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(54) FLEXIBLE HEAT PIPE

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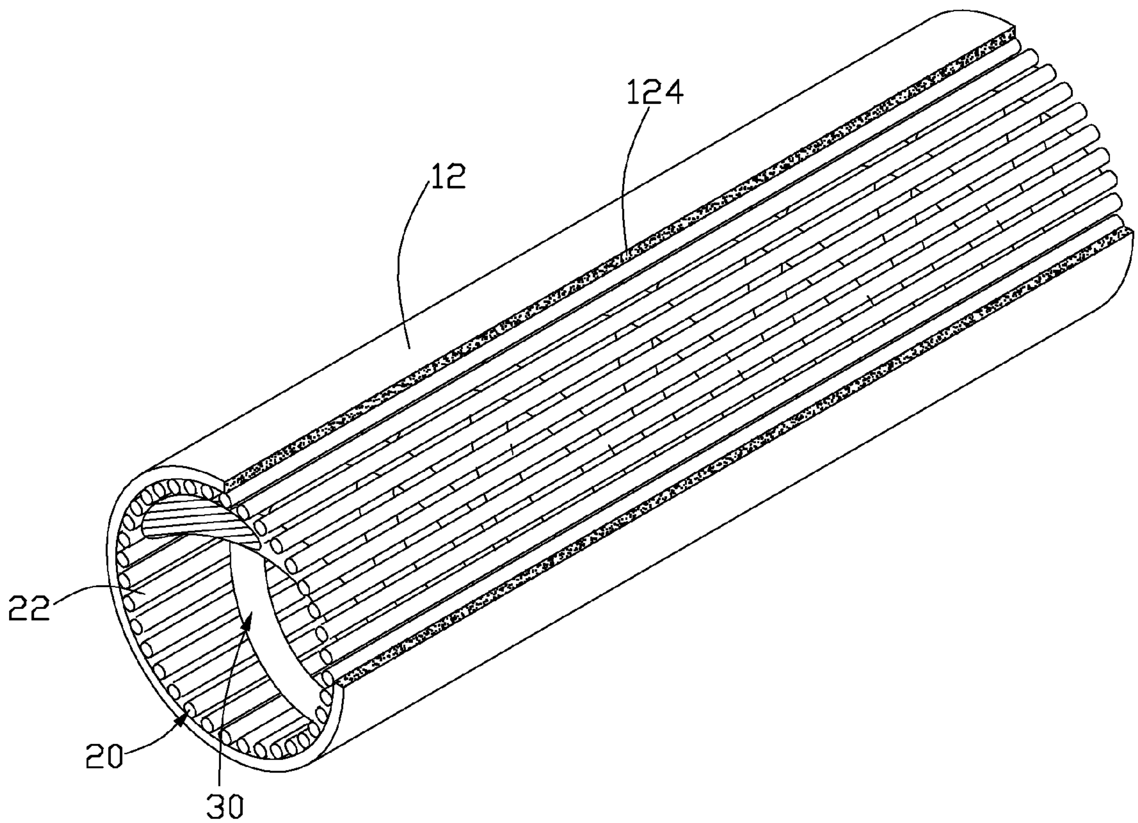
(57) **ABSTRACT**

A flexible heat pipe (**10**) includes a casing (**12**), a wick structure (**20**) arranged in the casing, and a working medium saturated in the wick structure. The casing includes an evaporation section (**122**), a condensation section (**126**), and a flexible adiabatic section (**124**) connecting the evaporation section with the condensation section. The wick structure includes a first portion (**21**), a second portion (**23**) and a third portion respectively disposed in the evaporation, the condensation and the adiabatic sections of the casing. The adiabatic section of the casing further accommodates a supporting member (**30**) therein for supporting the third portion of the wick structure to have an intimate contact with an inner surface of the adiabatic section.



