US 20120227934A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2012/0227934 A1

(43) Pub. Date: Sep. 13, 2012

HUANG

(54) **HEAT PIPE HAVING A COMPOSITE WICK STRUCTURE AND METHOD FOR MAKING THE SAME**

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(21) Appl. No.: **13/045,676**

(22) Filed: **Mar. 11, 2011**

Publication Classification

(51) **Int. Cl.**

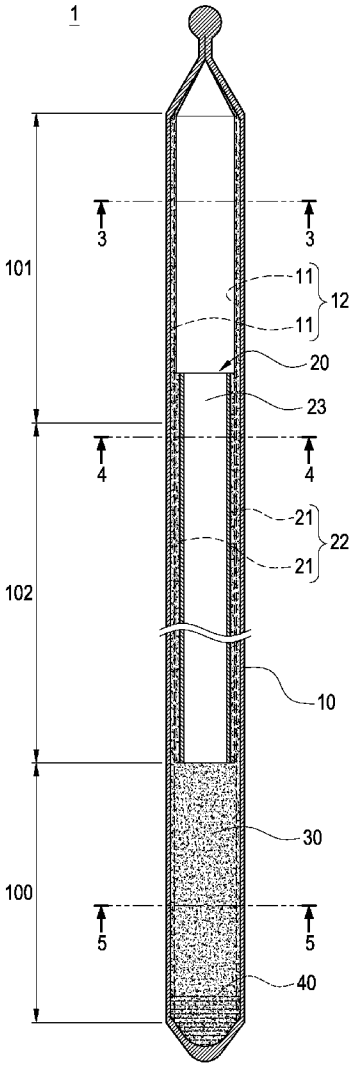
F28D 15/04 (2006.01)

B21D 53/02 (2006.01)

(52) **U.S. Cl.** **165/104.26**; 29/890.032

(57) **ABSTRACT**

A heat pipe having a composite wick structure includes a first pipe, a second pipe, a third wick structure, a working fluid, an evaporating section, a condensing section and a transferring section. The inner wall of the first pipe is provided with a first wick structure. The evaporating section is formed on one side of the first pipe. The condensing section is formed on the other side of the first pipe. The transferring section is formed in the first pipe between the evaporating section and the condensing section. The second pipe is received in the first pipe and located in the transferring section. The outer wall of the second pipe is provided with a second wick structure. The third wick structure is provided between the first wick structure and the second wick structure. The working fluid is filled in the first pipe. By this structure, the condensed working fluid in the first pipe can quickly flow from the condensing section through the transferring section back to the evaporating section. The present invention also provides a method for making such a heat pipe.



