0018] As apparent from the above description, the air conditioning system is safe from the fear of environmental pollution, has a simple structure, and does not require additional devices to reduce costs.

[0019] Further, the air conditioning system is suitable for a next-generation air conditioning system to be applied to a hybrid or electric automobile because it does not use engine heat or a refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The above and other features of the present invention will now be described in detail with reference to certain exemplary embodiments thereof illustrated the accompanying drawings which are given hereinbelow by way of illustration, and thus are not limitative of the present invention and wherein:

[0021] FIG. **1** is a schematic view explaining theory of a magnetocaloric effect;

[0022] FIG. **2** is an perspective view explaining the basic configuration of an air conditioning system in accordance with the present invention;

[0023] FIG. **3** is a partial cross-sectional view taken along the ling A-A of FIG. **2**;

[0024] FIG. **4** is a schematic view explaining a method of adjusting a temperature of the air conditioning system of FIG. **2**;

[0025] FIG. **5** illustrates an application of the air conditioning system of FIG. **2**;

[0026] FIG. **6** illustrates another application of the air conditioning system of FIG. **2**;

[0027] FIG. **7** illustrates another air conditioning system in accordance with the present invention;

[0028] FIG. **8** illustrates another air conditioning system in accordance with the present invention; and

[0029] FIG. **9** is a top plan view illustrating the air conditioning system of FIG. **8**.

[0030] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various preferred features illustrative of the basic principles of the invention. The specific design features of the present invention as disclosed herein, including, for example, specific dimensions, orientations, locations, and shapes will be determined in part by the particular intended application and use environment.

[0031] In the figures, reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

DETAILED DESCRIPTION OF THE INVENTION

[0032] Reference will now be made in greater detail to an air conditioning system according to exemplary embodiments of the present invention with reference to the accompanying drawings. Wherever possible, the same reference numerals will be used throughout the drawings and the description to refer to the same or like parts.

[0033] Referring to FIGS. **2** and **3**, an air conditioning system according to the first embodiment has an air-cooled structure in which a permanent magnet **20** is installed on one side of each rotary magnetic disc **10**, each magnetic disc **10** absorbs or radiates heat according to a rotating angle thereof, and this heat heats or cools air introduced from the outside by means of heat exchangers **30** and **40**.

[0034] The magnetic discs **10** are disposed in parallel along a rotary shaft **11**, has the shape of an annular ring, the central portion of which is open. The central portion of each magnetic disc **10** is provided with a crisscross frame such that the magnetic discs **10** can share the rotary shaft **11** with each other. This magnetic disc **10** is made of a ferromagnetic material showing a strong magnetocaloric effect at an approximately room temperature. One example of the ferromagnetic material includes gadolinium, which is a rare-earth metal having high magnetic susceptibility, or a GdSiGe based mixture.

[0035] Each permanent magnet **20** is installed within a rotational radius of each magnetic disc **10**, and thus applies a magnetic field to each magnetic disc **10** rotating within a predetermined section. Each permanent magnet **20** is provided with a receiving slot opposite sides of which serves as N and S poles of each permanent magnet **20**. Each rotary magnetic disc **10**, which is located in the receiving slot of each permanent magnet **20**, intersects the magnetic field of each permanent magnet **20** at a right angle. Preferably, the magnitude of the magnetic field applied to each magnetic disc **10** by each permanent magnet **20** must be more than 2 tesla. Alternatively, a superconductive magnet or an electromagnet may be naturally used instead of the permanent magnet **20**.

[0036] The heat exchangers are made up of the heat exchanger **30** for heating and the heat exchanger **40** for cooling. The heat exchanger **30** for heating is installed on the side of the permanent magnets **20**, and includes at least a heat radiation fin **31**. The heat exchanger **40** for cooling is installed on the side opposite the heat exchanger **30** for heating, and includes at least a heat absorption fin **41**. Parts of the rotary magnetic discs **10**, which are introduced into and heated inside the receiving slots of the permanent magnets **20**, radiate heat through the beat exchanger **30** for heating, and other parts, which come out of and is cooled outside the receiving slots, absorb heat from the heat exchanger **40** for cooling.

[0037] A method of adjusting temperature of the air conditioning system will be described with reference to FIG. **4**. Magnetic flux density is a little different depending on a position in the receiving slot of each permanent magnet **20**.

[0038] In detail, the magnetic flux density is relatively high in the proximity of the N pole or the S pole, whereas it is somewhat low between the N pole and the S pole. Thus, as illustrated in FIG. **4**, if the rotary shaft **11** of the magnetic discs **10** is adapted to be able to move in an axial direction thereof and then to adjust an amount of intersecting magnetic flux of the magnetic discs **10**, the temperature of the air conditioning system can be adjusted. In the case of the permanent magnets, the intensity of the magnetic field cannot be arbitrarily adjusted. However, the aforementioned method makes it possible to control the temperature, particularly to adjust a desired air-conditioning temperature. In various embodiments, the air conditioning system may have a structure in which at least one magnetic object pair (not shown) is installed on the upper and lower circumference of the rotary magnetic disc **10** corresponding to the permanent magnet **20**. Accordingly, as the rotary magnetic disc **10** is rotated around the rotary shaft **11** with a predetermined angle, an area where the magnetic object pair faces the permanent magnet **20** can be adjusted and thus a desired air conditioning temperature can be adjusted through adjustment of an amount at which the permanent magnet **20** intersects magnetic flux.

