(12) UK Patent Application (19) GB (11) 2 427 681 (13) A

(43) Date of A Publication 03.01.2007

(21) Application No: 0513113.1

(22) Date of Filing: 28.06.2005

(51) INT CL:
***F28D 15/02*** (2006.01) ***B21D 53/02*** (2006.01)
***B23P 15/26*** (2006.01)

(52) UK CL (Edition X ):
**F4U** U25A

(56) Documents Cited:
**JP 620245086 A** **JP 610070389 A**
**JP 030122496 A** **JP 2005016892 A**

(58) Field of Search:
UK CL (Edition X ) **F4S, F4U**
INT CL **B21D, B23P, F28D**
Other: **Online: WPI, EPODOC**

(71) Applicant(s):
**Asia Vital Component Co.,Ltd**
**(Incorporated in Taiwan)**
**No.248-27 Sinsheng Road,**
**Cianjhan District, Kaohsiung City 806,**
**Taiwan**

(72) Inventor(s):
**Pei-Pei Ding**
**Hsiu-Wei Yang**
**Jao-Ching Lin**
**Wen-Hwa Yu**
**Yen-Wen Chen**

(74) Agent and/or Address for Service:
**Alpha & Omega**
**Chine Croft, East Hill, OTTERY ST. MARY,**
**Devon, EX11 1PJ, United Kingdom**

(54) Abstract Title**: Heat pipe manufacturing method**

(57) A method of manufacturing a heat pipe 3 comprises forming a hollow package 3 having a cavity 33, mounting a sucking 61 onto an opening 312 formed on a flat surface 311 of the package 3 that communicates with the cavity 33, the sucking disk 61 being adapted to deaerate a gas from the cavity (fig 10) and also fill the cavity 33 with a working fluid 5 via the opening 312, and compressing the package 3 perpendicular to the flat surface 311 to deform a part of the package 3 to seal the opening 312. Sealing the opening 312 may comprise of moving a first 71 and/or second 72 loading element (figs 12, 21 & 22), and soldering or spot welding the opening 312. Two sucking disks 61 can be mounted onto separate openings (314 & 316, fig 20). Sucking disk(s) 61 may comprise of a deformation part 611 having a through hole 612, which receives a pipe 62 for deaerating and/or filling the cavity 33. Prior to filling the cavity 33, the working fluid 5 may be vaporized (fig 13).Opening 312 may be located in a projecting part (34, fig 15) of the heat pipe 3 and sealing may take place by clamping and clipping (fig 16) the projecting part (34) and soldering the clipped end. Alternatively, the projecting part may be melted using an excimer laser.

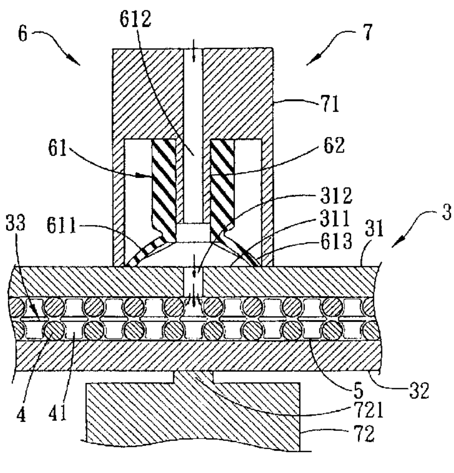


FIG 11

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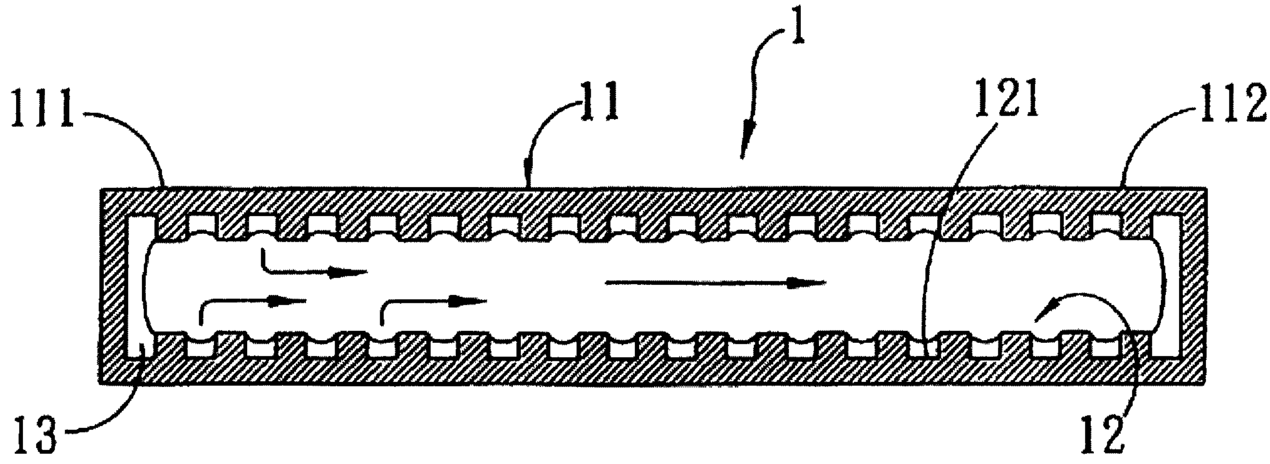



