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(54) **COOLING JACKET**

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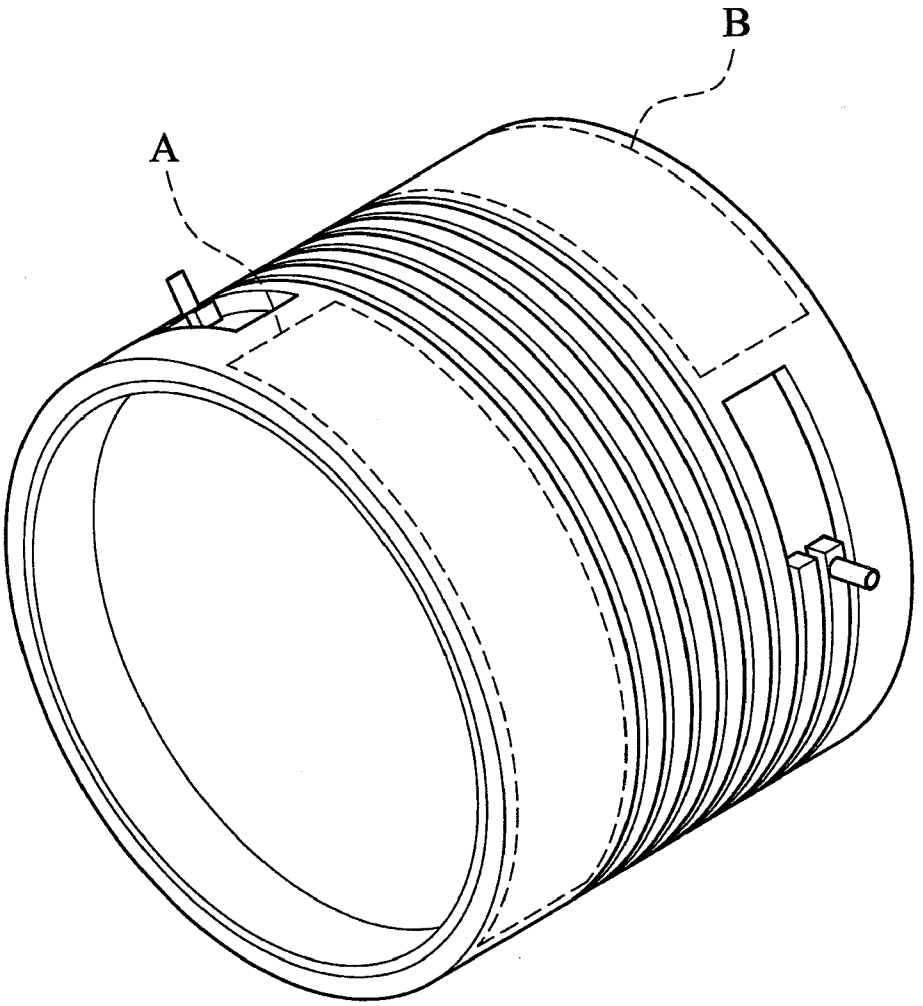
(57) **ABSTRACT**

A cooling jacket for cooling an electric motor is provided. The cooling jacket has one or more continuous S-shaped pipes, covering the electric motor, for conducting working fluid, wherein each continuous S-shaped pipe at least has: a forwarding portion and a reversed portion, respectively extending along two circumferential directions which are parallel but opposite to each other; and a turning portion connected between the forwarding portion and the reversed portion.