[0039] An application of the aforementioned air conditioning system will be described with reference to FIGS. **5** and **6**.

[0040] As illustrated in FIG. **5**, the air conditioning system includes a heating channel and a cooling channel, which are partitioned by a partition **61**. The heat exchanger **30** for heating is assigned to the heating channel, whereas the heat exchanger **40** for cooling is assigned to the cooling channel. A common fan **50** is installed upstream the heat exchangers **30** and **40** in order to ventilate both the heating channel and the cooling channel, and a temperature door **70** is installed on the partition downstream the heat exchangers **30** and **40**. Alternatively, the temperature door **70** may be installed upstream the heat exchangers **30** and **40**. In this case, the air flowing through the heating channel and the air flowing through the cooling channel are mixed with each other from the viewpoint of air flow. A reference number **60**, which has not been yet described, indicates a case corresponding to a conventional heating ventilation and air conditioning (HVAC) housing.

[0041] Alternatively, as illustrated in FIG. **6**, the fans **50** may be separately installed upstream the heat exchangers **30** and **40**. In this case, the temperature door **70** is removed.

[0042] Unlike the air-cooled type described above, the air conditioning system of various embodiments may be designed in a water-cooled type.

[0043] Referring to FIG. **7**, the exemplary air conditioning system is similar to that described above in that a permanent magnet **200** for applying a magnetic field is installed on one side of each magnetic disc **200** rotated around a rotary shaft **201** in a predetermined angle, but it is different from that described above in that each magnetic disc **200** has a hollow structure without opening the central portion thereof.

[0044] As for an internal structure of each magnetic disc **200**, an inner wall of each hollow magnetic disc **200** is provided with a casing **210**, which prevents contact with water and has good heat transferability. The casing **210** is provided therein with an adiabatic partition **220**. A vertical part of the adiabatic partition **220** partitions an interior of the casing **210** into two spaces, one of which is located on the side of a permanent magnet and the other on the side opposite the permanent magnet. A horizontal part of the adiabatic partition **220** increases a heat transfer contact area between a fluid flowing in the casing **210**.

[0045] Meanwhile, the magnetic disc **200** and its casing **210** are rotated together around the rotary shaft **201**, but the adiabatic partition **220** is not rotated together, namely is fixed. Part of the rotary magnetic disc **200** which is located on the side of the permanent magnet **230** always generates heat, and the opposite part always absorbs heat. Thus, in the case in which the adiabatic partition **220** is fixed despite the rotation of the magnetic disc **200**, water is allowed to flow only to the permanent magnet (i.e. heating channel) inside the magnetic disc during heating operation, and to flow only the opposite side (i.e. cooling channel) during cooling operation. Of course, because the magnetic disc **200** is rotated relative to the adiabatic partition **220**, the water may be infiltrated from the heating channel to the cooling channel or vice versa through a gap between the adiabatic partition **220** and the magnetic disc **200**, more particularly between the adiabatic partition **220** and the casing **210**.

[0046] As described above, the magnetic flux density is relatively high in the proximity of the N pole or the S pole, whereas it is somewhat low between the N pole and the S pole. Thus, as illustrated in FIG. **7**, if the rotary shaft **201** of the magnetic discs **200** is adapted to be able to move in an axial direction thereof, and then to adjust an amount of intersecting magnetic flux of the magnetic discs **200**, the temperature of the air conditioning system can be adjusted. In another aspect the air conditioning system of various exemplary embodiments may have a structure in which at least one magnetic object pair (not shown) is installed on the upper and lower circumference of the magnetic disc **200** corresponding to the permanent magnet **230**. The magnetic disc **200** can be rotated around the rotary shaft **201** in a predetermined angle. Since an area where the magnetic object pair faces the permanent magnet **230** can be adjusted by rotating the magnetic disc **200** around the rotary shaft **201** at the predetermined angle, a desired air conditioning temperature can be adjusted.

[0047] In this manner, the hot water having passed through the heating channel in the magnetic disc **200** radiates heat at the heat exchanger for heating, and then flows into a pump, while the cold water having passed through the cooling channel absorbs heat at the heat exchanger for cooling, and then flows into the pump. The pump circulates the water along each channel again.

[0048] Unlike the exemplary embodiments described above, the ferromagnetic material of the magnetic disc may be configured to reciprocate with respect to the permanent magnet.

[0049] As illustrated in FIG. **8**, the air conditioning system of various embodiments may have a structure in which at least one magnetic object pair **110** is installed on the outer circumference of a movable cylinder **100**, i.e., a magnetic disc, configured to reciprocate in an axial direction thereof, and in which at least one permanent magnet pair **120** is installed outside the magnetic object pair **10** corresponding to the magnetic object pair **110**. The magnetic object pair **110** is installed on the outer circumference of the movable cylinder **100** in a diagonal direction, and the permanent magnet pair **120** is spaced apart from the magnetic object pair **110**, and applies a magnetic field to the other permanent magnet pair

120 through a portion of the magnetic object pair **110** which reciprocates along the axial direction of the movable cylinder **100** as the movable cylinder **100** moves along its axial direction which changes the magnetic flux density.