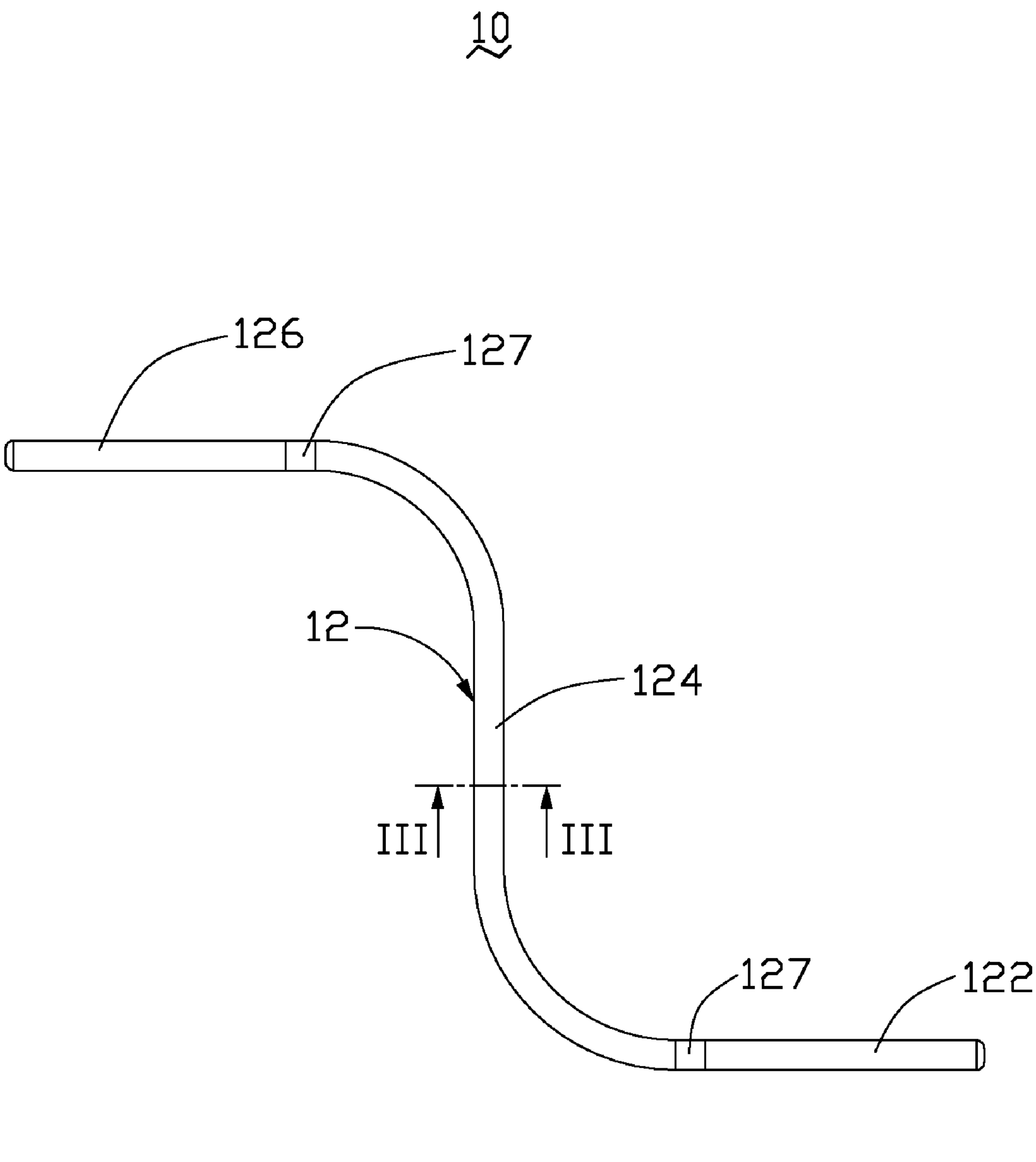


FIG. 1

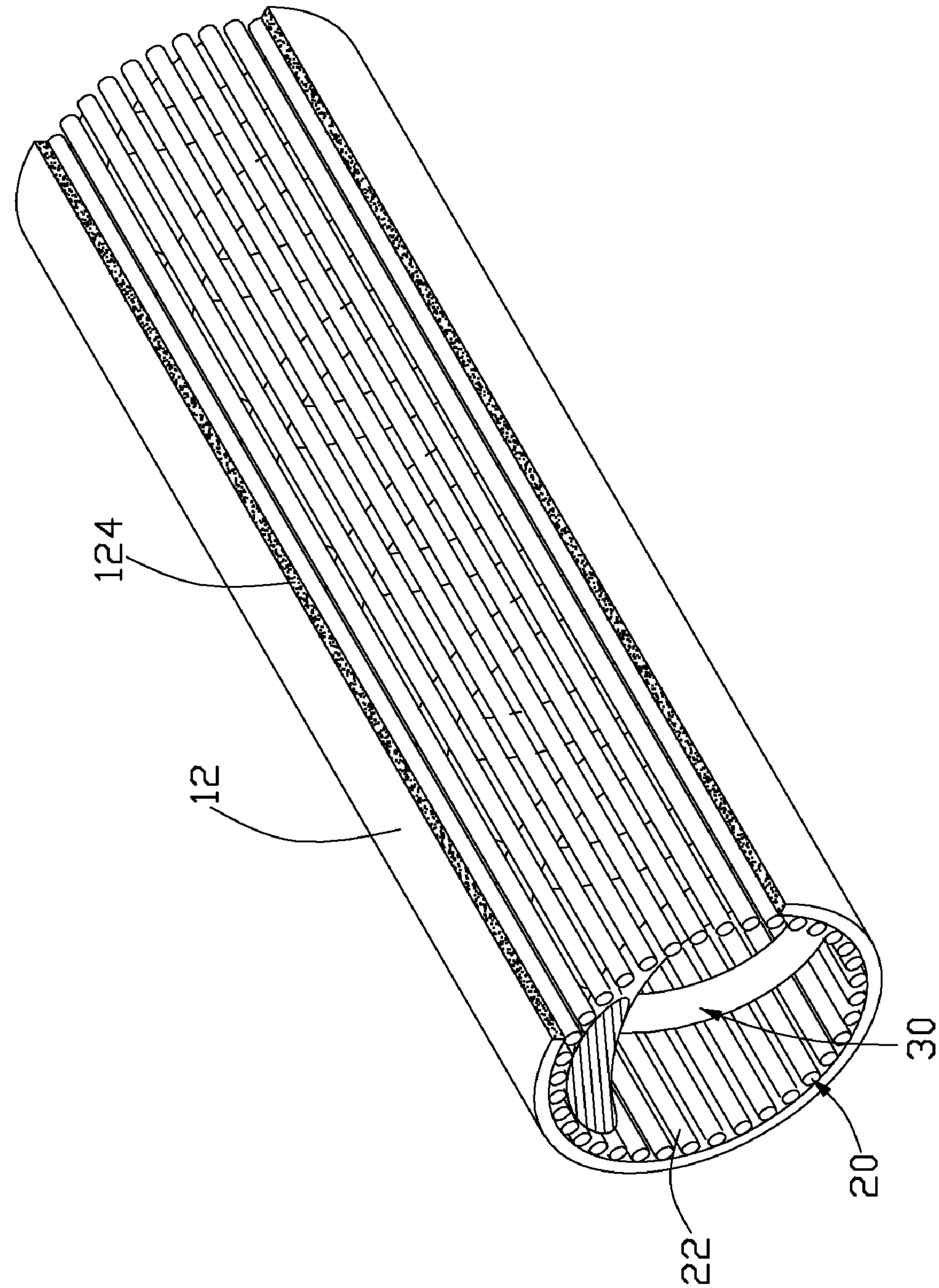


FIG. 2

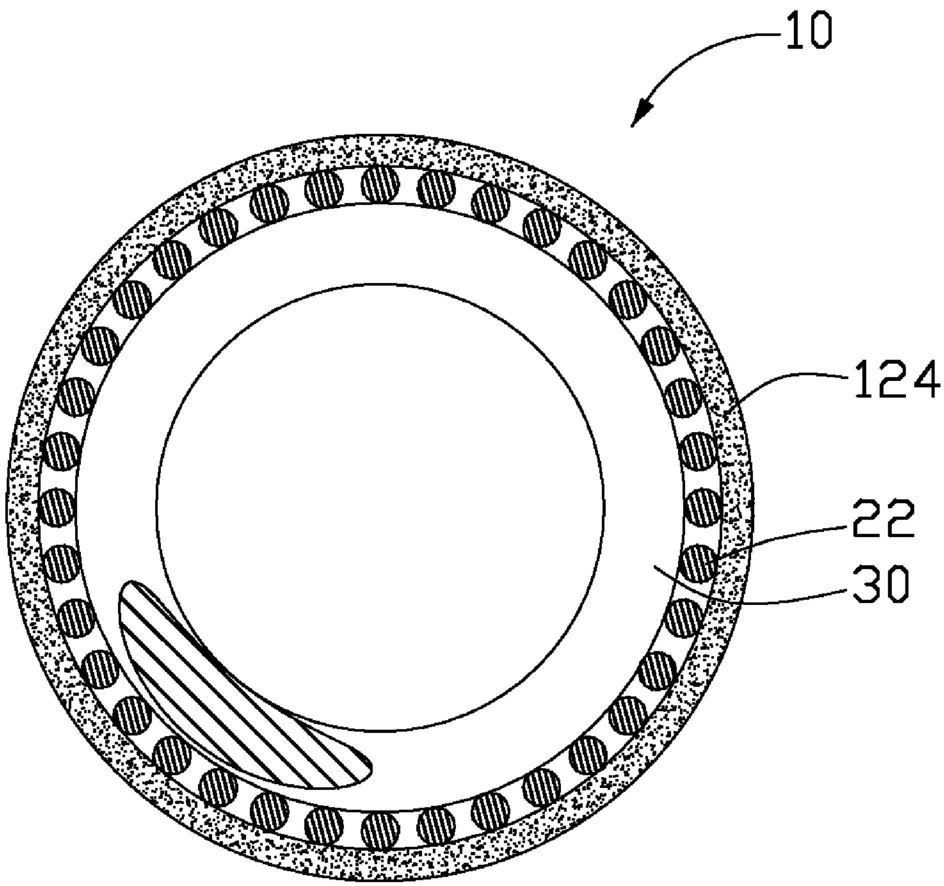


FIG. 3

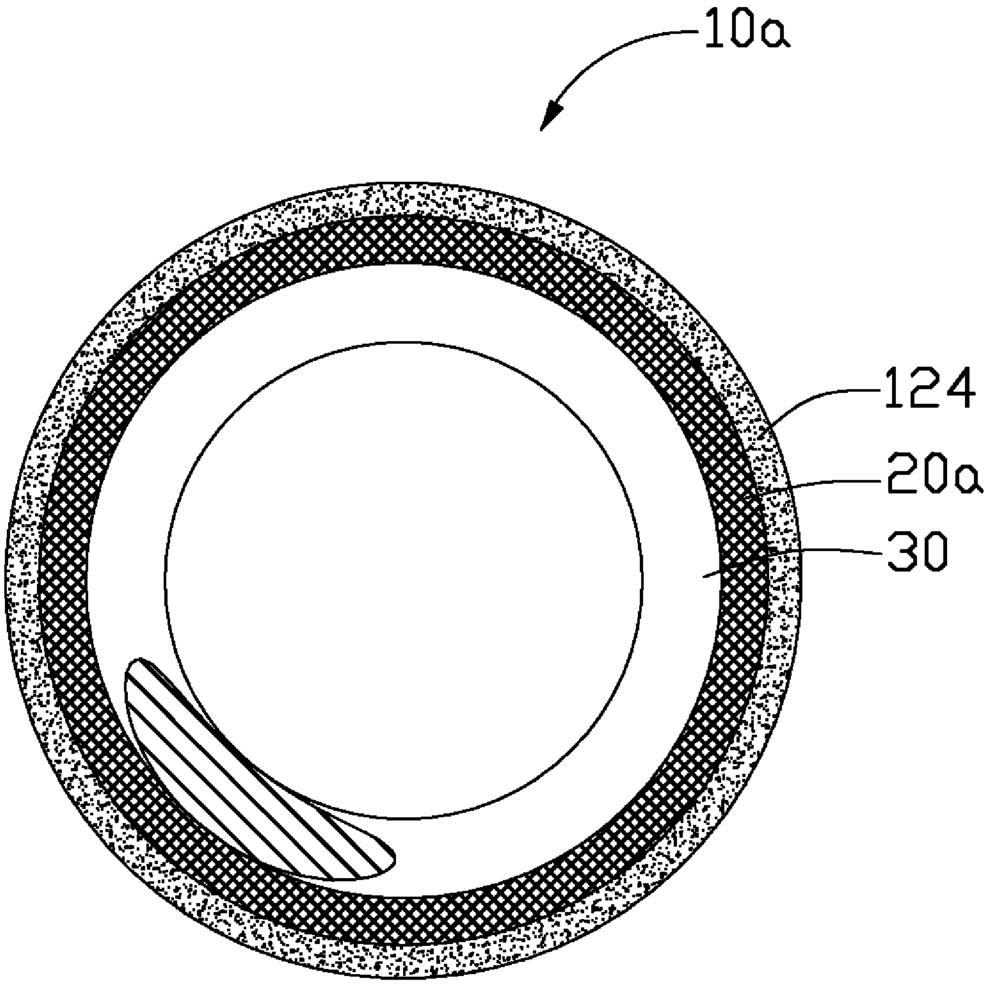


FIG. 4

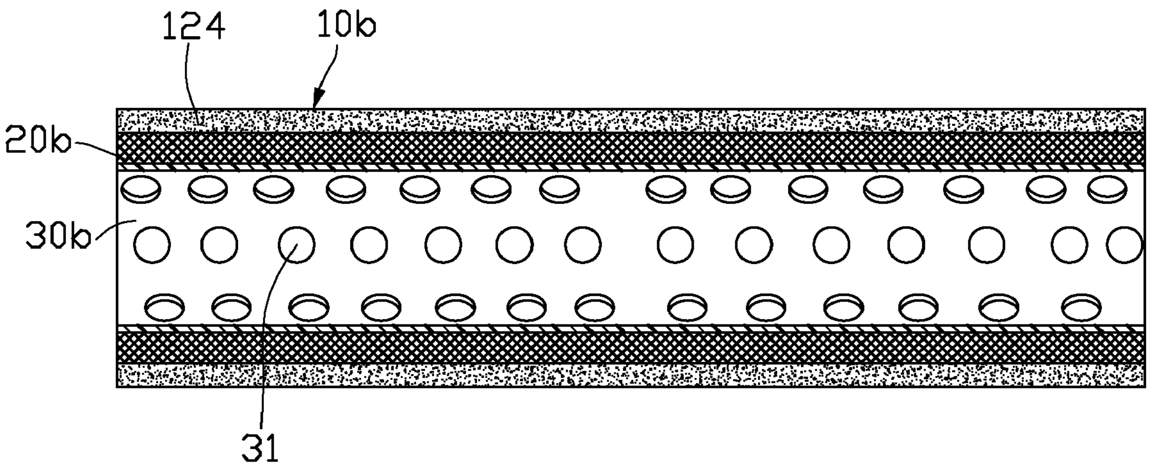


FIG. 5

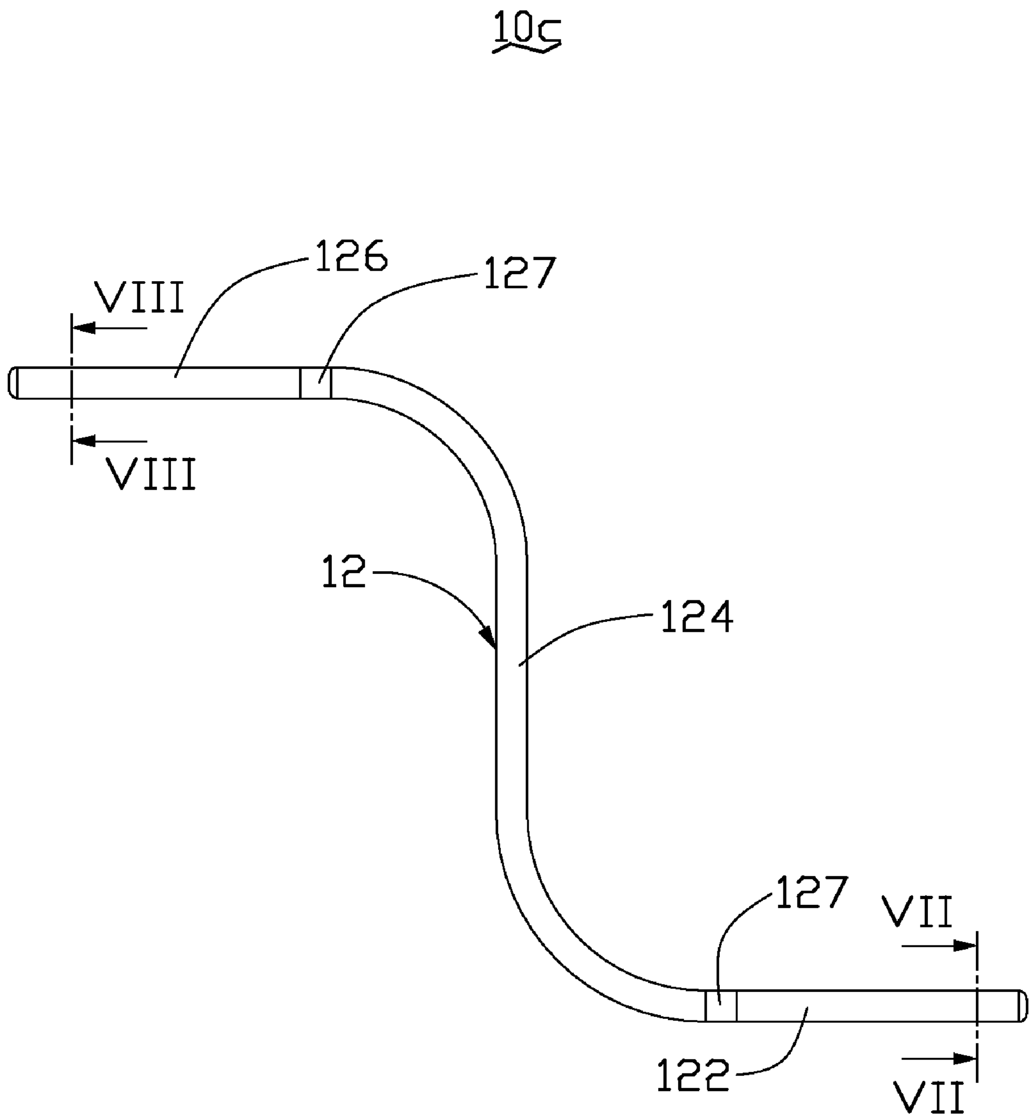


FIG. 6

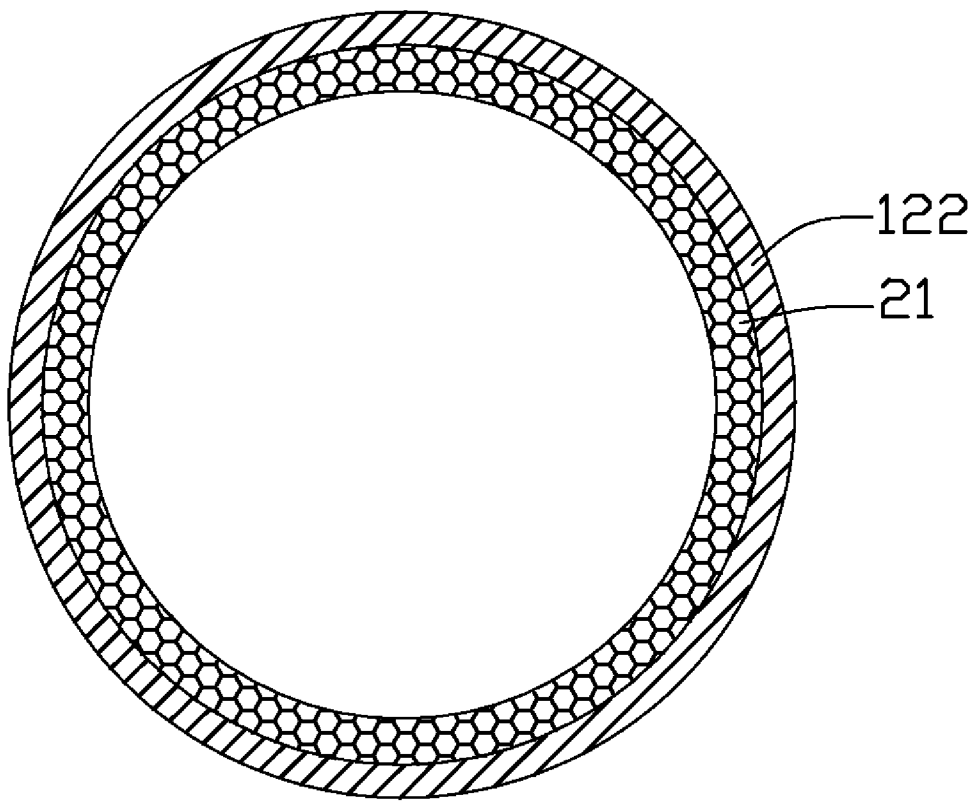


FIG. 7

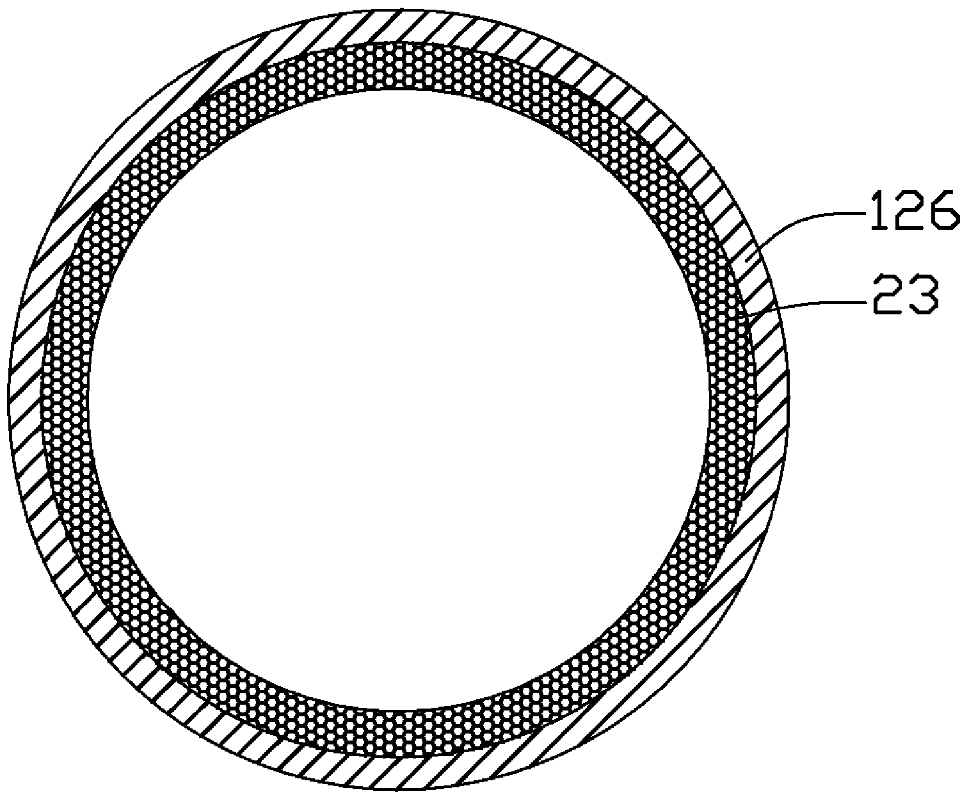


FIG. 8

FLEXIBLE HEAT PIPE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a heat pipe, and more particularly to a flexible heat pipe having a high heat transfer capability when it is bent.