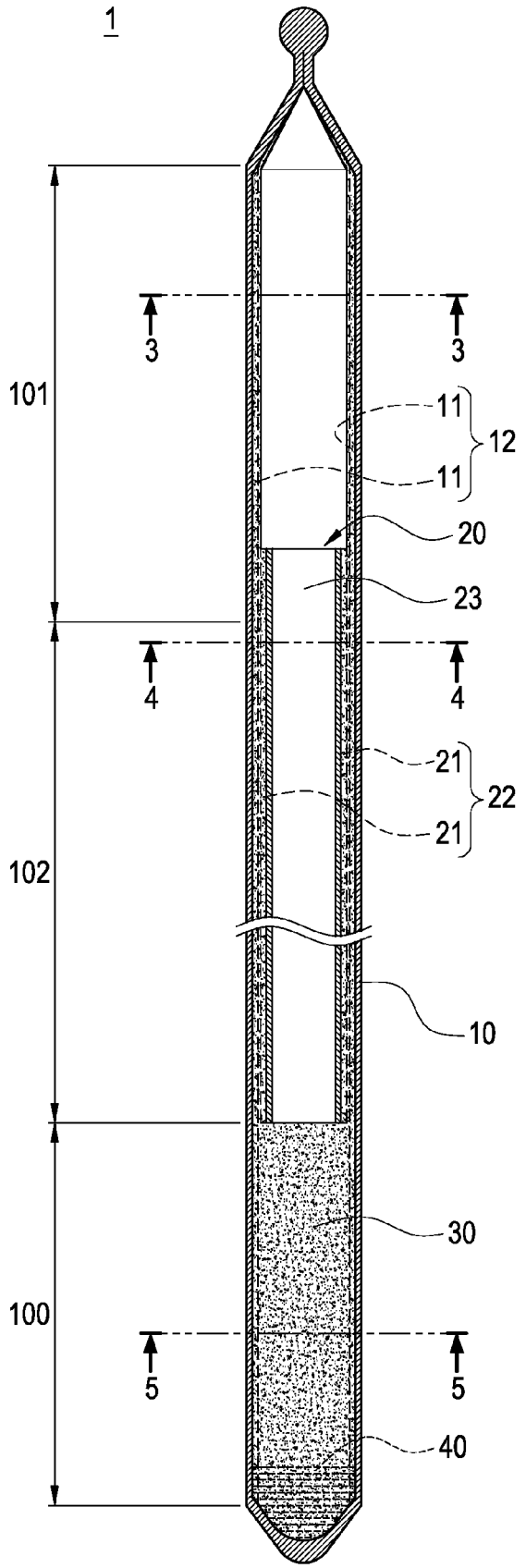


FIG.1

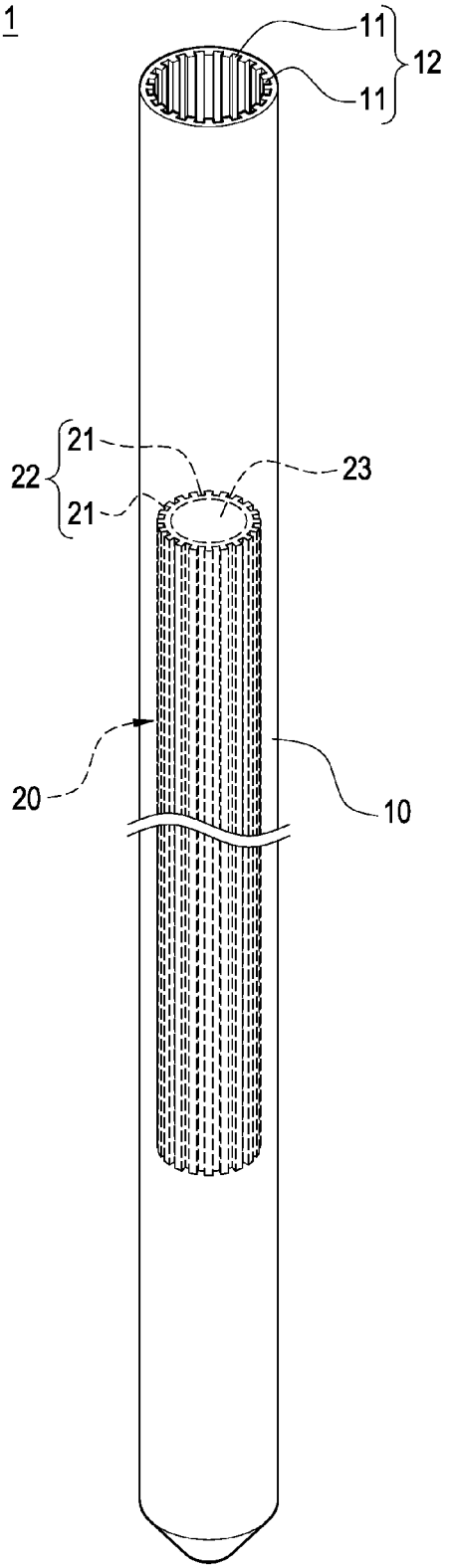


FIG.2

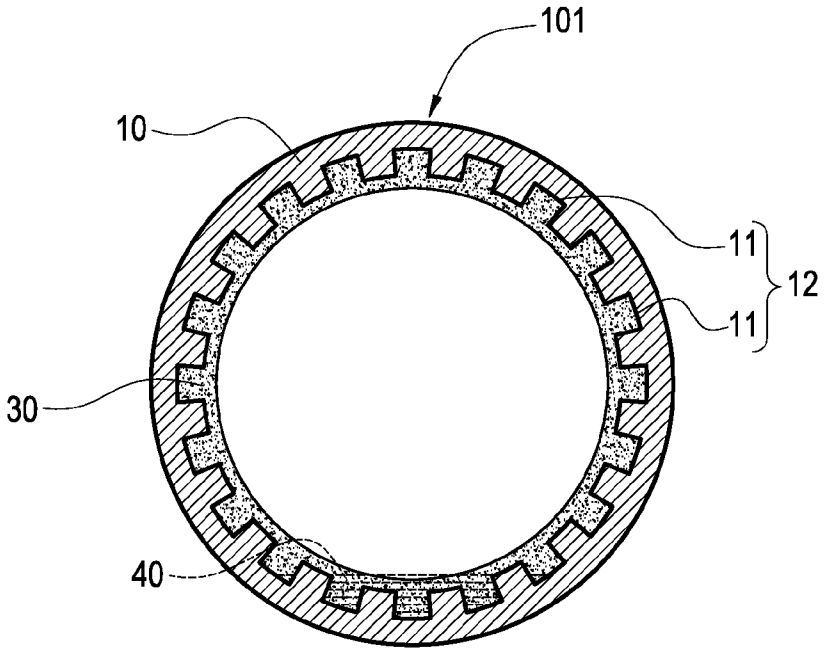


FIG.3

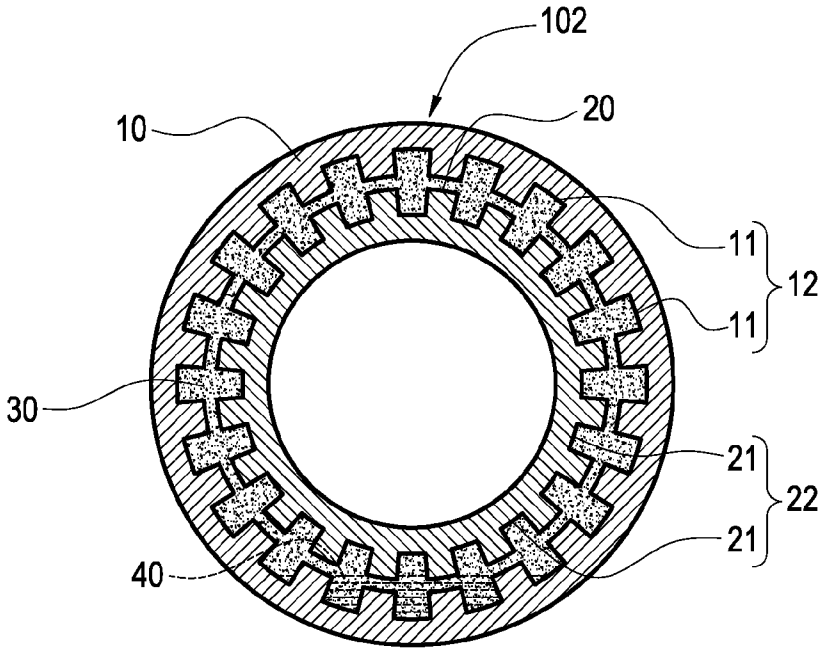


FIG.4

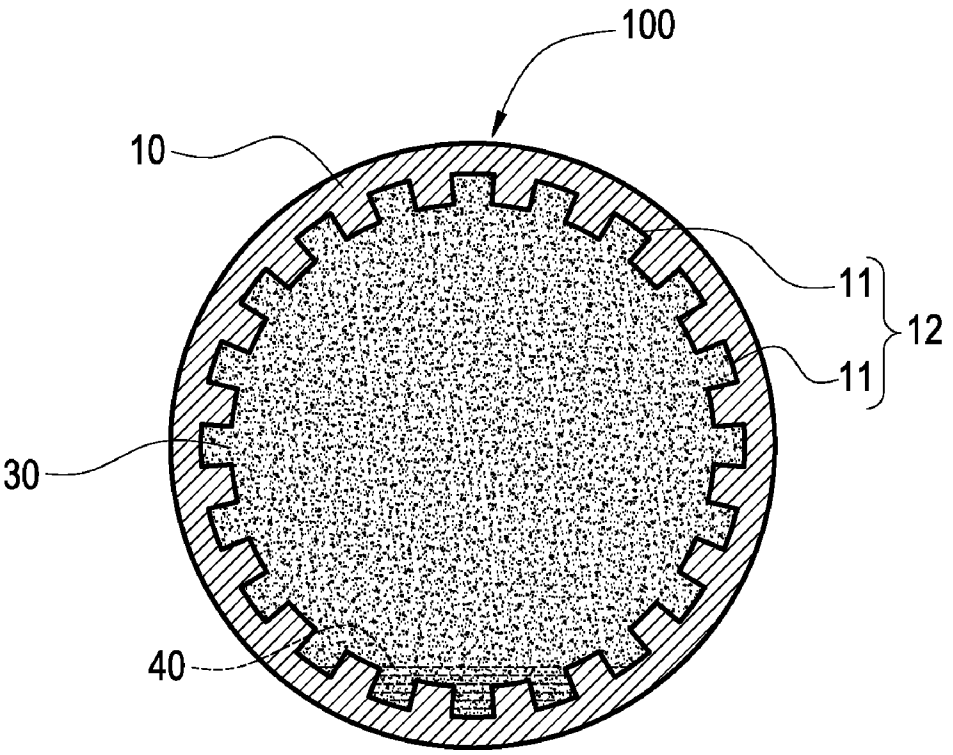


FIG.5

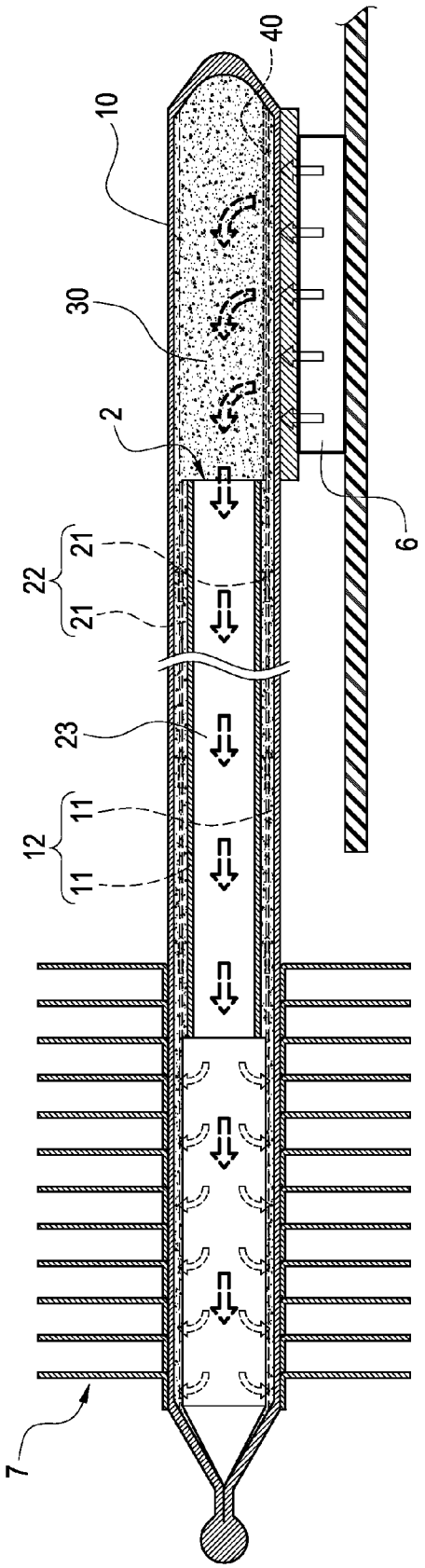


FIG.6

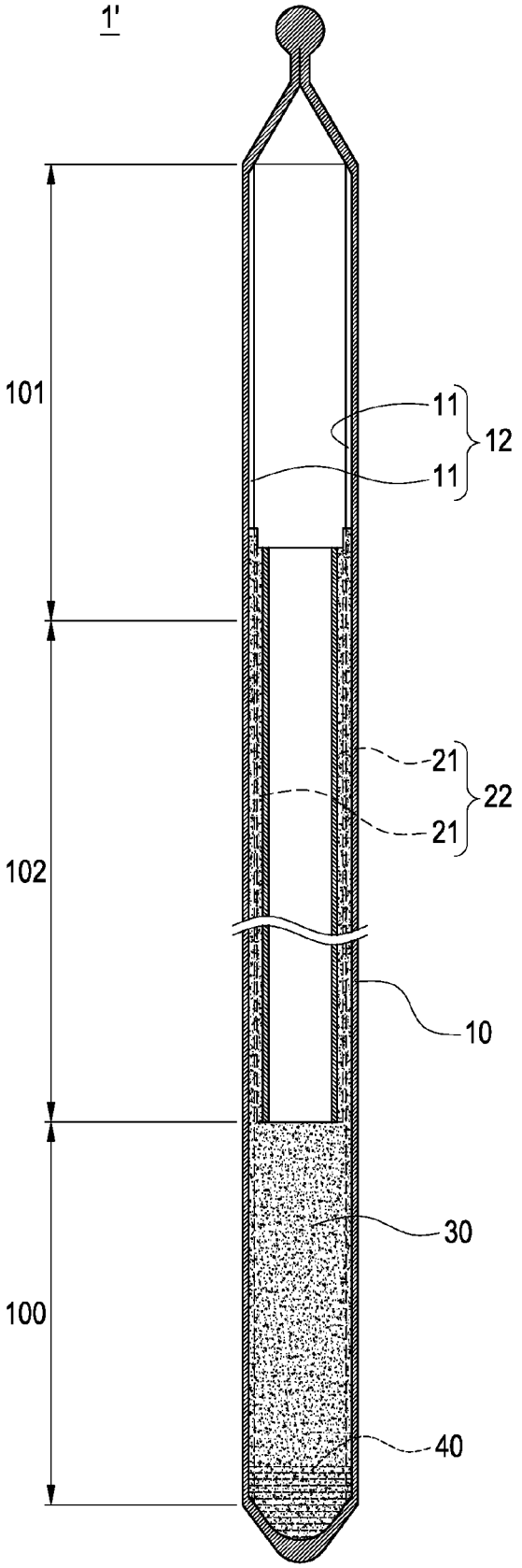


FIG.7