FIG 1

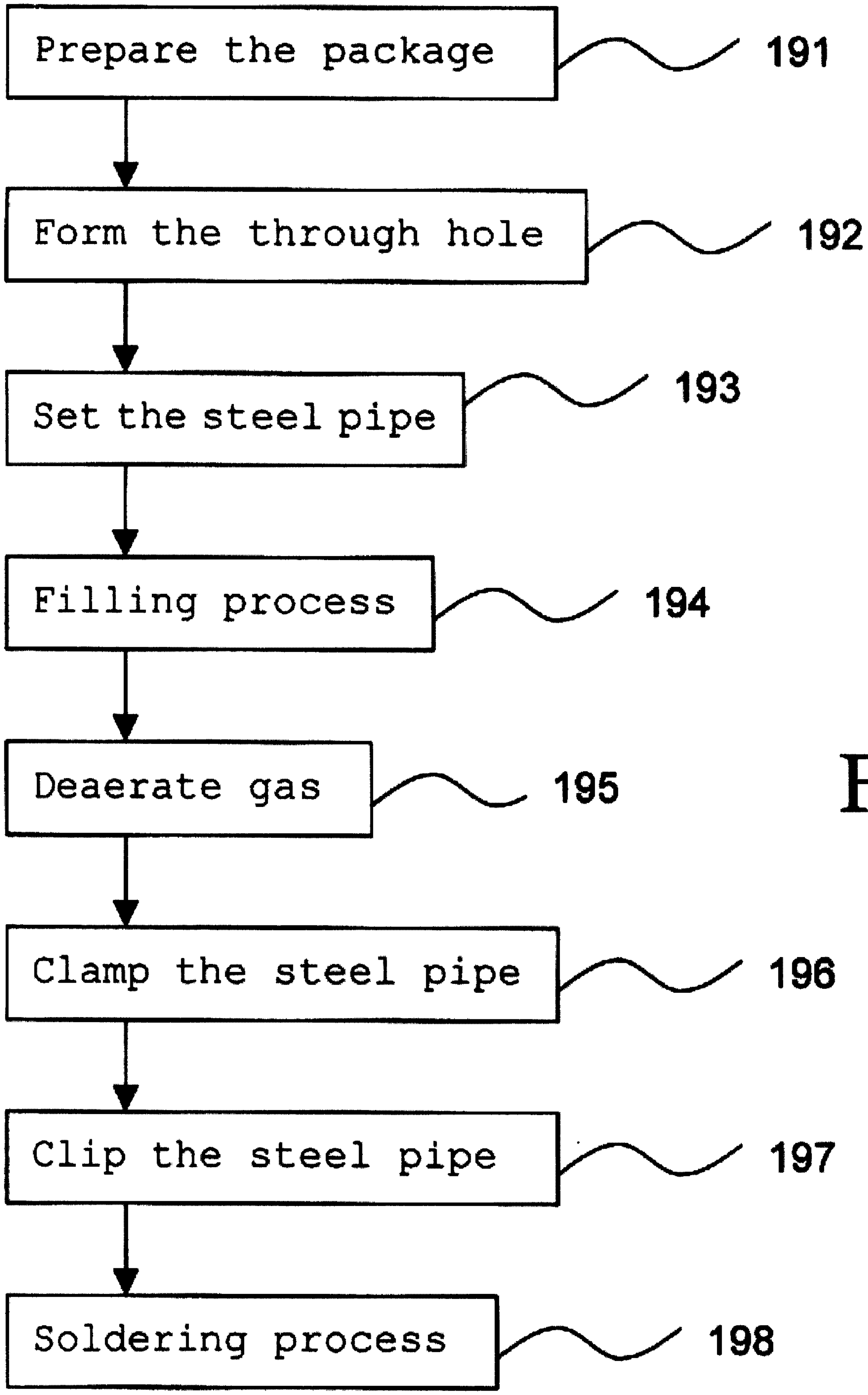

Prepare the package
191
Form the through hole
192
Set the steel pipe
193
Filling process
194
Deaerate gas
195
Clamp the steel pipe
196
Clip the steel pipe
197
Soldering process
198