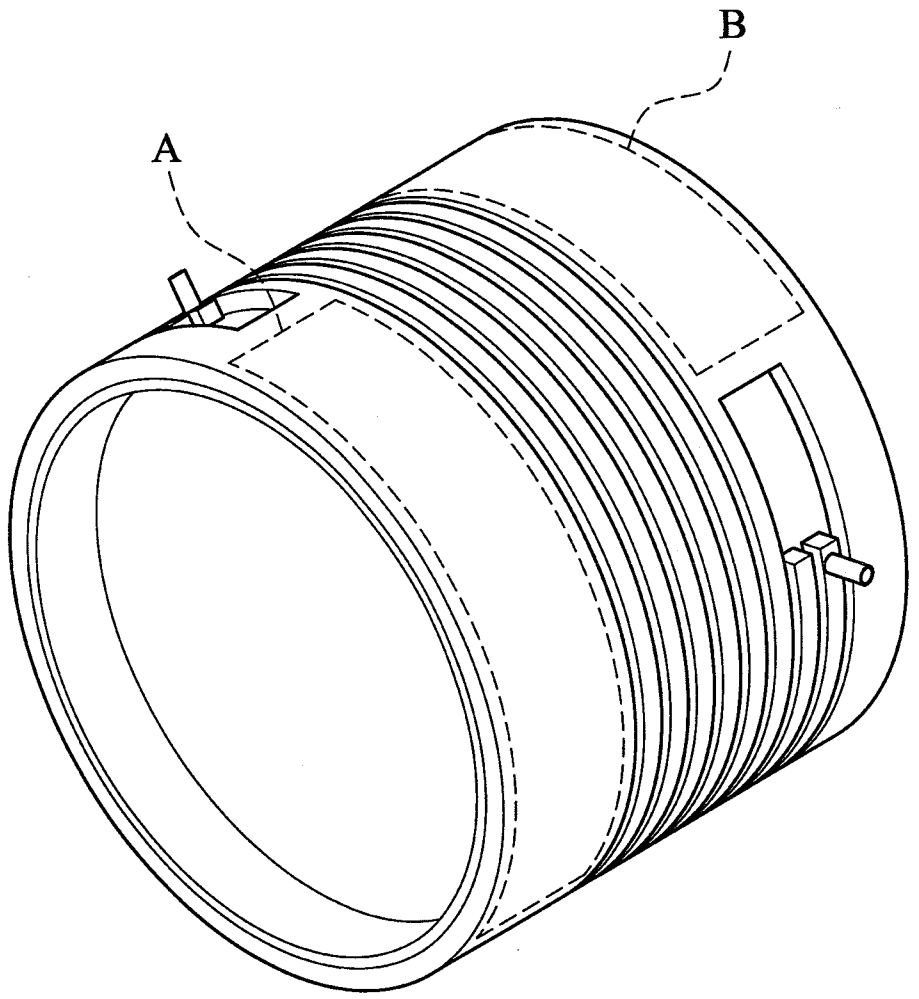


FIG. 1

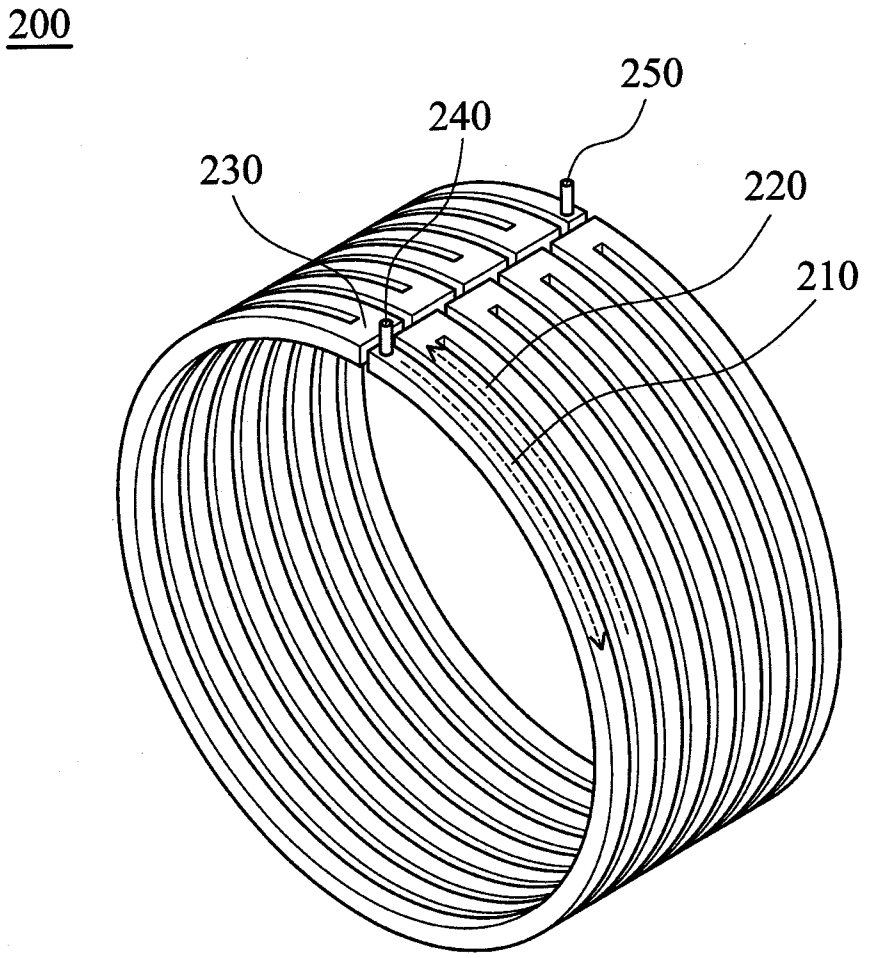


FIG. 2A

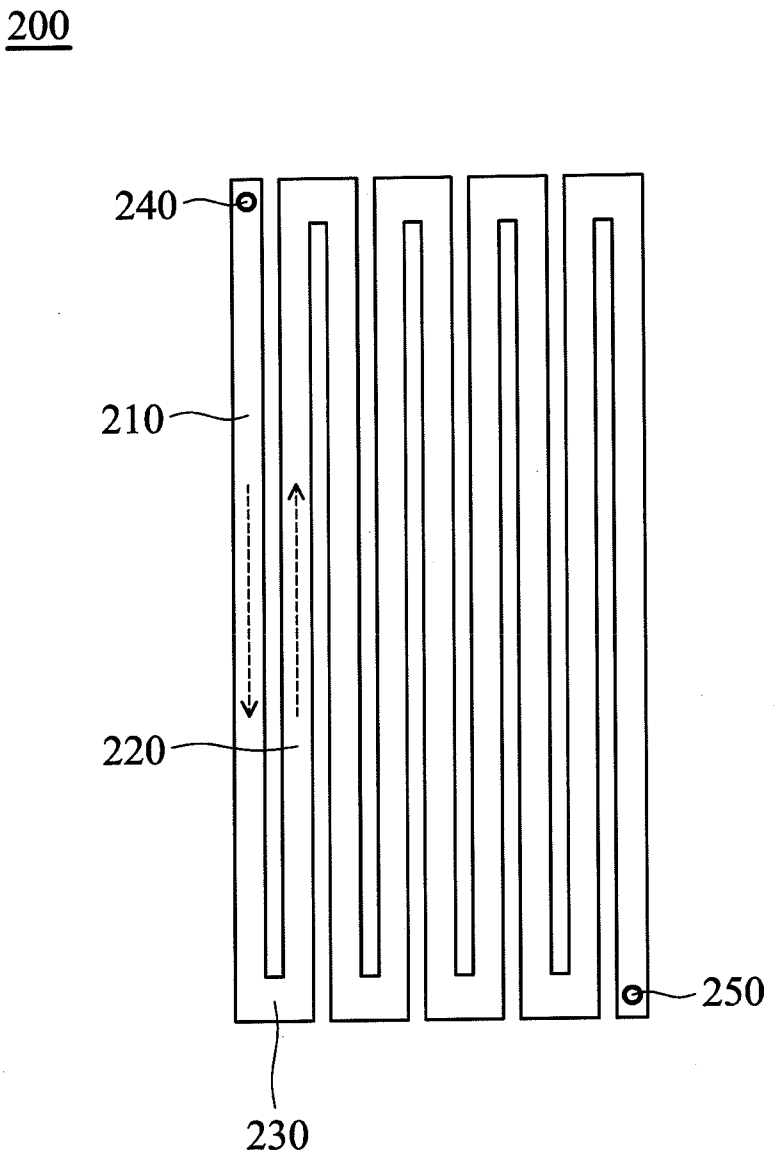


FIG. 2B

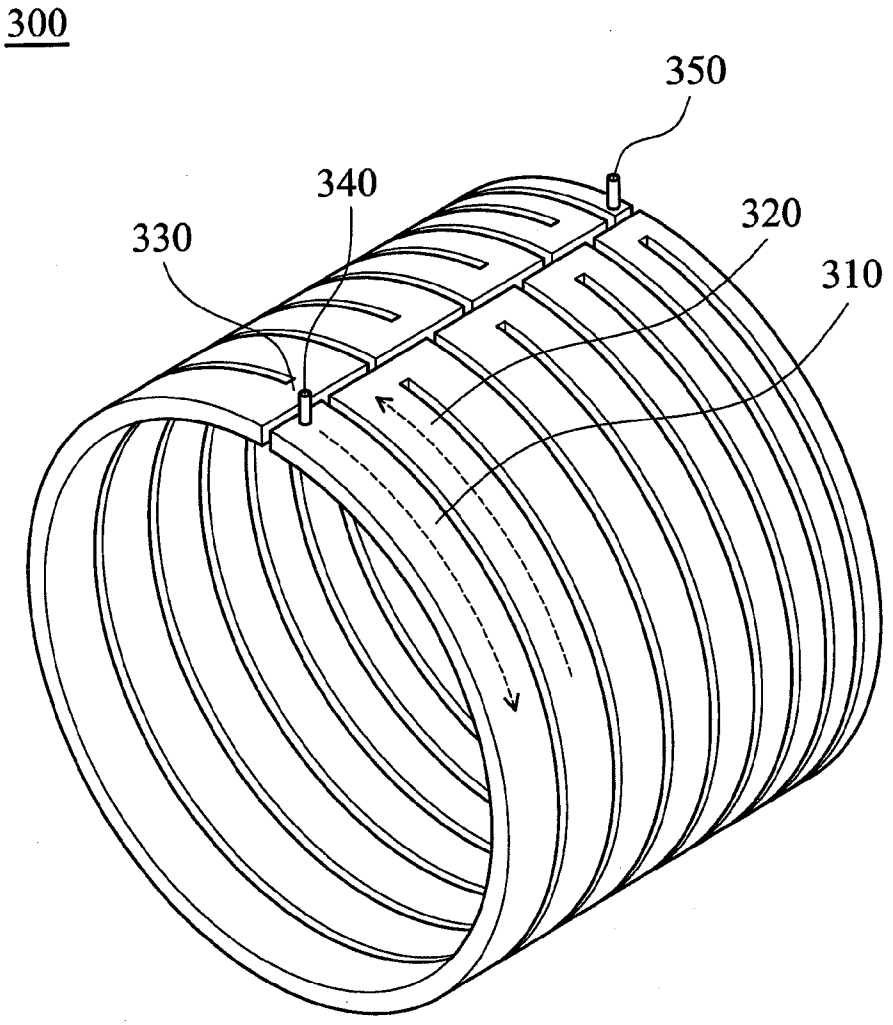


FIG. 3A

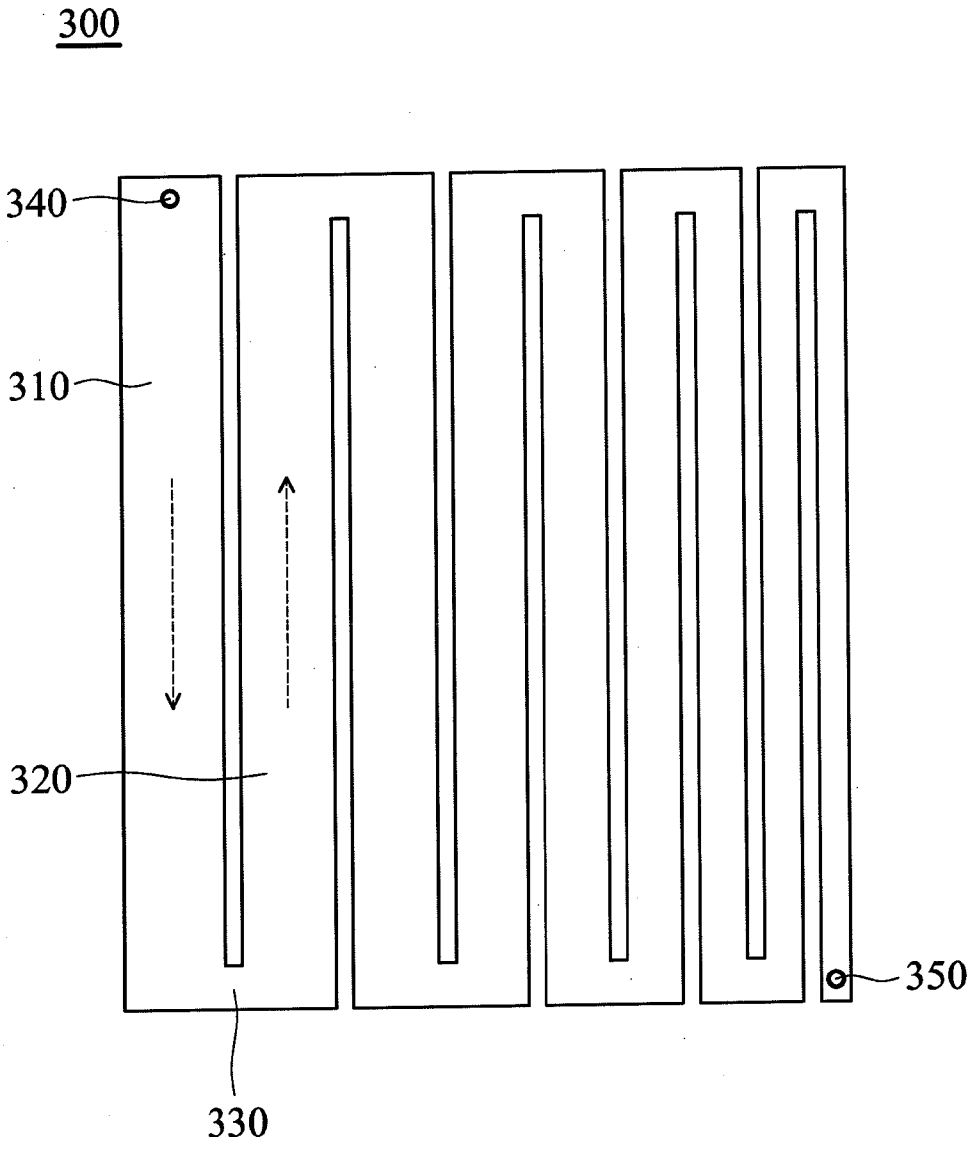


FIG. 3B

400