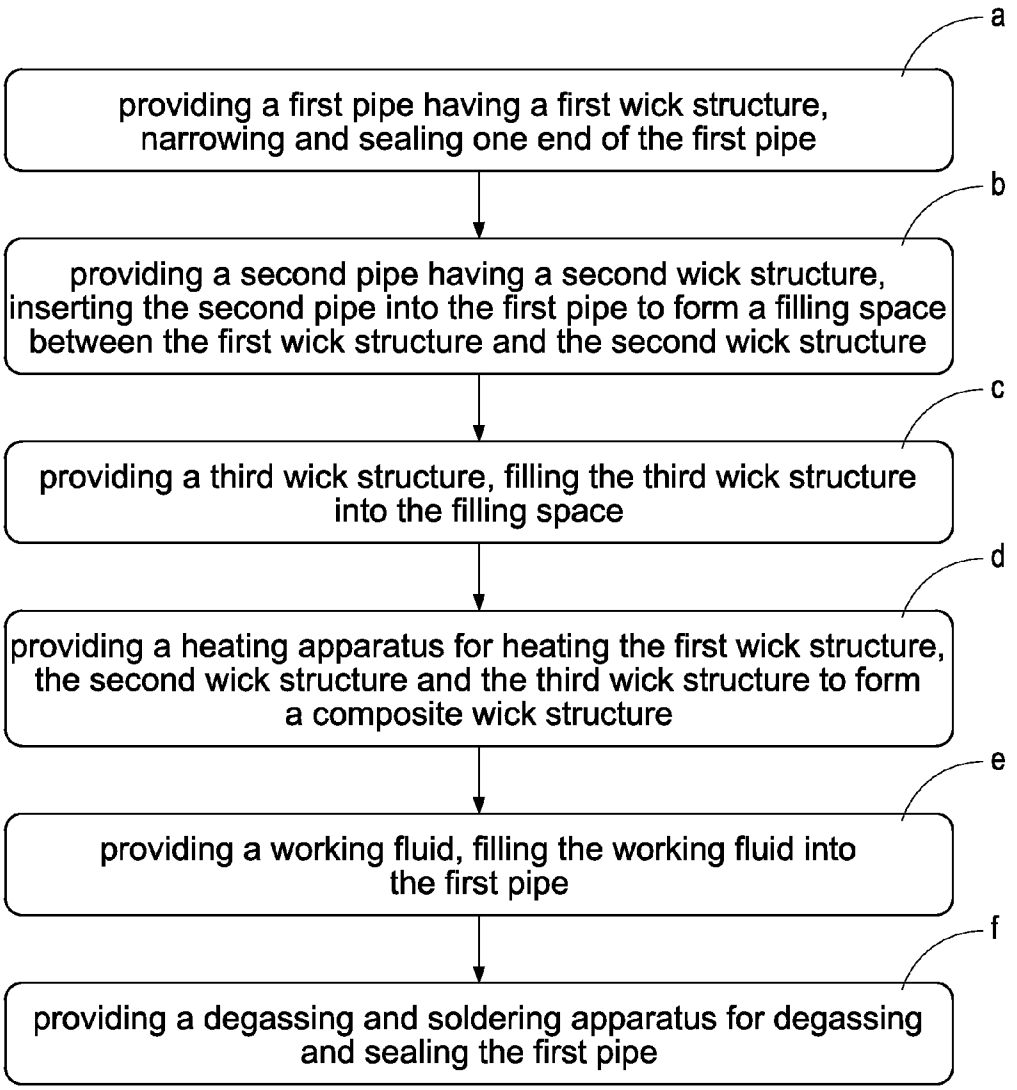

a
providing a first pipe having a first wick structure, narrowing and sealing one end of the first pipe
b
providing a second pipe having a second wick structure, inserting the second pipe into the first pipe to form a filling space between the first wick structure and the second wick structure
c