FIG 2

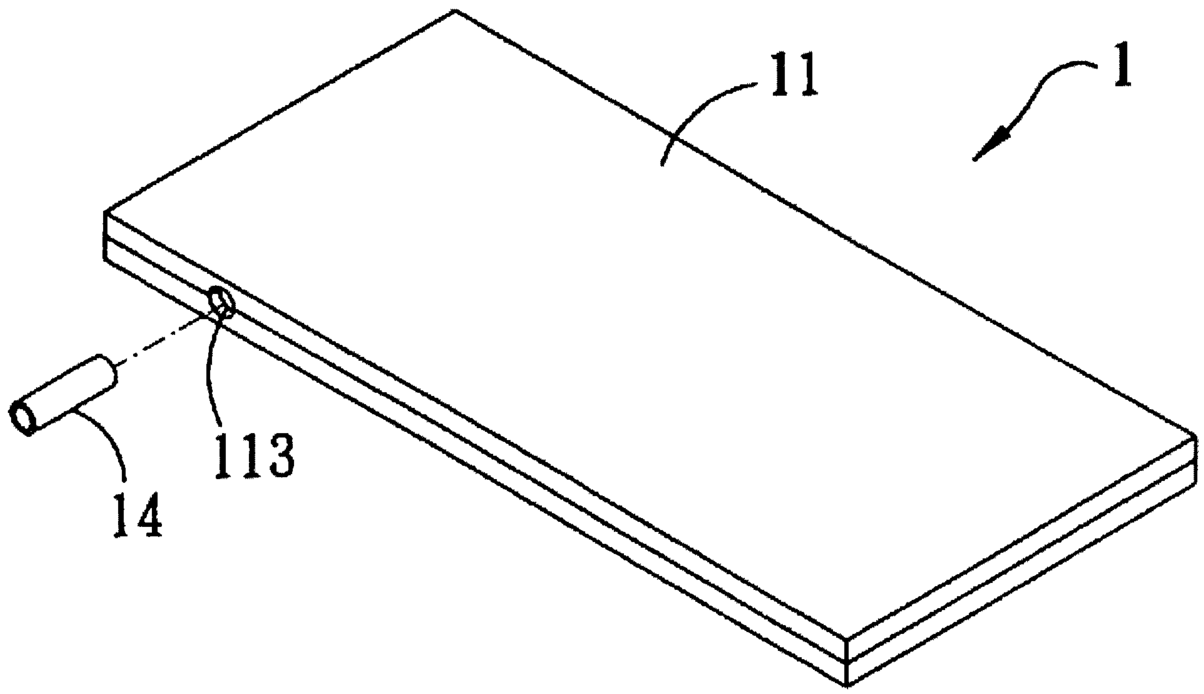



FIG 3

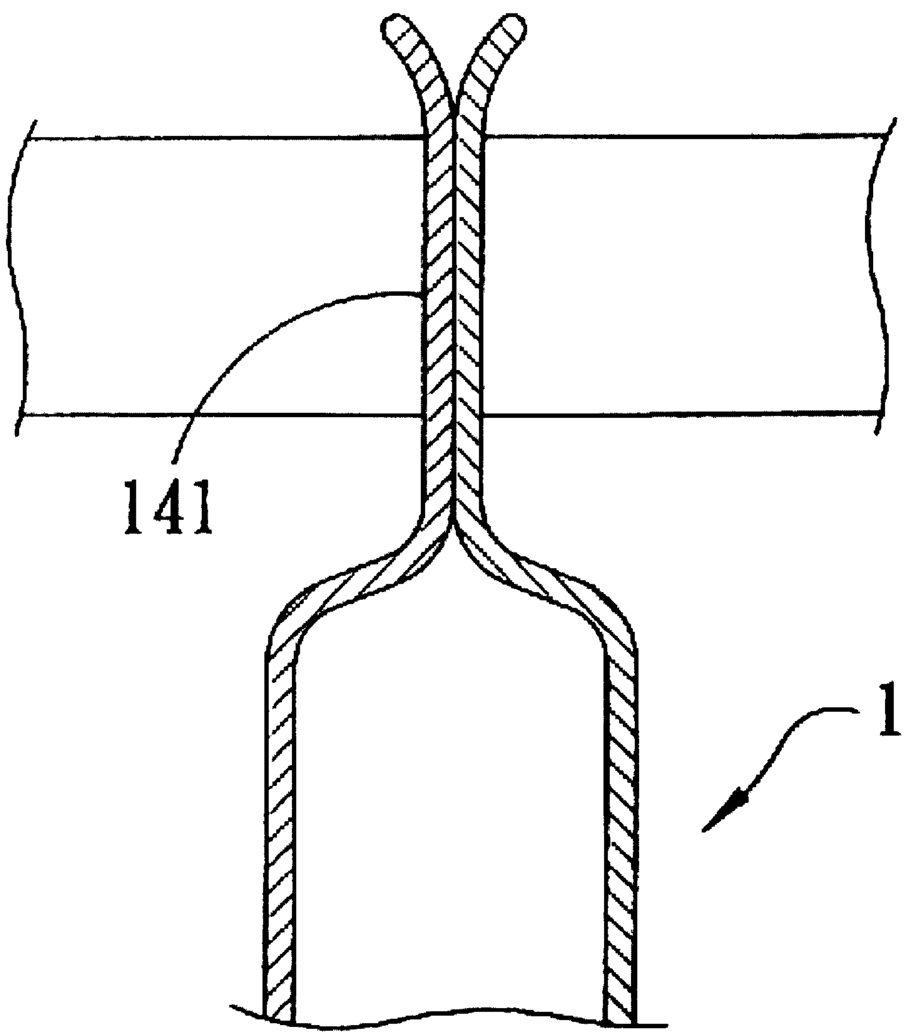



FIG 4

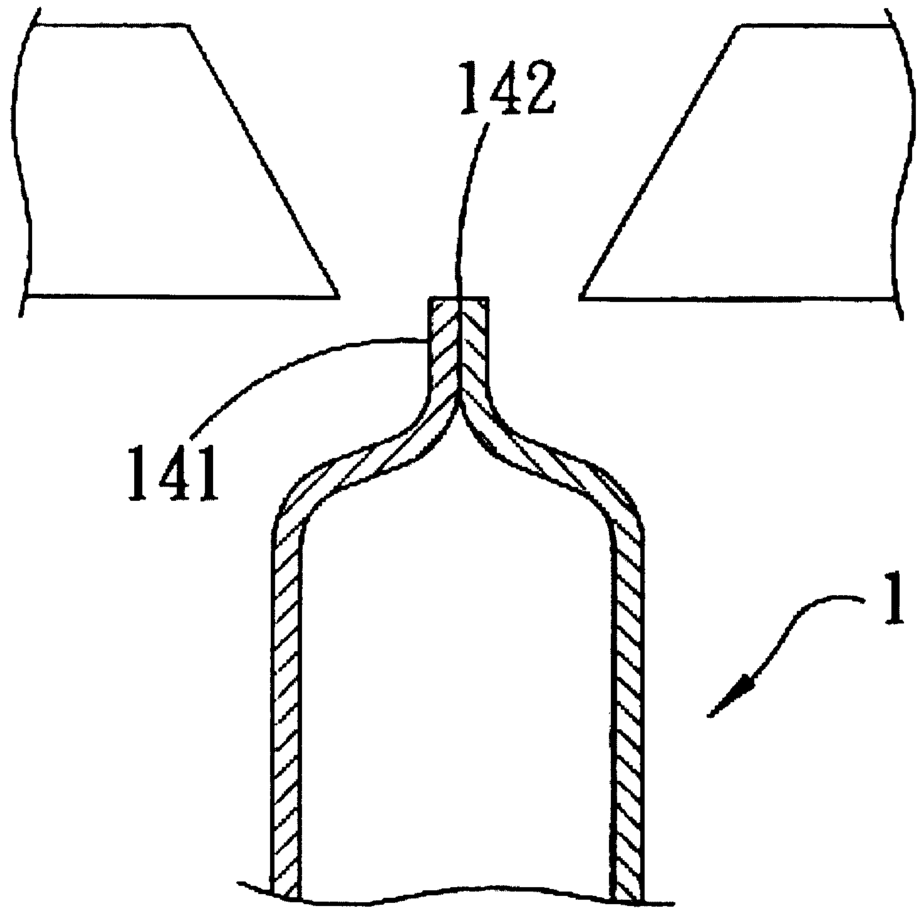



FIG 5

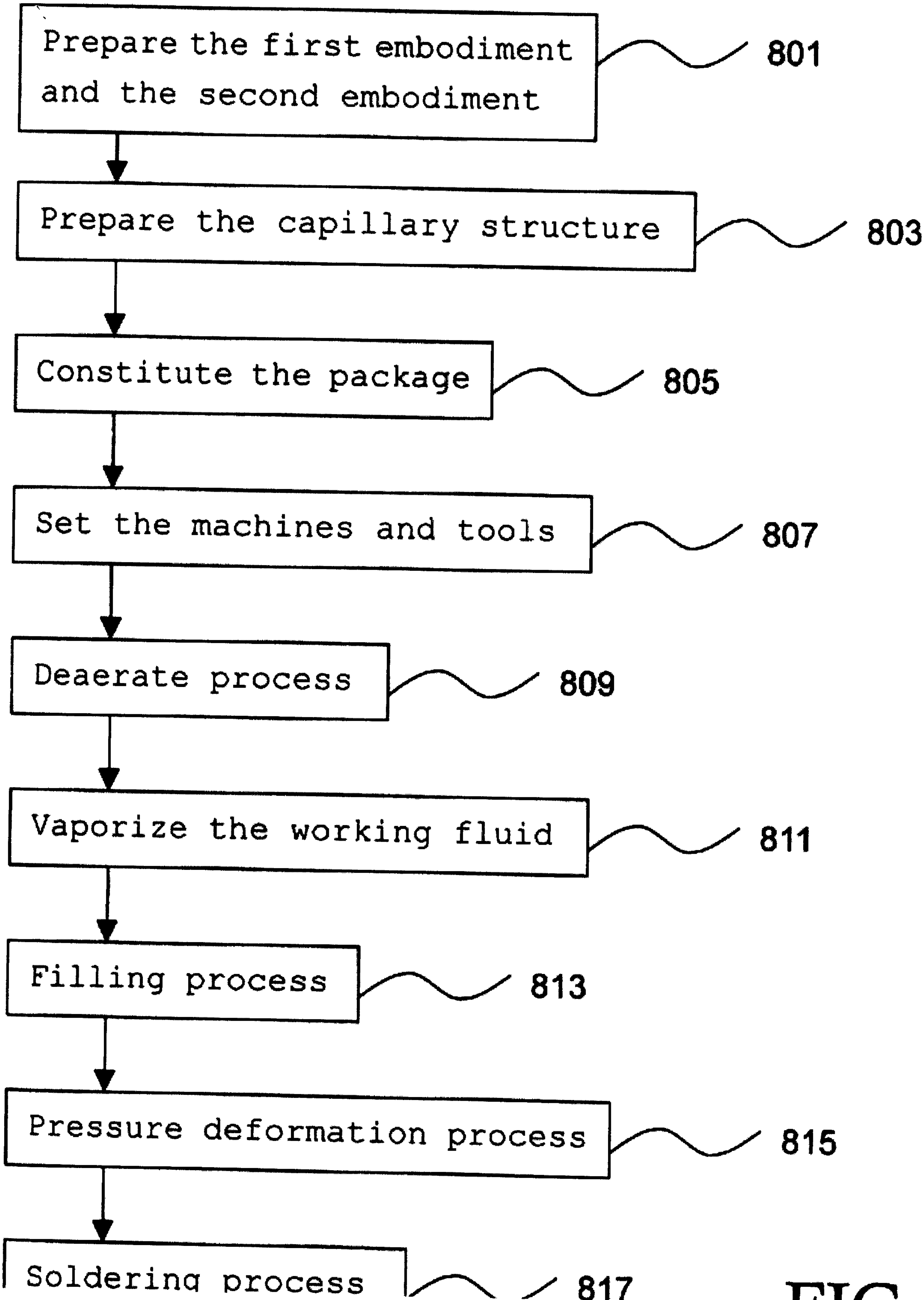

Prepare the first embodiment and the second embodiment
801
Prepare the capillary structure
803
Constitute the package
805
Set the machines and tools
807
Deaerate process
809
Vaporize the working fluid
811
Filling process
813
Pressure deformation process
815
Soldering process
817