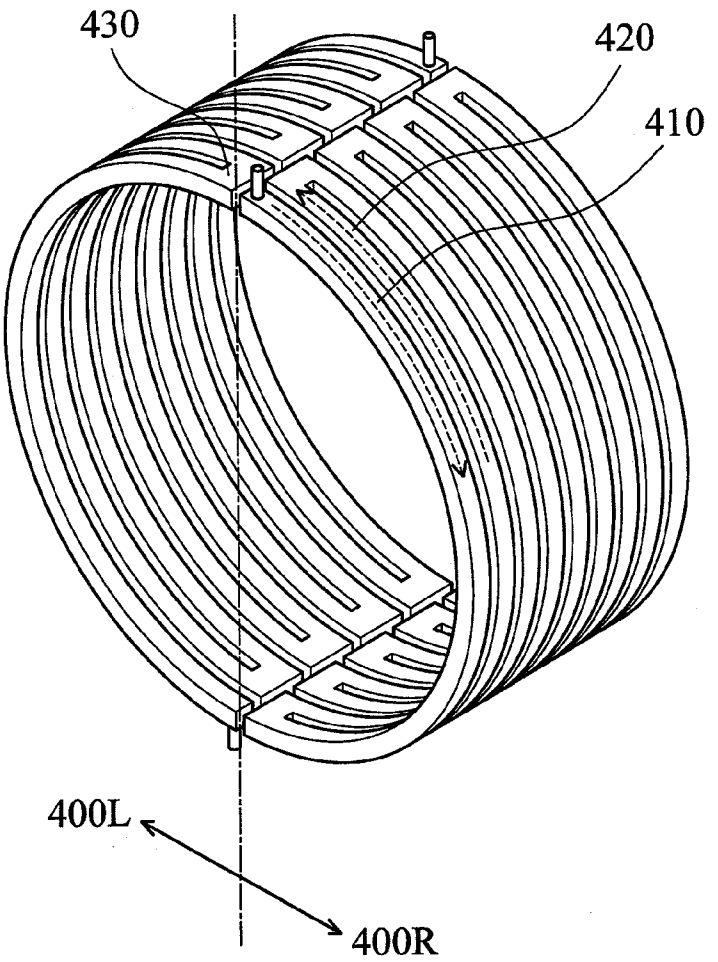


FIG. 4A

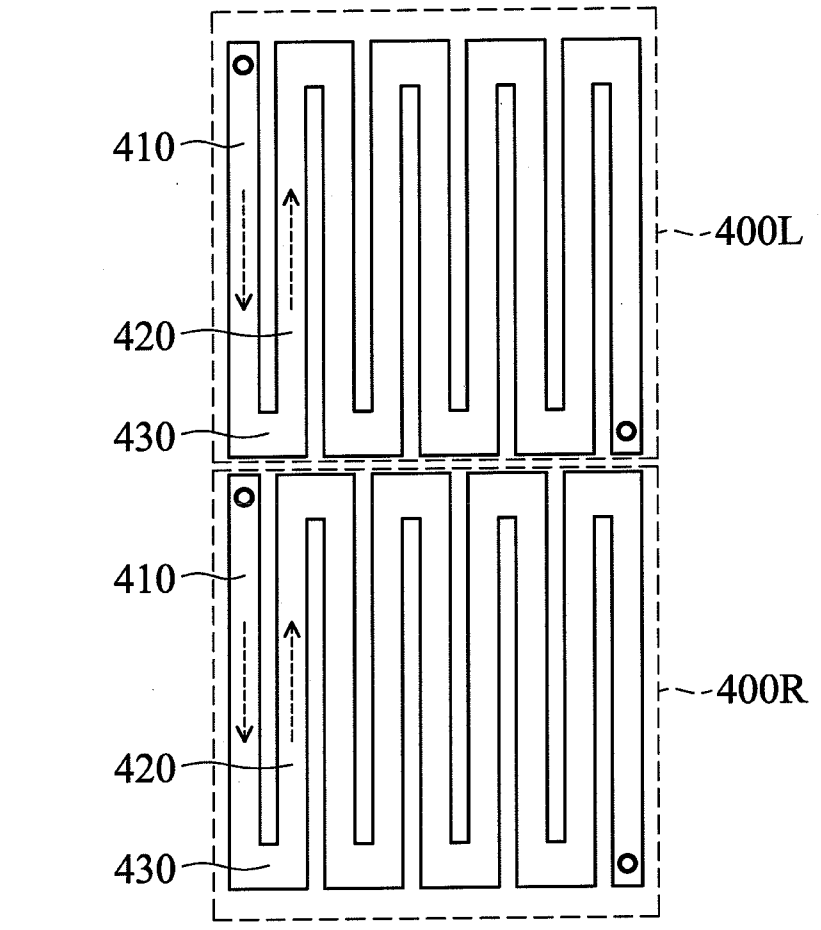


FIG. 4B

500

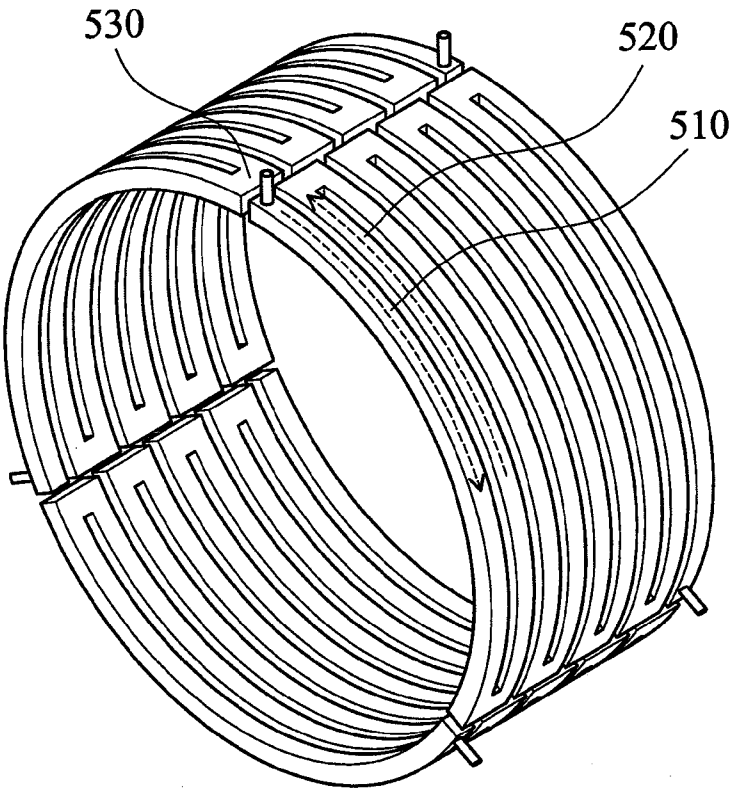


FIG. 5A

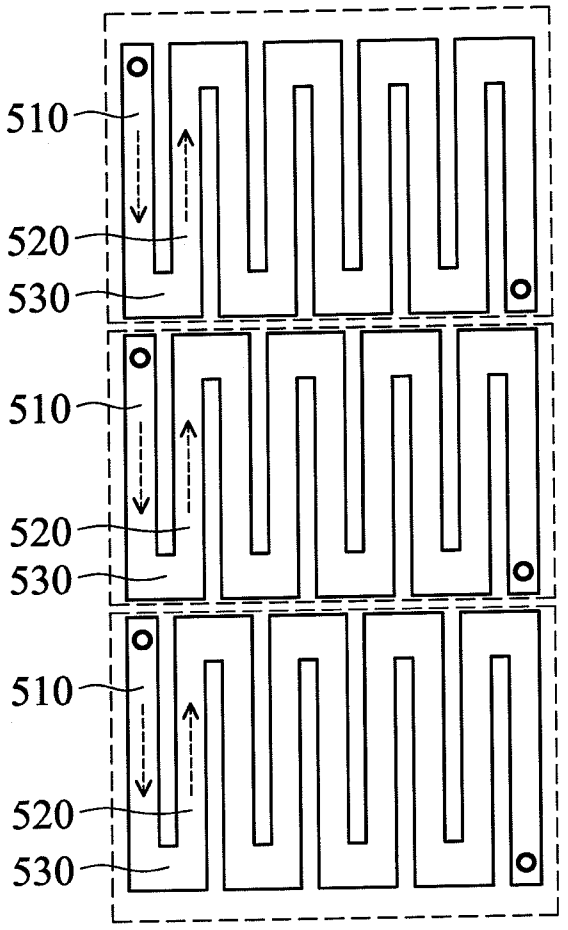


FIG. 5B

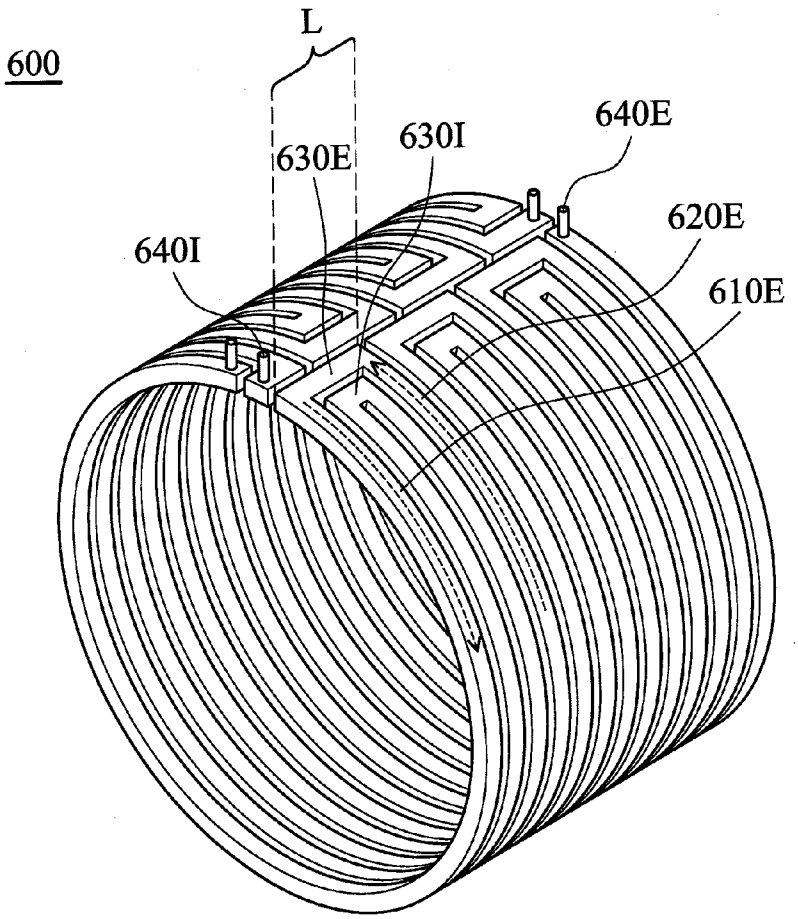


FIG. 6A