providing a third wick structure, filling the third wick structure into the filling space
d
providing a heating apparatus for heating the first wick structure, the second wick structure and the third wick structure to form a composite wick structure
e
providing a working fluid, filling the working fluid into the first pipe
f
providing a degassing and soldering apparatus for degassing and sealing the first pipe

FIG.8

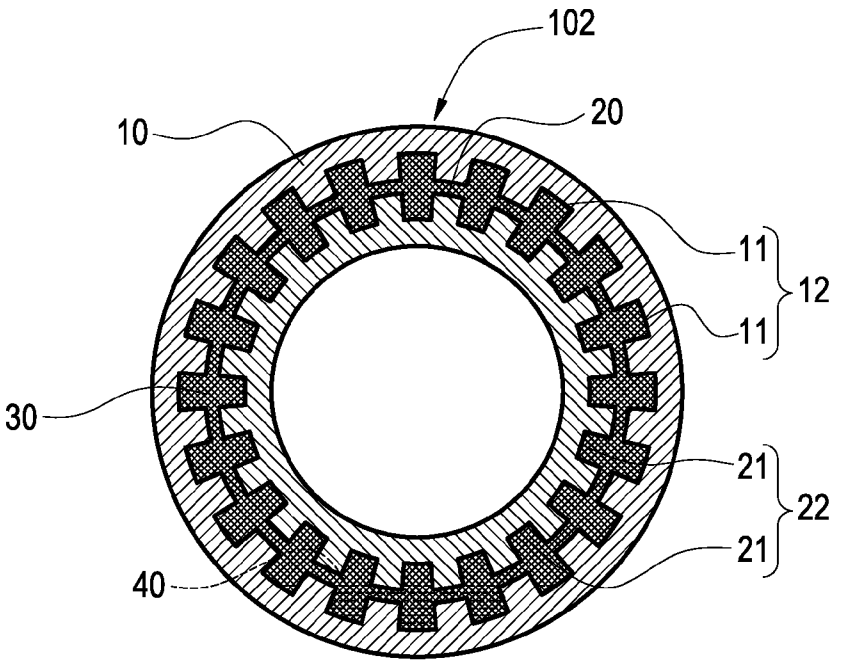


FIG.9

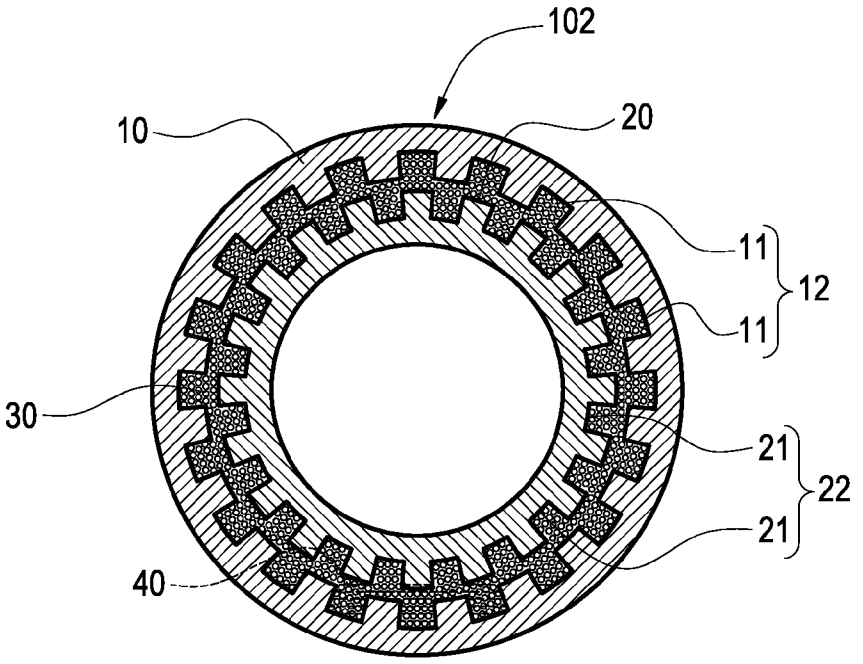


FIG.10

HEAT PIPE HAVING A COMPOSITE WICK STRUCTURE AND METHOD FOR MAKING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a heat pipe, in particular to a heat pipe having a composite wick structure and a method for making the same.