[0003] 2. Description of Related Art

[0004] Flexible heat pipes are traditionally used in microelectronics to help transfer heat from heat producing products. The typical flexible heat pipe includes a casing and a wick structure contacting with an inner surface of the casing. The wick structure contains a working medium. The casing includes an evaporation section connected with a heat generating electronic component such as a CPU, a condensation section connected with a heat dissipating apparatus such as a heat sink, and a flexible adiabatic section connecting the evaporation section with the condensation section for transferring heat. The wick structure is selected from mesh wick, or fibrous wick which provides capillary force to help circulation of the working medium between the evaporation section and the condensation section of the casing.

[0005] In ordinary use, the adiabatic section of the flexible heat pipe needs to be bent to achieve miniaturization of the electronic products. However, the wick structure may separate from the inner surface of the casing since the wick structure has a different flexibility coefficient to that of the casing. This decreases heat exchange between the casing and the wick structure and liquid transportation capability of the wick structure, which further decreases heat transfer through the flexible heat pipe. Therefore, there is a need for a flexible heat pipe which can be bent without overly decreasing its heat transfer capability.

SUMMARY OF THE INVENTION

[0006] The present invention relates to a flexible heat pipe. The flexible heat pipe includes a casing and a wick structure arranged in the casing. The wick structure contains a working medium. The casing includes an evaporation section, a condensation section, and a flexible adiabatic section connecting the evaporation section with the condensation section. The wick structure includes first, second and third portions respectively disposed in the evaporation, the condensation and the adiabatic sections of the casing. The adiabatic section of the casing further accommodates a supporting member therein for supporting the third portion of the wick structure to have an intimate contact with an inner surface of the adiabatic section.