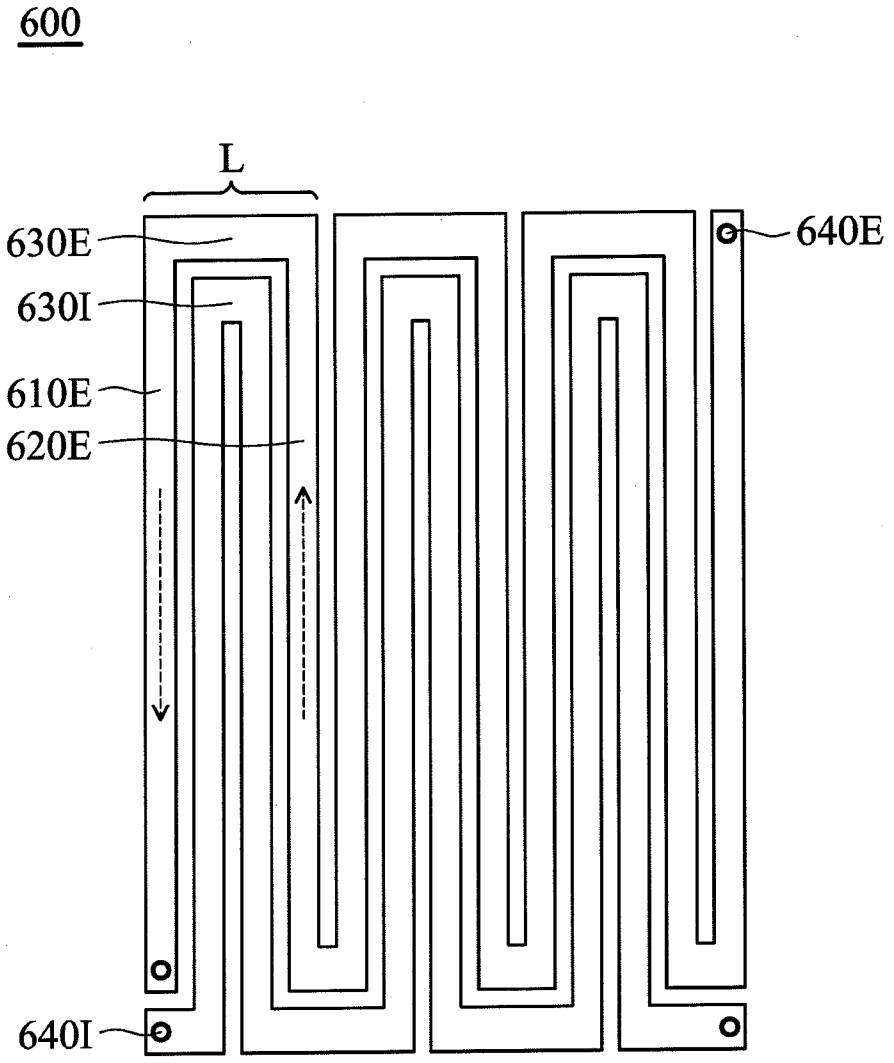


FIG. 6B

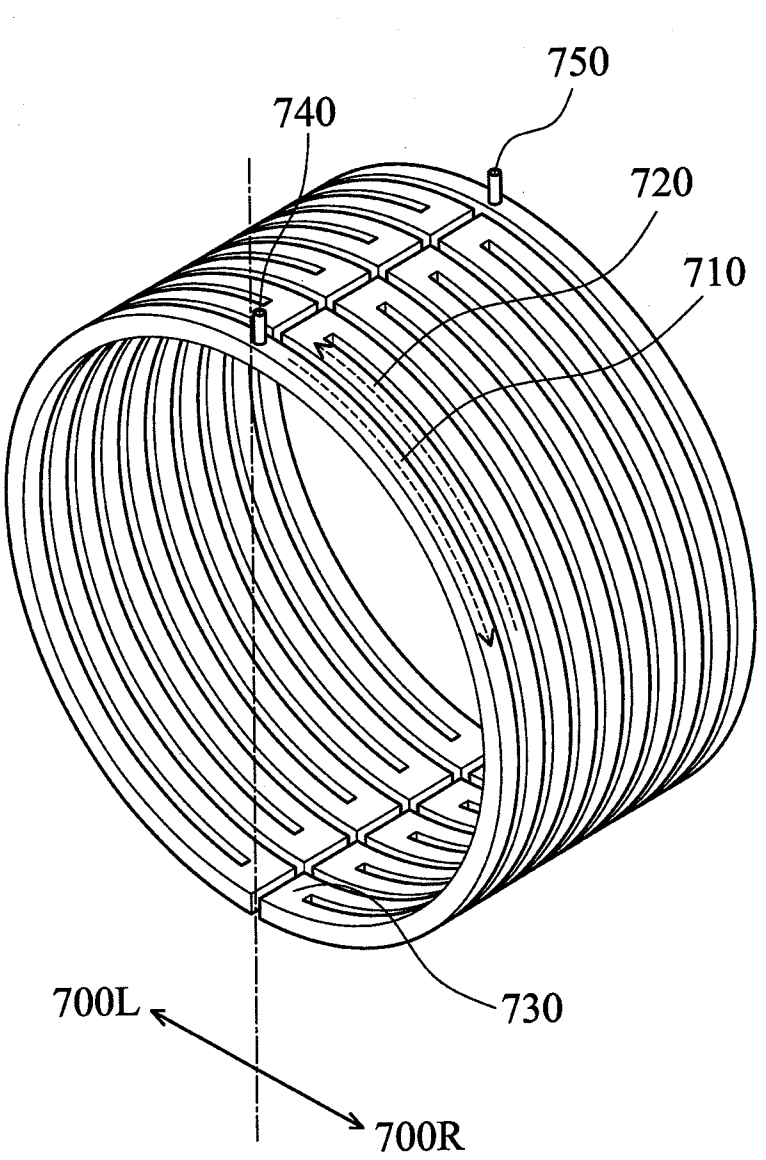


FIG. 7A

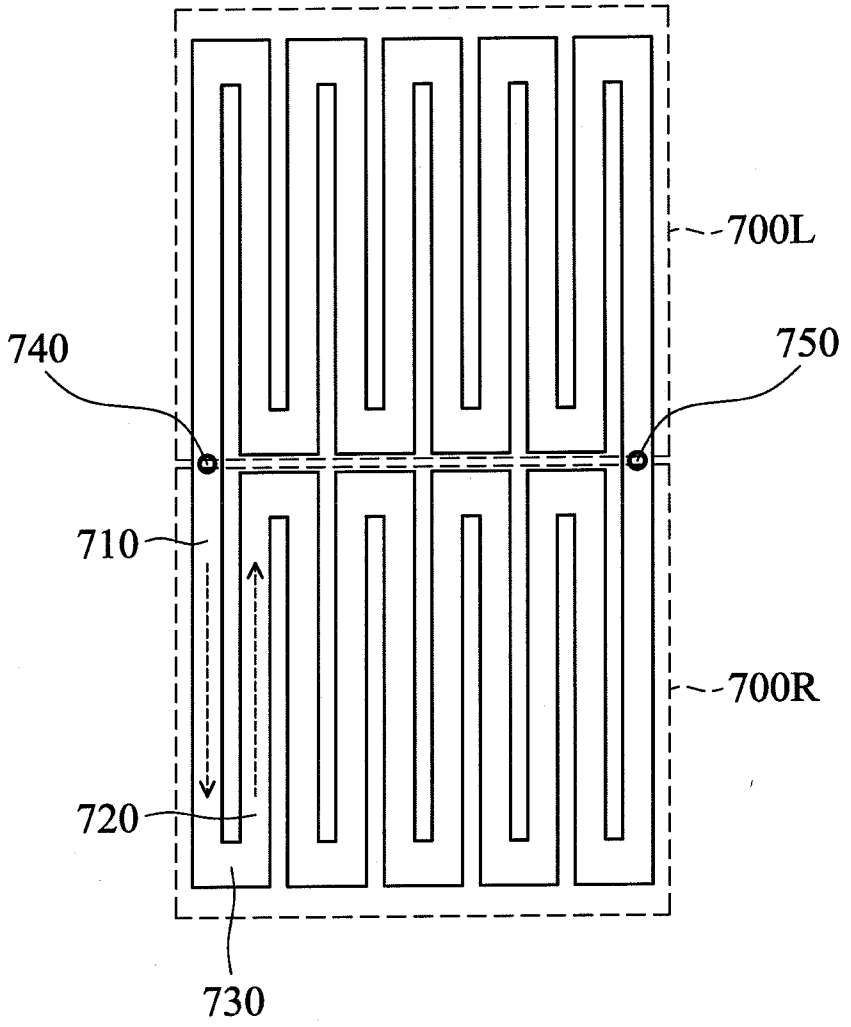


FIG. 7B

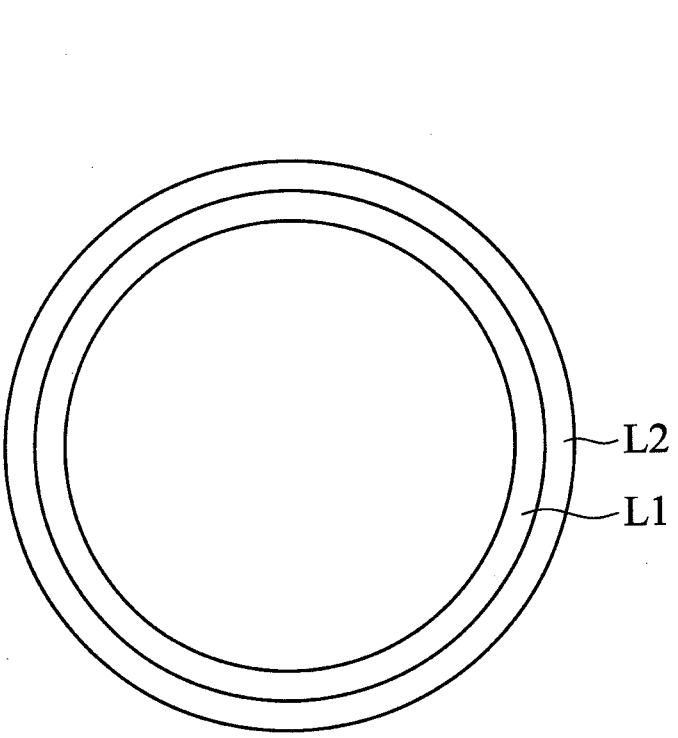


FIG. 8

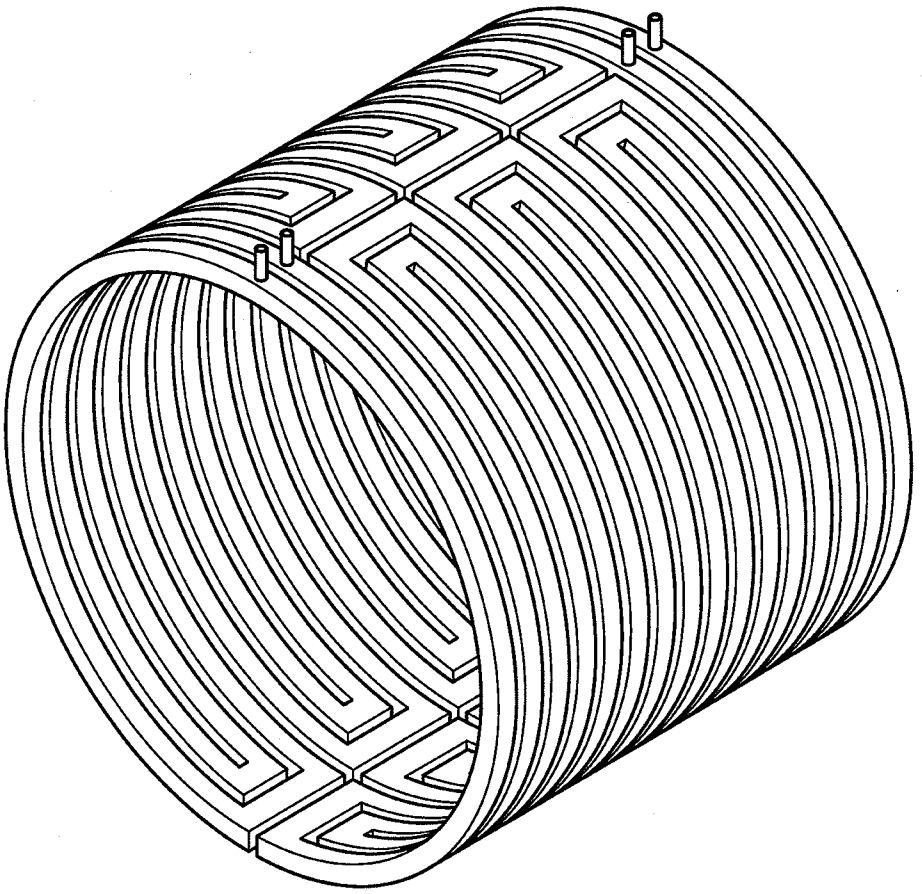


FIG. 9

COOLING JACKET

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Non-provisional application claims priority under 35 U.S.C. §119(a) on Patent Application No(s). 100142813, filed in Taiwan, Republic of China on Nov. 23, 2011, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to heat dissipation technology for electric motor.

[0004] 2. Description of the Related Art

[0005] To maintain the performance and prolong the life-cycle of an electric motor, the heat generated from a operating electric motor should be appropriately dissipated.