FIG 6

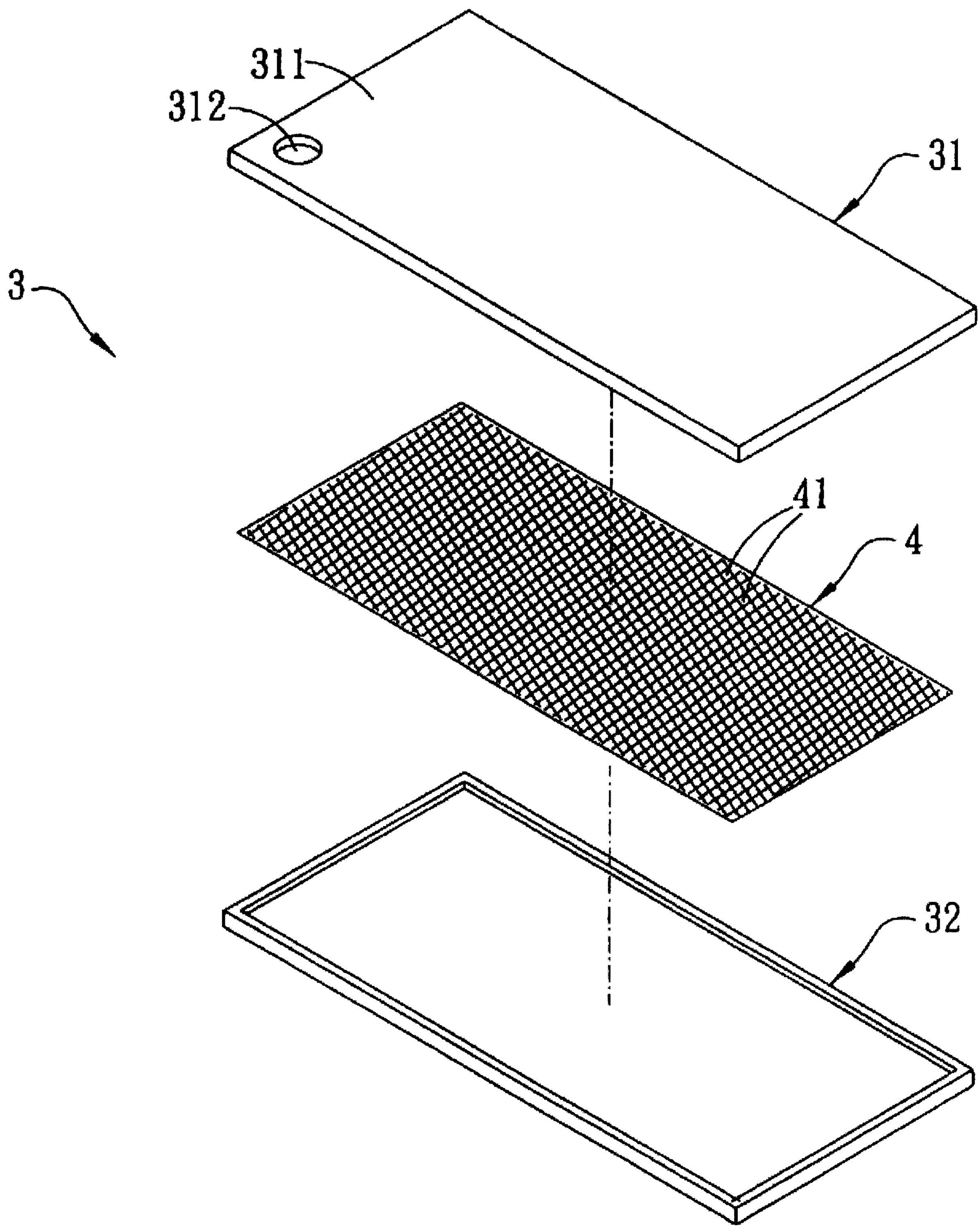



FIG 7