[0003] 2. Description of Prior Art

[0004] A heat-pipe type heat sink constituted of heat pipes and a heat-dissipating fin set can solve the problem relating to heat dissipation of a processor which generates more and more amount of heat recently. Thus, such a heat-pipe type heat sink has already replaced a conventional heat sink constituted of heat-dissipating fins and a fan. However, the existing heat pipes still have problems with regard to its heat-conducting rate and the slow reflow of an internal working fluid. Therefore, it is an important issue for the present Inventor to solve the above-mentioned problems.

[0005] The conventional heat pipe includes a metallic pipe, a wick structure and a working fluid.

[0006] The metallic pipe has a sealed chamber. The wick structure is provided on inner walls of the metallic pipe. The working fluid is filled in the sealed chamber of the metallic pipe. An air channel is formed inside the wick structure. The wick structure serves as a liquid reflow channel. By this arrangement, the conventional heat pipe is obtained.

[0007] The conventional heat pipe transfers the heat by means of the liquid-vapor phase transition of the working fluid, however, the wick structure in the conventional heat pipe is formed as only one layer. Thus, the reflow rate of the working fluid is restricted by the one-layer wick structure. Further, since the vapor-flowing direction is opposite to the liquid-reflowing direction, and the air channel is arranged adjacent to the liquid channel, the vapor-flowing rate and the liquid-reflowing rate may be negatively affected due to the interference occurred in an adjoining area between the air channel and the liquid channel. As a result, the heat-conducting performance of the conventional heat pipe cannot be enhanced further.

SUMMARY OF THE INVENTION

[0008] The present invention is to provide a heat pipe having a composite wick structure and a method for making the same. With a multi-layer composite wick structure in a transferring section of the heat pipe, the working fluid condensed in the condensing section of the heat pipe can quickly flow through the transferring section back to the evaporating section.

[0009] The present invention provides a heat pipe having a composite wick structure, including a first pipe, a second pipe, a third wick structure, a working fluid, an evaporating section, a condensing section and a transferring section. A first wick structure is provided on inner walls of the first pipe. The evaporating section is formed on one side of the first pipe. The condensing section is formed on the other side of the first pipe away from the evaporating section. The transferring section is provided in the first pipe between the evaporating section and the condensing section. The second pipe is received in the first pipe and located in the transferring section. A second wick structure is formed on outer walls of the second pipe. The third wick structure is provided between the first wick structure and the second wick structure. The working fluid is filled in the first pipe.

[0010] The present invention provides a method for making a heat pipe having a composite wick structure, including steps of:

[0011] a) providing a first pipe having a first wick structure, narrowing and sealing one end of the first pipe;

[0012] b) providing a second pipe having a second wick structure, inserting the second pipe into the first pipe to form a filling space between the first wick structure and the second wick structure;

[0013] c) providing a third wick structure, filling the third wick structure into the filling space;

[0014] d) providing a heating apparatus for heating the first wick structure, the second wick structure and the third wick structure to form a composite wick structure;

[0015] e) providing a working fluid, filling the working fluid into the first pipe; and

[0016] f) providing a degassing and soldering apparatus for degassing and sealing the first pipe.

[0017] The present invention has the following advantageous effects. The first pipe and the second pipe are arranged to separate an air channel from a liquid channel in the transferring section. The liquid-phase working fluid and the vapor-phase working fluid can be transferred quickly without any interference, thereby increasing the heat-conducting performance of the heat pipe.

BRIEF DESCRIPTION OF DRAWING

[0018] FIG. **1** is an assembled cross-sectional view of a heat pipe of the present invention;

[0019] FIG. **2** is an assembled view showing that a second pipe is inserted into a first pipe according to the present invention;

[0020] FIG. **3** is a cross-sectional view of a condensing section taken along the line **3-3** in FIG. **1**;

[0021] FIG. **4** is a cross-sectional view of a transferring section taken along the line **4-4** in FIG. **1**;

[0022] FIG. **5** is a cross-sectional view of an evaporating section taken along the line **5-5** in FIG. **1**;

[0023] FIG. **6** is an assembled view showing that the heat pipe of the present invention is applied to an electronic heat-generating element;

[0024] FIG. **7** is an assembled cross-sectional view showing the heat pipe of another embodiment of the present invention;

[0025] FIG. **8** is a flow chart showing the method for making the heat pipe of the present invention;

[0026] FIG. **9** is an assembled cross-sectional view showing the heat pipe of a further embodiment of the present invention; and

[0027] FIG. **10** is an assembled cross-sectional view showing the heat pipe of a still further embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] The detailed description and technical contents of the present invention will become apparent with the following detailed description accompanied with related drawings. It is noteworthy to point out that the drawings is provided for the illustration purpose only, but not intended for limiting the scope of the present invention.