[0006] The prior art usually uses a cooling pipe and the working fluid that flows through the cooling pipe to dissipate the heat generated from the electric motor. FIG. **1** is a schematic diagram of the cooling pipe in the prior art. In FIG. **1**, the electric motor (not shown) is basically in a column shape, and, to fit the shape of the electric motor, the cooling pipe extends in a spiral fashion from an inlet to an outlet and covers the electric motor. From this diagram, it can be seen that the cooling pipe does not cover the areas A and B of the electric motor which is near the inlet and outlet of the cooling pipe, thus causing heat concentration in the areas A and B and influencing the entire heat dissipation of the electric motor. Although in some designs the cooling pipe can cover these areas, the working fluid usually loses its kinetic energy when flowing through these areas due to the poor convective heat transfer ability of the fluid in a spiral pipe (from the principles of fluid dynamics, the fluid in the spiral pipe has little pressure drop, which leads to a low convective heat transfer rate and poor convective heat transfer ability)

[0007] It can be noted that the heat dissipating area provided by the cooling pipe and the quantity of the working fluid that flows in the cooling pipe are both limited to the size of the electric motor. Therefore, how to design a cooling device to dissipate more heat in the limited regions is an important issue which needs to be solved.

BRIEF SUMMARY OF THE INVENTION

[0008] The present invention provides a cooling jacket for cooling an electric motor. The cooling jacket comprises one or more continuous S-shaped pipes, covering the electric motor, for conducting working fluid, wherein each continuous S-shaped pipe at least comprises: a forwarding portion and a reversed portion, respectively extending along two circumferential directions which are parallel but opposite to each other; and a turning portion connected between the forwarding portion and the reversed portion.

[0009] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0011] FIG. **1** is a schematic diagram of the cooling pipe in the prior art.

[0012] FIG. **2**A is a three dimensional (3D) view of the cooling jacket according to an embodiment of the present invention. FIG. **2**B is an illustrative diagram where the cooling jacket in FIG. **2**A is spread into a plane for easy comprehension.

[0013] FIG. **3**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **3**B is an illustrative diagram where the cooling jacket in FIG. **3**A is spread into a plane.

[0014] FIG. **4**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **4**B is an illustrative diagram where the cooling jacket in FIG. **4**A is spread into a plane.

[0015] FIGS. **5**A and **5**B shows three sets of continuous S-shaped pipes in a cooling jacket **500**.

[0016] FIG. **6**A is a 3D view of the cooling jacket according to an embodiment of the present invention.

[0017] FIG. **6**B is an illustrative diagram where the cooling jacket in FIG. **4**A is "spread" into a 2D plane.

[0018] FIG. **7**A is a 3D view of the cooling jacket according to an embodiment of the present invention.

[0019] FIG. **7**B is an illustrative diagram where the cooling jacket in FIG. **4**A is "spread" into a 2D plane.

[0020] FIG. **8** is a schematic diagram of a two-layered cooling jacket according to an embodiment of the present invention.

[0021] FIG. **9** shows a combination of the cooling jackets in FIGS. **6**A and **7**.

DETAILED DESCRIPTION OF THE INVENTION

[0022] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

[0023] FIG. **2**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **2**B is an illustrative diagram where the cooling jacket in FIG. **2**A is "spread" into a 2D plane for easy comprehension. Although the cooling jacket of the present invention is originally designed for high-power and high-accuracy electric motors such as motors and power generators, the present invention should not be limited thereto. As shown in FIGS. **2**A and **2**B, the cooling jacket **200**, in addition to the working fluid inlet **240** and working fluid outlet **250**, further comprises "one set" of continuous S-shaped pipe (embodiments with several sets of continuous S-shaped pipes will be discussed later). The set of continuous S-shaped pipe covers the entire electric motor, and allows the working fluid to flow through the pipe. Thus, the heat generated from the electric motor can be dissipated by the flow of the working fluid, and the electric motor can be kept at a normal operating temperature. Generally, the working fluid of the present invention can be any kind of liquid which has temperature not higher than the normal operating temperature of the electric motor. For example, the liquid can be water, lubricant oil, mixed liquid of 50% ethylene glycol and 50% water, or water with anti-freeze agent, however the present invention should not be limited thereto. In addition, the liquid in the cooling jacket of the present invention can be propelled by various motors or pumps (not shown in Figs.). The purpose of the present invention is to overcome defects in

heat dissipation in the prior art due to limited cooling area and limited working fluid quantity. The present invention achieves this purpose by increasing the flow speed of the working fluid (given the same propelling power as that in the prior art). The principle of the present invention will be further described in detail later.

[0024] In comparison between FIGS. **1** and **2**A, it can be seen that the cooling jacket of the present invention has a quite different structure from that in the prior art. The cooling pipe described in "Description of the Related Art" is in a spiral shape, but the cooling pipe of the present invention is substantially in a continuous S shape. For illustration, the continuous S-shaped piped cooling jacket **200** of the present invention can be divided into three parts: the forwarding portion(s) **210**, the reversed portion(s) **220** and the turning portion(s) **230**. In order to cover as much of the electric motor as possible, the forwarding portion **210** and the reversed portion **220** are juxtaposed (parallel) to each other, and both extend along a circumferential direction. In addition, the forwarding portion **210** and the reversed portion **220** respectively extend in opposite directions (where the forwarding portion **210** extends clockwise, while the reversed portion **220** extends counter-clockwise), thus allowing the working fluid to flow in opposite directions. The turning portion **230** of the present invention is connected between the forwarding portion **210** and the reversed portion **220** for turning the working fluid 180 degrees. The major difference between the prior art and the present invention is the turning portion **230**. In the present invention, the working fluid has a great pressure drop when flowing through the turning portion **230**, thus increasing the flow speed as well as the convective heat transfer rate (h value, in the unit of W/m2k) there. Since the heat exchanged between the cooling flow and the electric motor is basically in direct proportion to the convective heat transfer rate, the cooling jacket of the present invention can greatly improve the defects of the heat concentration around the inlets and outlet of the spiral shaped cooling pipes in the prior art (as shown in FIG. **1**).

[0025] FIG. **3**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **3**B is an illustrative diagram where the cooling jacket in FIG. **3**A is "spread" into a 2D plane. In FIG. **3**B, the continuous S-shaped pipe of the cooling jacket **300** has substantially the same structure as that in FIG. **2**B, and can be divided into three parts: the forwarding portion(s) **310**, the reversed portion(s) **320** and the turning portion(s) **330**. However, different from FIG. **2**B, the continuous S-shaped pipe in FIG. **3**B has an unequal pipe diameter. Specifically, the pipe diameter of the forwarding and the reversed portions of the continuous S-shaped pipe reduce from the working fluid inlet **340** to the working fluid outlet **350**. In a traditional cooling pipe, as flowing in a long path, the working fluid will gradually absorb heat, raise its temperature, and decrease the heat transfer rate. The purpose of this embodiment is to increase the flow speed as well as the convective heat transfer rate of the working fluid and prevent the heat concentration at the ends of the pipes by gradually reducing the pipe diameter. Although a pipe with decreasing pipe diameter is described in this embodiment, the present invention should not be limited thereto. In other embodiments, in order to achieve the best heat dissipating result, the pipe diameter of each section of the continuous S-shaped pipe of the present invention can be varied according to the heat distribution pattern of the electric motor.