[0007] Other advantages and novel features of the present invention will become more apparent from the following detailed description of preferred embodiments when taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a schematic view of a flexible heat pipe in accordance with a first embodiment of the present invention;

[0009] FIG. **2** is a partly sectional view of an adiabatic section of the flexible heat pipe of FIG. **1**;

[0010] FIG. **3** is a cross-sectional view of the flexible heat pipe of FIG. **1**, taken along line III-III thereof;

[0011] FIG. **4** is similar to FIG. **3**, but shown a flexible heat pipe in accordance with a second embodiment of the present invention;

[0012] FIG. **5** is a longitudinal sectional view of an adiabatic section of a flexible heat pipe in accordance with a third embodiment of the present invention;

[0013] FIG. **6** is a schematic view of a flexible heat pipe in accordance with a fourth embodiment of the present invention;

[0014] FIG. **7** is a cross-sectional view of the flexible heat pipe of FIG. **6**, taken along line VII-VII thereof; and

[0015] FIG. **8** is a cross-sectional view of the flexible heat pipe of FIG. **6**, taken along line VIII-VIII thereof.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Referring to FIGS. **1** and **2**, a flexible heat pipe **10** according to a first embodiment of the present invention is shown. The heat pipe **10** includes a casing **12**, and a wick structure **20** disposed in the casing **12**. The wick structure **20** contains working medium (not shown).

[0017] The casing **12** includes an evaporation section **122** for connecting with a heat generating electronic component (not shown) such as a CPU, a condensation section **126** for connecting with a heat dissipating apparatus (not shown) such as a heat sink, and an adiabatic section **124** connecting the evaporation section **122** with the condensation section **126** for transferring heat therebetween. The adiabatic section **124** connects with the evaporation and the condensation sections **122**, **126** via two connecting members **127**. Both the evaporation and the condensation sections **122**, **126** of the casing **12** are made of high thermally conductive material such as copper, stainless steel or aluminum. The adiabatic section **124** is made of flexible material such as plastics, rubber or soft metal.

[0018] Particularly referring to FIG. **3**, the wick structure **20** is a fibrous wick including a plurality of wires **22**. The wires **22** are evenly distributed around an inner surface and parallel to an axis of the casing **12**. The wires **22** are made of flexible material such as copper, stainless steel, or fiber. The wires **22** are each separated by a small distance from the wires adjacent to them along a circumference of the casing **12** so as to provide a capillary force therebetween. The working medium is a fluid having a lower boiling point and being compatible with the casing **12** and the wick structure **20**, such as water, alcohol, kerosene, or paraffin. The heat pipe **10** further includes a supporting member **30** for holding the wick structure **20** in intimate contact with the inner surface of the casing **12**.

[0019] The supporting member **30** is a coil spring, and is inserted into an inner surface of the wick structure **20**. A diameter of an outer surface of the supporting member **30** is marginally greater than or equal to that of the inner surface of the wick structure **20** so as to push the wick structure **20** towards the inner surface of the casing **12**. The supporting member **30** is made of a flexible material such as copper, stainless steel, or polyamide so that the supporting member **30** provides a radial resilient force which pushes the wick structure **20** into intimate contact with the inner surface of the casing **12**.

[0020] In the present flexible heat pipe **10**, the supporting member **30** is inserted into the inner surface of the wick structure **20** and holds the wick structure **20** in intimate contact with the inner surface of the casing **12**. When the flexible adiabatic section **124** of the heat pipe **10** is bent, the wick structure **20** and the supporting member **30** at this section accordingly bends. Meanwhile, the supporting member **30** generates a resilient force which urges the wick structure **20** towards the inner surface of the casing **12**. Therefore, the wick structure **20** of the heat pipe **10** remains in intimate contact with the inner surface of the casing **12** when it is bent. In this way significant reduction of the heat transfer capability of the flexible heat pipe **10** caused by bending of the adiabatic section **124** of the casing **12** is avoided.

[0021] Referring to FIG. **4**, a flexible heat pipe **10***a* according to a second embodiment of the present invention is shown. The wick structure **20***a* in the second embodiment of the present flexible heat pipe **10***a* is different from the wick structure **20** in the first embodiment of the present flexible heat pipe **10**. In the second embodiment, the wick structure **20***a* of the heat pipe **10***a* is a mesh wick woven from a plurality of metal wires such as copper wires, or stainless steel wires. Alternatively, the mesh wick may also be woven from a plurality of fiber wires. The mesh wick is urged to have an intimate contact with the inner surface of the casing **12** via the supporting member **30**.

[0022] Referring to FIG. **5**, a flexible heat pipe **10***b* according to a third embodiment of the present invention is shown. In the third embodiment, the supporting member **30***b* of the heat pipe **10***b* is a column shaped tube, where a diameter of an outer surface of the tube is a bit greater than or equal to that of the inner surface of the wick structure **20***b*. As a result of the difference in diameter between the outer surface of the tube and the inner surface of the wick structure **20***b*, the wick structure **20***b* is pushed towards the inner surface of the casing **12**. The tube defines a plurality of pores **31** in a periphery wall thereof, so that the working medium can flow through these pores **31**. Preferably, the porosity of the supporting member **30***b* should be about 70%.