[0029] Please refer to FIGS. **1** to **5**. The present invention provides a heat pipe having a composite wick structure. The heat pipe **1** includes a first pipe **10**, a second pipe **20**, a third wick structure **30** and a working fluid **40**.

[0030] Please refer to FIG. **2** first. The first pipe **10** is made of metal having good thermal conductivity, such as copper. The inner walls of the first pipe **10** are provided with a plurality of grooves **11** arranged at intervals in parallel to an axial line of the first pipe **10**. Each of the grooves **11** is configured to extend through the front and rear ends of the first pipe **10**. These grooves **11** form the first wick structure **12** of the present embodiment, but it is not limited thereto.

[0031] The second pipe **20** is also made of metal having good thermal conductivity, such as copper. Outer walls of the second pipe **20** are provided with a plurality of grooves **21** arranged at intervals in parallel to an axial line of the second pipe **20**. Each of the grooves **21** is configured to extend through the front and rear ends of the second pipe **20**. These grooves **21** form the second wick structure **22** of the present embodiment, but it is not limited thereto. On the other hand, the inner wall surface of the second pipe is a smooth surface **23**. The length and diameter of the second pipe **20** are both smaller than those of the first pipe **10**, so that the second pipe **20** can be received in a middle portion of the first pipe **10**. The grooves **21** of the second pipe **20** may be aligned with the grooves **11** of the first pipe **10** respectively as shown in FIG. **4**. Alternatively, the grooves **21** of the second pipe **20** may be staggered with respect to the grooves **11** of the first pipe **10** respectively as shown in FIG. **10**. The second wick structure **22** may be made of sintered metal powder or metallic woven meshes (not shown).

[0032] The third wick structure **30** of the present embodiment is made of sintered metal powder, but it is not limited thereto. The third wick structure **30** is filled in the first pipe **10**, and a portion of the third wick structure **30** is located between the first wick structure **12** and the second wick structure **22**. By this arrangement, the second pipe **20** can be firmly supported and position in the first pipe **10**.

[0033] The working fluid **40** may be pure water, which is filled in the first pipe **10**. After the interior of the first pipe **10** is degassed to become vacuum, the first pipe **10** is sealed to obtain a desired heat pipe **1**.

[0034] According to the thermal contact location in practice use, the heat pipe **1** can be divided into an evaporating section **100**, a condensing section **101** and a transferring section **102** as shown in FIG. **1**. The evaporating section **100** is brought into thermal contact with a heat source **6** as shown in FIG. **6**. The condensing section **101** is brought into thermal contact with a heat-dissipating fin set **7** as shown in FIG. **6** and is located away from the evaporating section **100**. The transferring section **102** is located between the evaporating section **100** and the condensing section **101**. In the present embodiment, the second pipe **20** is located in the transferring section **102** of the heat pipe **1**. In the transferring section **102**, the first wick structure **12**, the second wick structure **22** and the third wick structure **30** constitute a three-layer composite wick structure.

[0035] Please refer to FIG. **6**. The heat pipe **1** of the present invention can be combined with the heat-dissipating fin set **7** for dissipating the heat generated by an electronic heat-generating source **6** (such as a processing chip) on a mother board. The evaporating section **100** of the heat pipe **1** is adhered to a heat-generating surface of the electronic heat-generating source **6**, so that the heat generated by the electronic heat-generating source **6** can be absorbed by the evaporating section **100**. As a result, the liquid-phase working fluid **40** in the evaporating section **100** is heated to become a vapor-phase working fluid **40**. The vapor-phase working fluid **40** flows through the second pipe **20** in the transferring section **102**. The smooth surface **23** inside the second pipe **20** has a smaller flow resistance, so that the vapor-phase working liquid **40** can pass through the second pipe **20** quickly and then arrive the condensing section **101** in the first pipe **10**. With the heat-dissipating fin set **7** connected to the condensing section **101**, the latent heat of the vapor-phase working fluid **40** can be released and dissipated to the outside, whereby the vapor-phase working fluid **40** is condensed into a liquid-phase working fluid **40**. The working fluid **40** condensed in the condensing section **101** flows back to the transferring section **102** by means of a capillary force generated by the first wick structure **12** and the third wick structure **30**. Then, the condensed working fluid **40** flows from the transferring section **102** back to the evaporating section **100** by means of a larger capillary force generated by the composite wick structure constituted of the first wick structure **12**, the second wick structure **22** and the third wick structure **30**. In this way, the working fluid **40** can be continuously circulated in the heat pipe **1**.

[0036] Please refer to FIG. **7**. In addition to the above embodiment, the present invention can be carried out in another aspect, in which only the first wick structure **12** is formed in the condensing section **101** of the heat pipe V. Due to its small thermal resistance, the first wick structure **12** can accelerate the flowing rate of the working fluid **40** in the heat pipe V.

[0037] Please refer to FIGS. **1** and **8**. The present invention provides a method for making a heat pipe having a composite wick structure, which includes steps of:

[0038] a) providing a first pipe **10** having a first wick structure **12**, narrowing and sealing one end of the first pipe **10**;

[0039] b) providing a second pipe **20** having a second wick structure **22**, inserting the second pipe **20** into the first pipe **10** to form a filling space between the first wick structure **12** and the second wick structure **22**;

[0040] c) providing a third wick structure **30**, filling the third wick structure **30** into the filling space;

[0041] d) providing a heating apparatus for heating the first wick structure **12**, the second wick structure **22** and the third wick structure **30** to form a composite wick structure;

[0042] e) providing a working fluid **40**, filling the working fluid **40** into the first pipe **10**; and

[0043] f) providing a degassing and soldering apparatus for degassing and sealing the first pipe **10**.