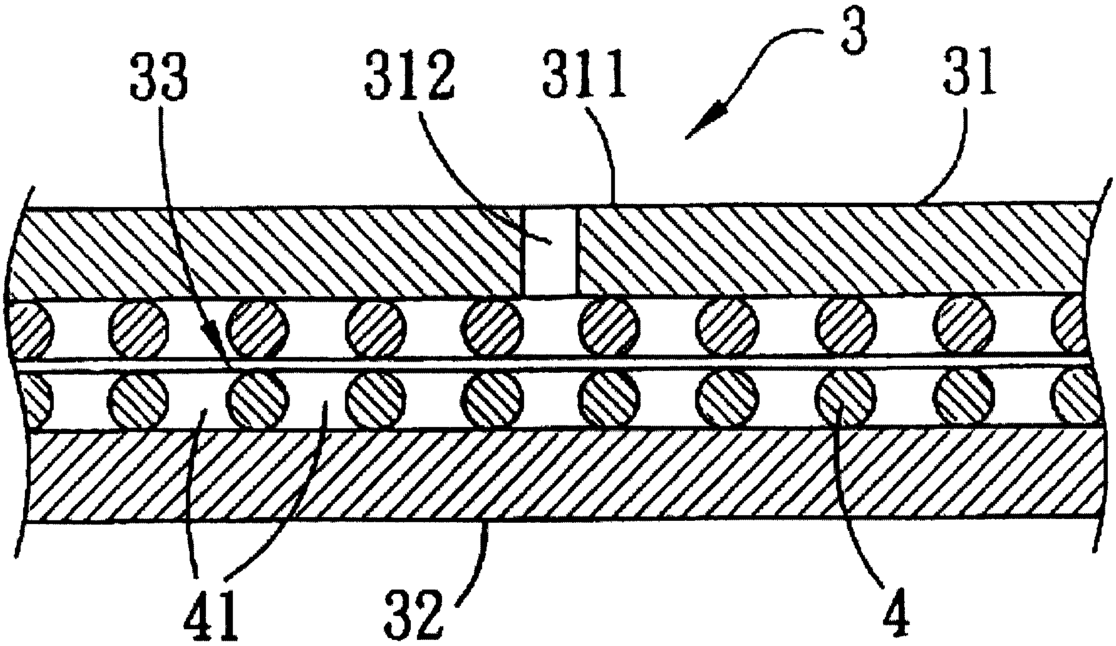



FIG 8

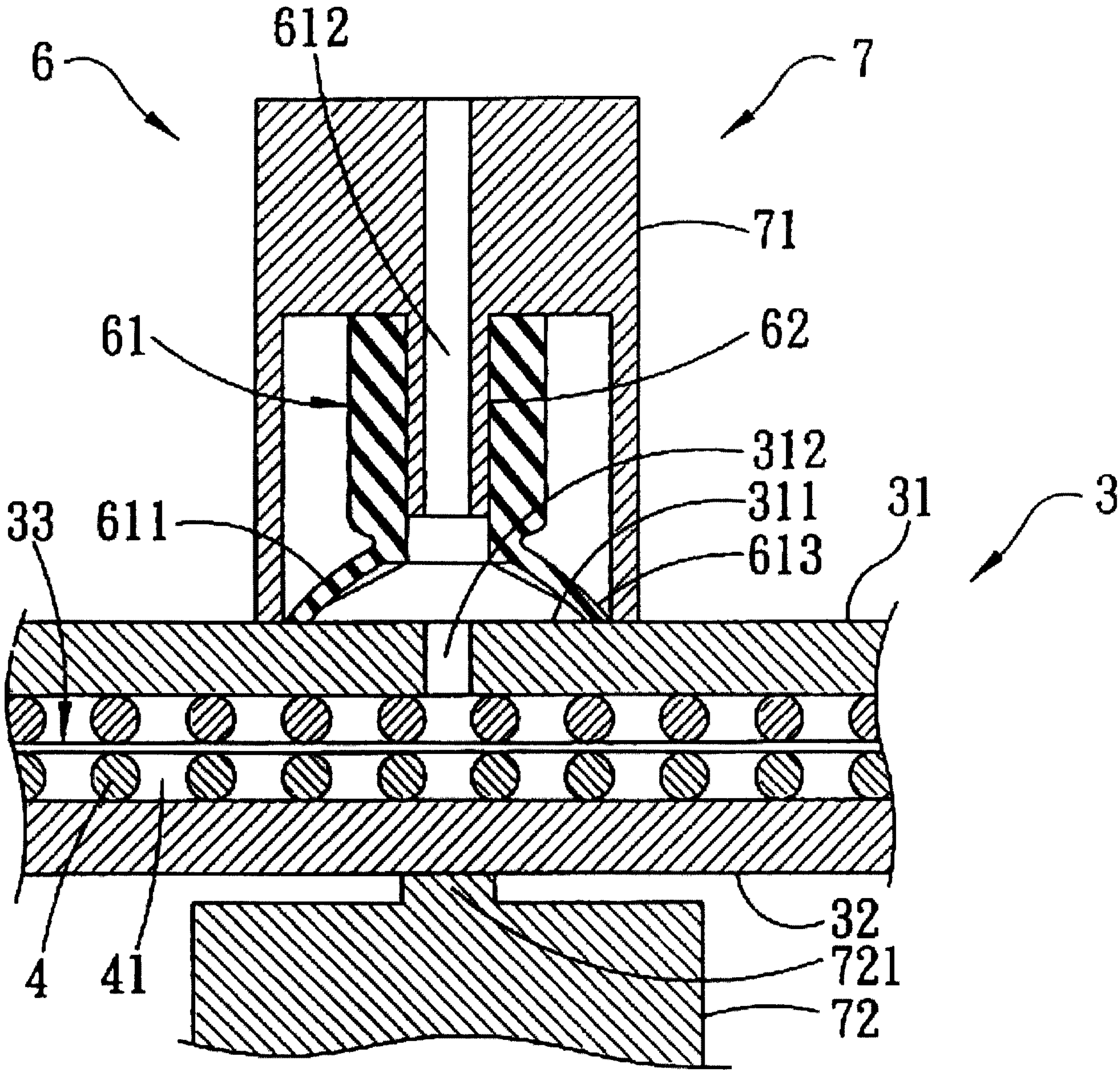