[0026] FIG. **4**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **4**B is an illustrative diagram where the cooling jacket in FIG. **4**A is "spread" into a 2D plane. In FIG. **4**B, the continuous S-shaped pipe of the cooling jacket **300** has substantially the same structure as that in FIG. **2**B, and can be divided into three parts: the forwarding portion(s) **410**, the reversed portion(s) **420** and the turning portion(s) **430**. However, unlike in FIG. **2**B, the cooling jacket **400** in FIG. **4**B has "two" sets of continuous S-shaped pipes **400**L and **400**R. For illustration, the two sets of the continuous S-shaped pipes **400**L and **400**R have the same size (the total length of the pipe **400**L or **400**R is half of that in FIG. **2**B), and each pipe **400**L or **400**R covers half of the circumference of the electric motor. However, in other embodiments, these two continuous S-shaped pipes may have different sizes and cover a different area of the electric motor. Compared with the embodiment in FIG. **2**B (given that the working fluid has the same temperature at the working fluid inlet in both embodiments of FIGS. **2**B and **4**B), the working fluid in FIG. **4**B flows through a much shorter length before being expelled, thus removing heat from the electric motor more rapidly. It should be noted that the cooling jacket of the present invention may have any number of sets of continuous S-shaped pipes. Specifically, the cooling jacket may have two or more continuous S-shaped pipes. For example, the cooling jacket may have N sets of the continuous S-shaped pipes for respectively covering 1/N of the circumference of the electric motor. FIGS. **5**A and **5**B show three sets of continuous S-shaped pipes in a cooling jacket **500**. Since those skilled in the art can easily understand the structural features of the cooling jacket **500**, it will not be described in detail.

[0027] FIG. **6**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **6**B is an illustrative diagram where the cooling jacket in FIG. **4**A is "spread" into a 2D plane. The cooling jacket **600** in FIGS. **6**A and **6**B also has two sets of continuous S-shaped pipes **600**E and **600**I. However, the turning portions **630**E and **630**I of the continuous S-shaped pipes **600**E and **600**I have different overall lengths. As shown in FIG. **6**B, the turning portion **630**E of the continuous S-shaped pipe **600**E is connected to the forwarding portion **610**E at an angle of 90 degrees. It extends along the axis direction of the electric motor for a short distance L, and is connected to the reversed portion **620**E at another angle of 90 degrees. The turning portion **630**I of the pipe **600**I is juxtaposed with the turning portion **630**E of the pipe **600**E. In this better embodiment, the working fluid inlets **640**E of the pipes **600**E and working fluid inlets **640**I of the pipes **600**I may be on two opposite sides of the cooling jacket **600** so that the working fluid in the pipes **600**E and **600**I can flow in two opposite directions. The purpose of this manner is to further even the heat distribution of the electric motor, thus preventing the heat concentration at the ends of the cooling jacket.

[0028] FIG. **7**A is a 3D view of the cooling jacket according to an embodiment of the present invention. FIG. **7**B is an illustrative diagram where the cooling jacket in FIG. **4**A is "spread" into a 2D plane. Similarly, the cooling jacket **700** in FIG. **7**B has two sets of continuous S-shaped pipes **700**R and **700**L, and each has the forwarding portions **710**, the reversed portions **720** and the turning portions **730**. However, different from that in FIG. **4**B, the two pipes **700**R and **700**L are in a

mirrored arrangement, and share the same starting end, i.e., the working fluid inlet **740**, and the same terminating end, i.e., the working fluid outlet **750**. The cooling jacket **700** overcomes the defects of heat concentration around the ends of the spiral shaped pipes in the prior art, and evens the heat distribution of the electric motor.

[0029] FIG. **8** is a schematic diagram of a two-layered cooling jacket according to an embodiment of the present invention. The cooling jacket **800** has an inner layer L**1** and an outer layer L**2**, where each layer may have continuous S-shaped pipes having the same structure as, or similar structure to, those described above. The inner layer L**1** and the outer layer L**2** are respectively disposed at different circumferences of the electric motor (having different radiuses). In some embodiments, each layer has its own and dependent working fluid inlet and outlet. In some embodiments, the inlets of the two layers may be disposed at opposite sides of the cooling jacket to make the working fluid in the layers flow in opposite directions for preventing heat concentration and improving heat dissipation. Note that the two-layered cooling jacket is merely for illustration, the present invention should not be limited to any number of layers.

[0030] Those skilled in the art can modify and the combine the cooling jackets in the previous embodiments according to the spirit of the present invention. For example, FIG. **9** shows a combination of the cooling jackets in FIGS. **6**A and **7**, where the arrangement for the two sets of continuous S-shaped pipes is like that in FIG. **6**A but the arrangement for the inlets and outlets is like that in FIG. **7**. The cooling jacket **900** in FIG. **9** can prevent the heat concentration around the ends of the pipe, but has better heat distribution than the cooling jacket **600** in FIG. **6**A. Since the cooling jacket of the present invention has various modifications and combinations, they will not be further discussed.

[0031] While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. A cooling jacket for cooling an electric motor comprising:

one or more continuous S-shaped pipes, covering the electric motor, for conducting working fluid, wherein each continuous S-shaped pipe at least comprises:

a forwarding portion and a reversed portion, respectively extending along two respective circumferential directions which are parallel but opposite to each other; and

a turning portion connected between the forwarding portion and the reversed portion.

2. The cooling jacket as claimed in claim **1**, wherein the forwarding portions and/or the reversed portions of the continuous S-shaped pipe have unequal pipe diameters.

3. The cooling jacket as claimed in claim **2**, wherein the pipe diameter of the continuous S-shaped pipe reduces from a working fluid inlet to a working fluid outlet.

4. The cooling jacket as claimed in claim **1**, wherein the cooling jacket has N sets of the continuous S-shaped pipes, and each set of the continuous S-shaped pipe covers a part of the electric motor.

5. The cooling jacket as claimed in claim **1**, wherein the cooling jacket has N sets of the continuous S-shaped pipes, and each set of the continuous S-shaped pipe covers 1/N of the circumference of the electric motor.

6. The cooling jacket as claimed in claim **1**, wherein the cooling jacket has two sets of the continuous S-shaped pipes, and the starting ends of the two sets of the continuous S-shaped pipes share a working fluid inlet.

7. The cooling jacket as claimed in claim **1**, wherein the cooling jacket has two sets of the continuous S-shaped pipes, and the terminating ends of the two sets of the continuous S-shaped pipes share a working fluid outlet.

8. The cooling jacket as claimed in claim **1**, wherein the flowing directions of the working fluid in any two sets of the continuous S-shaped pipes are opposite to each other.

9. The cooling jacket as claimed in claim **1**, further comprising a first continuous S-shaped pipe having a first forwarding portion, a first reversed portion and a first turning portion; and a second continuous S-shaped pipe having a second forwarding portion, a second reversed portion and a second turning portion, wherein each of the first forwarding, reversed and turning portions is respectively juxtaposed to the second forwarding, reversed and turning portions.

10. The cooling jacket as claimed in claim **1**, wherein each set of the continuous S-shaped pipes covers a different circumference of the electric motor.

* * * * *