[0050] Meanwhile, as illustrated in FIG. **9**, the movable cylinder **100** can be rotated around a central shaft **101** in a predetermined angle. Thus, an area where the magnetic object pair **110** faces the permanent magnet pair **120** can be adjusted by rotating the movable cylinder **100** around the central shaft **101** at a predetermined angle. Thereby, a desired air conditioning temperature can be adjusted. As described above, the air conditioning temperature is controlled through adjustment of an amount at which the magnetic object pair **10** intersects magnetic flux.

[0051] The heat exchange and circulation of the air conditioning system of various embodiments can be varied on the basis of the aforementioned embodiments and any well-known technology.

[0052] Although exemplary embodiments of the present invention have been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

1. An air conditioning system comprising:

at least a magnetic disc disposed in parallel along a rotary shaft thereof;

at least a magnet installed within a rotational radii of the respective magnetic discs, and applying magnetic fields to the magnetic disc, wherein the magnet is fixed;

a heat exchanger for heating installed on a side of the magnets, and having at least a heat radiation fin; and

a heat exchanger for cooling installed on a side opposite the magnets, and having at least a heat absorption fin.

2. The air conditioning system as set forth in claim **1**, wherein at least one magnet is a permanent magnet, superconductive magnet or an electromagnet

3. The air conditioning system as set forth in claim **1**, wherein at least one magnetic disc is made of a ferromagnetic material.

4. The air conditioning system as set forth in claim **1**, wherein the rotary shaft is configured to move in an axial direction thereof whereby a desired air conditioning temperature can be controlled through adjusting magnetic flux density of the magnet.

5. The air conditioning system as set forth in claim **1**, wherein magnetic object pairs are installed on the upper and lower circumference of the magnetic disc corresponding to the magnet.

6. The air conditioning system as set forth in claim **5**, wherein the rotary shaft is configured to be rotatable within a predetermined angle whereby an area where the magnetic object pairs face the magnet can be adjusted by rotating the magnetic disc around the rotary shaft.

7. The air conditioning system as set forth in claim **1**, wherein at least one magnetic object pair is installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least one pair of the magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to reciprocate in an axial direction thereof.

8. The air conditioning system as set forth in claim **1**, wherein at least one magnetic object pair is installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least one pair of the magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to rotate around the rotary shaft thereof at a predetermined angle.

9. The air conditioning system as set forth in claim **1**, further comprising a heating channel and a cooling channel that are partitioned by a partition, wherein the heat exchanger for heating is disposed on the heating channel, and the heat exchanger for cooling is disposed on the cooling channel.

10. The air conditioning system as set forth in claim **9**, further comprising a common fan installed upstream the heat exchangers in order to ventilate both the heating channel and the cooling channel, wherein the partition downstream the heat exchangers includes a temperature door.

11. The air conditioning system as set forth in claim **9**, further comprising fans installed upstream the heat exchangers in order to feed air each heat exchanger.

12. An air conditioning system comprising:

at least a hollow magnetic disc configured to rotate;

magnets installed within rotational radii of the respective magnetic discs, and applying magnetic fields to the magnetic disc, wherein the magnets are fixed;

an adiabatic partition installed in each magnetic disc so as not to be rotated together with each magnetic disc, and partitioning an interior of each magnetic disc into a space of a magnet side and a space opposite the magnet side;

a heating channel causing a fluid to be fed into the magnetic discs, to pass through the magnet side, and to exchange heat at a heat exchanger for heating; and

a cooling channel causing a fluid to be fed into the magnetic discs, to pass through a side opposite the magnet side, and to exchange heat at a heat exchanger for cooling.

13. The air conditioning system as set forth in claim **12**, wherein the magnet is a permanent magnet superconductive magnet or an electromagnet.

14. The air conditioning system as set forth in claim **12**, wherein the magnetic disc is made of a ferromagnetic material.

15. The air conditioning system as set forth in claim **12**, wherein at least one magnetic object pair is installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least a pair of magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to reciprocate in an axial direction thereof.

16. The air conditioning system as set forth in claim **12**, wherein at least one magnetic object pair is installed on an outer circumference of the magnetic disc in a diagonal direction thereof and at least a pair of magnets is spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined angle, wherein the magnetic disc is configured to be able to rotate around the rotary shaft thereof at a predetermined angle.

17. An air conditioning system comprising:

a movable cylinder configured to reciprocate in an axial direction thereof;

at least one magnetic object pair installed on an outer circumference of the movable cylinder in a diagonal direction; and

at least one permanent magnet pair spaced apart from the magnetic object pair, and applying magnetic fields to the magnetic object pair within a predetermined section,

wherein an area where the magnetic object pair faces the permanent magnet pair is adjusted by rotating the movable cylinder around a shaft thereof at a predetermined angle.

* * * * *