FIG 9

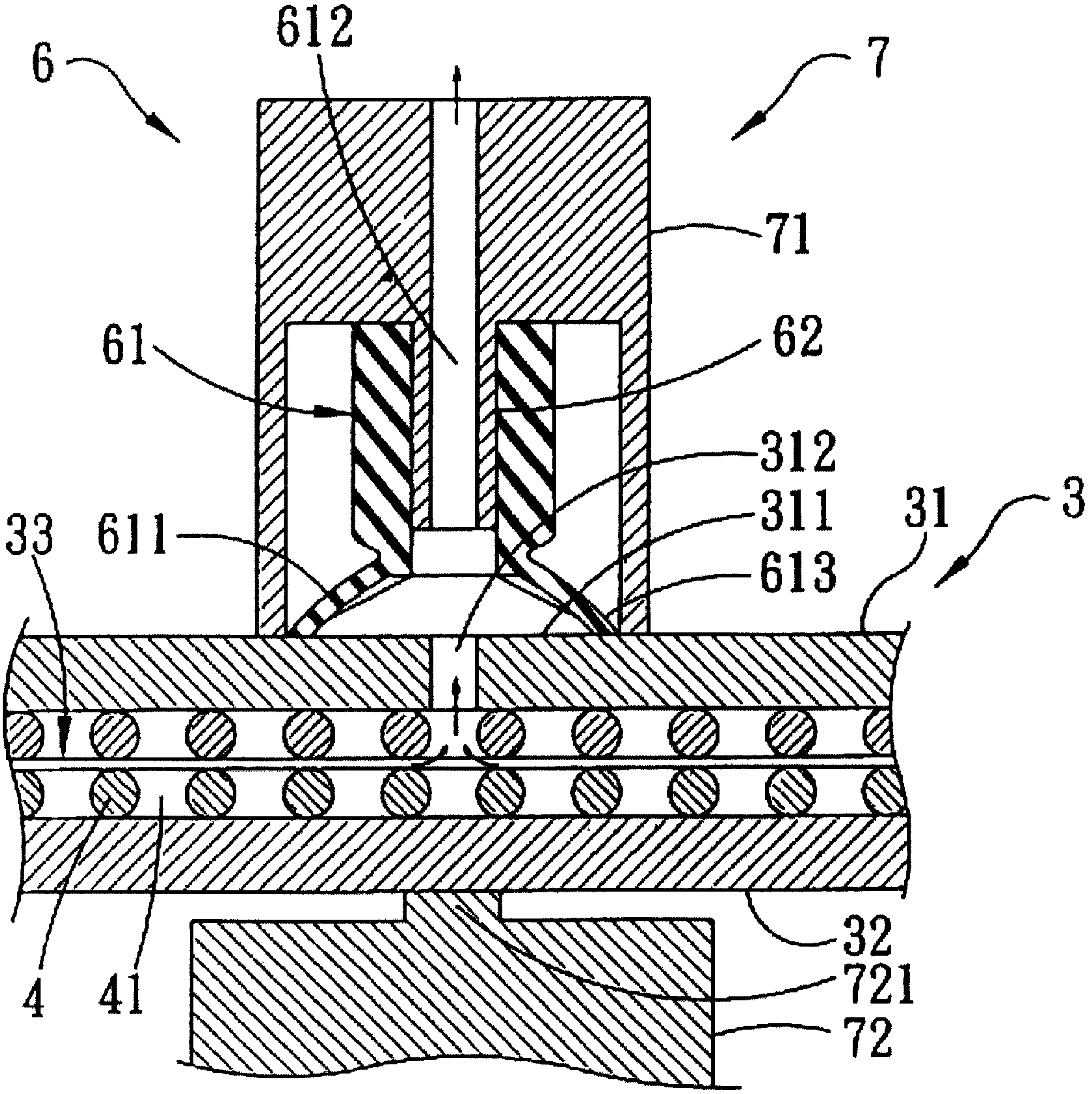