[0023] Referring to FIGS. **6** to **8**, a flexible heat pipe **10***c* according to a fourth embodiment of the present invention is shown. In the fourth embodiment, the wick structure of the flexible heat pipe **10***c* is divided into a first portion **21**, a second portion **23** and a third portion (not shown) along a main axis of the casing **12**. The first portion **21**, the second portion **23** and the third portion of the wick structure are respectively disposed in the evaporation, the condensation and the adiabatic sections **122**, **126**, **124** of the casing **12**. Both the first and the second portion **21**, **23** of the wick structure are sintered wicks, whilst the third portion of the wick structure is a mesh wick or a fibrous wick. Alternatively, the first and second portions **21**, **23** of the wick structure may be of types differing from each other, e.g. the first portion **21** of the wick structure may be a grooved wick, whilst the second portion **23** of the wick structure may be a sintered wick. An average capillary pore size of the first portion **21** of the wick structure is greater than that of the second portion **21** of the wick structure, thus allowing the small-sized second portion **23** of the wick structure to develop a large capillary force to rapidly absorb the condensed working medium. In this way the working medium can be caused to rapidly enter into the second portion **23** of the wick structure at the condensation section **126** of the casing **12**. Meanwhile, the large-sized first portion **21** of the wick structure provides a reduced amount of resistance to the working medium flowing through the adiabatic section **124** towards the evaporation section **122** of the casing **12**. As a consequence, the circulation speed of the working medium in the casing **12** is increased, which further improves the heat transfer capability of the flexible heat pipe **10***c*.

[0024] It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A flexible heat pipe comprising:

a casing comprising an evaporation section, a condensation section, and a flexible adiabatic section connecting the evaporation section with the condensation section;

a wick structure arranged in the casing and comprising first, second and third portions respectively disposed in the evaporation, the condensation and the adiabatic sections of the casing, the adiabatic section of the casing further accommodating a supporting member therein configured for supporting the third portion of the wick structure to have an intimate contact with an inner surface of the adiabatic section; and

a working medium contained in the wick structure.

2. The flexible heat pipe as described in claim **1**, wherein the supporting member is a coil spring.

3. The flexible heat pipe as described in claim **1**, wherein the supporting member is a tube lining an inner surface of the third portion of the wick structure, the supporting member defines a plurality of pores therein allowing flowing of the working medium through the supporting member.

4. The flexible heat pipe as described in claim I, wherein a diameter of an outer surface of the supporting member is a bit greater than that of an inner surface of the third portion of the wick structure.

5. The flexible heat pipe as described in claim **1**, wherein the third portion of the wick structure is a mesh wick woven from a plurality of wires.

6. The flexible heat pipe as described in claim **1**, wherein the third portion of the wick structure is a fibrous wick comprising a plurality of wires distributed around the inner surface of the adiabatic section of the casing.

7. The flexible heat pipe as described in claim I, wherein the first, the second and the third portions of the wick structure are integrally formed as a single piece.

8. The flexible heat pipe as described in claim **1**, wherein the first and second portions of the wick structure are formed separately from the third section of the wick structure.

9. The flexible heat pipe as described in claim **8**, wherein the first and second portions of the wick structure are sintered wick.

10. The flexible heat pipe as described in claim **9**, wherein the first and second portions of the wick structure have different pore sizes.

11. The flexible heat pipe as described in claim **10**, wherein an average capillary pore size of the first portion of the wick structure is greater than that of the second portion of the wick structure.

12. The flexible heat pipe as described in claim **1**, wherein the adiabatic section of the heat pipe is made of materials selected from plastics, rubber and soft metal.

13. The flexible heat pipe as described in claim **1**, wherein the working medium is selected from the group consisting of water, alcohol, kerosene, and paraffin.

14. A flexible heat pipe comprising:

a casing comprising rigid evaporation and condensation sections at two end portions of the casing and a flexible adiabatic section interconnecting the evaporation and condensation sections;

a wick structure attached to an inner surface of the casing;

a supporting member received in the flexible adiabatic section of the casing and pushing the wick structure against the inner surface of the casing; and

working fluid received in the casing and saturated in the wick structure.

15. The flexible heat pipe as described in claim **14**, wherein the supporting member comprises a coil spring.

16. The flexible heat pipe as described in claim **14**, wherein the supporting member comprises a tube with a plurality of pores defined in a wall thereof.

17. The flexible heat pipe as described in claim **14**, wherein the wick structure comprises a plurality of axially extended wires.

18. The flexible heat pipe as described in claim **14**, wherein the wick structure comprises a mesh.

19. The flexible heat pipe as described in claim **14**, wherein the wick structure has a first wick portion at the evaporation section, a second wick portion at the condensation section and a third wick portion at the adiabatic section, the first wick portion and the second wick portions being made of one of sintered wick and groove wick.

20. The flexible heat pipe as described in claim **19**, where the first wick portion has a pore size larger than that of the second wick portion.

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