[0044] More specifically, in the present embodiment, if the third wick structure **30** is made of sintered metal powder, a core rod (not shown) has to be inserted into the second pipe **20** first. Then, as shown in FIG. **2**, the second pipe **20** together with the core rod are inserted into the first pipe **10**, thereby forming a filling space between the first wick structure **12** and the second wick structure **22**. Thereafter, metal powder is filled in the filling space. Then, a heating apparatus (not shown) is used to sinter the metal powder to form a composite wick structure constituted of the first wick structure **12**, the second wick structure **22** and the third wick structure **30** made of sintered metal powder.

[0045] As shown in FIG. **5**, in the evaporating section **100**, a solid body is formed by the first wick structure **12** constituted of the grooves **11** and the third wick structure **30** made by sintered metal powder. As shown in FIG. **3**, in the con-

densing section **101**, a hollow body is formed by the first wick structure **12** constituted of the grooves **11** and the third wick structure **30** made of sintered metal powder.

[0046] Please refer to FIGS. **9** and **10**. In addition to the above embodiment, the third wick structure **30** of the present invention may be made by metallic woven meshes shown in FIG. **9** or a bundle of fibers shown in FIG. **10**.

[0047] Although the present invention has been described with reference to the foregoing preferred embodiments, it will be understood that the invention is not limited to the details thereof. Various equivalent variations and modifications can still occur to those skilled in this art in view of the teachings of the present invention. Thus, all such variations and equivalent modifications are also embraced within the scope of the invention as defined in the appended claims.

What is claimed is:

1. A heat pipe having a composite wick structure, including:

a first pipe provided with a first wick structure on its inner wall;

an evaporating section formed on one side of the first pipe;

a condensing section formed on the other side of the first pipe away from the evaporating section;

a transferring section formed in the first pipe between the evaporating section and the condensing section;

a second pipe received in the first pipe and located in the transferring section, an outer wall of the second pipe being provided with a second wick structure;

a third wick structure provided between the first wick structure and the second wick structure; and

a working fluid filled in the first pipe.

2. The heat pipe having a composite wick structure according to claim **1**, wherein the first wick structure is constituted of a plurality of grooves formed on the inner wall of the first pipe.

3. The heat pipe having a composite wick structure according to claim **2**, wherein the second wick structure is constituted of a plurality of grooves formed on the outer wall of the second pipe.

4. The heat pipe having a composite wick structure according to claim **3**, wherein the grooves of the first pipe are aligned with the grooves of the second pipe respectively.

5. The heat pipe having a composite wick structure according to claim **3**, wherein the grooves of the first pipe are staggered with respect to the grooves of the second pipe respectively.

6. The heat pipe having a composite wick structure according to claim **1**, wherein the second wick structure is made of sintered metal powder.

7. The heat pipe having a composite wick structure according to claim **1**, wherein the second wick structure is made of metallic woven meshes.

8. The heat pipe having a composite wick structure according to claim **1**, wherein the third wick structure is made of sintered metal powder.

9. The heat pipe having a composite wick structure according to claim **1**, wherein the third wick structure is made of metallic woven meshes.

10. The heat pipe having a composite wick structure according to claim **1**, wherein the third wick structure is made of a bundle of fibers.

11. The heat pipe having a composite wick structure according to claim **1**, wherein an inner wall surface of the second pipe is a smooth surface.

12. The heat pipe having a composite wick structure according to claim **1**, wherein a solid body is formed in the evaporating section, the solid body is constituted of the first wick structure and the third wick structure.

13. The heat pipe having a composite wick structure according to claim **1**, wherein a hollow body is formed in the condensing section, the hollow body is constituted of the first wick structure and the third wick structure.

14. The heat pipe having a composite wick structure according to claim **1**, wherein the interior of the condensing section has the first wick structure.

15. A method for making a heat pipe having a composite wick structure, including steps of:

a) providing a first pipe having a first wick structure, narrowing and sealing one end of the first pipe;

b) providing a second pipe having a second wick structure, inserting the second pipe into the first pipe to form a filling space between the first wick structure and the second wick structure;

c) providing a third wick structure, filling the third wick structure into the filling space;

d) providing a heating apparatus for heating the first wick structure, the second wick structure and the third wick structure to form a composite wick structure;

e) providing a working fluid, filling the working fluid into the first pipe; and

f) providing a degassing and soldering apparatus for degassing and sealing the first pipe.

16. The method according to claim **15**, wherein the first wick structure is formed of a plurality of grooves on an inner wall of the first pipe.

17. The method according to claim **16**, wherein the second wick structure is constituted of a plurality of grooves on an outer wall of the second pipe.

18. The method according to claim **17**, wherein the grooves of the first pipe are aligned with the grooves of the second pipe respectively.

19. The method according to claim **17**, wherein the grooves of the first pipe are staggered with respect to the grooves of the second pipe respectively.

* * * * *