FIG 10

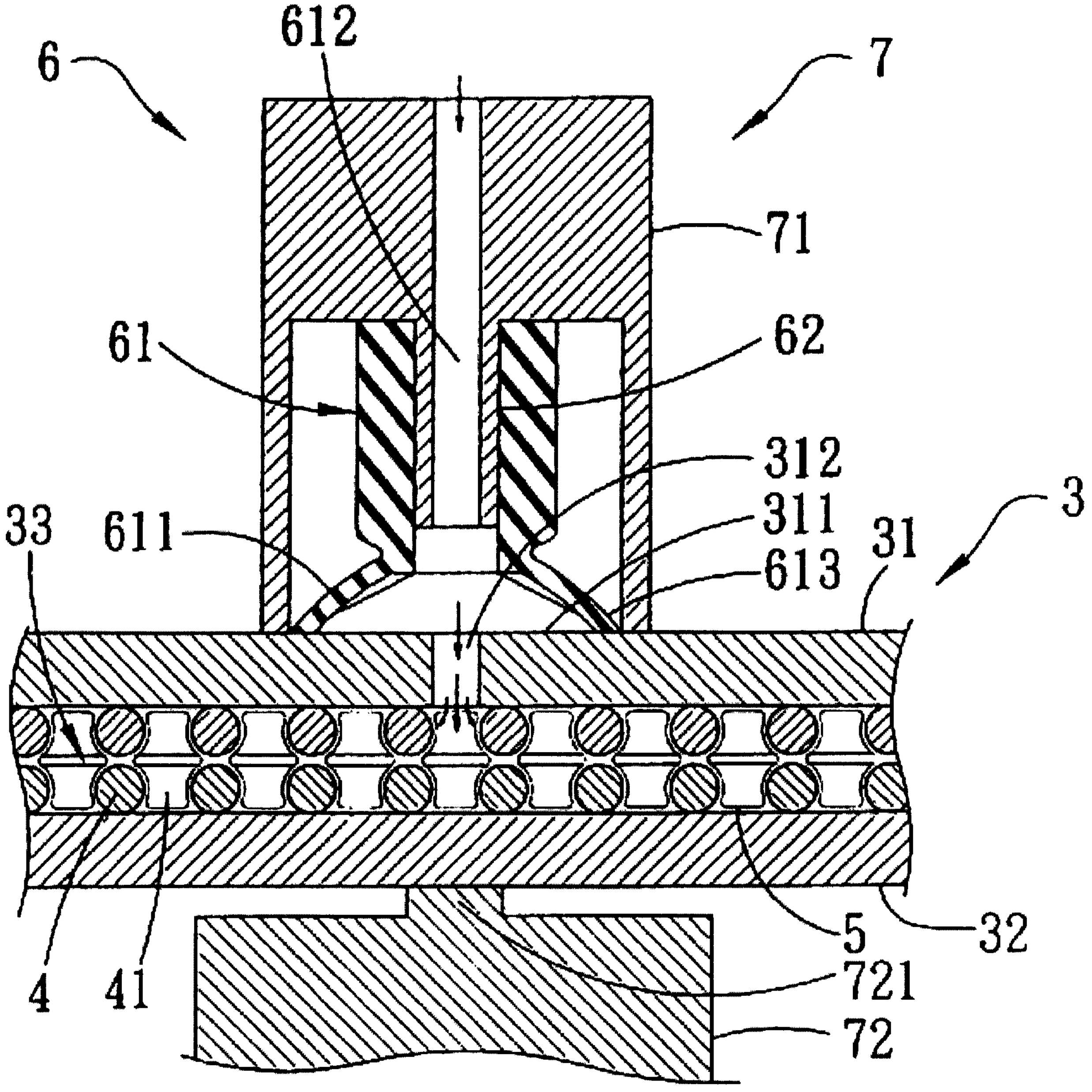



FIG 11

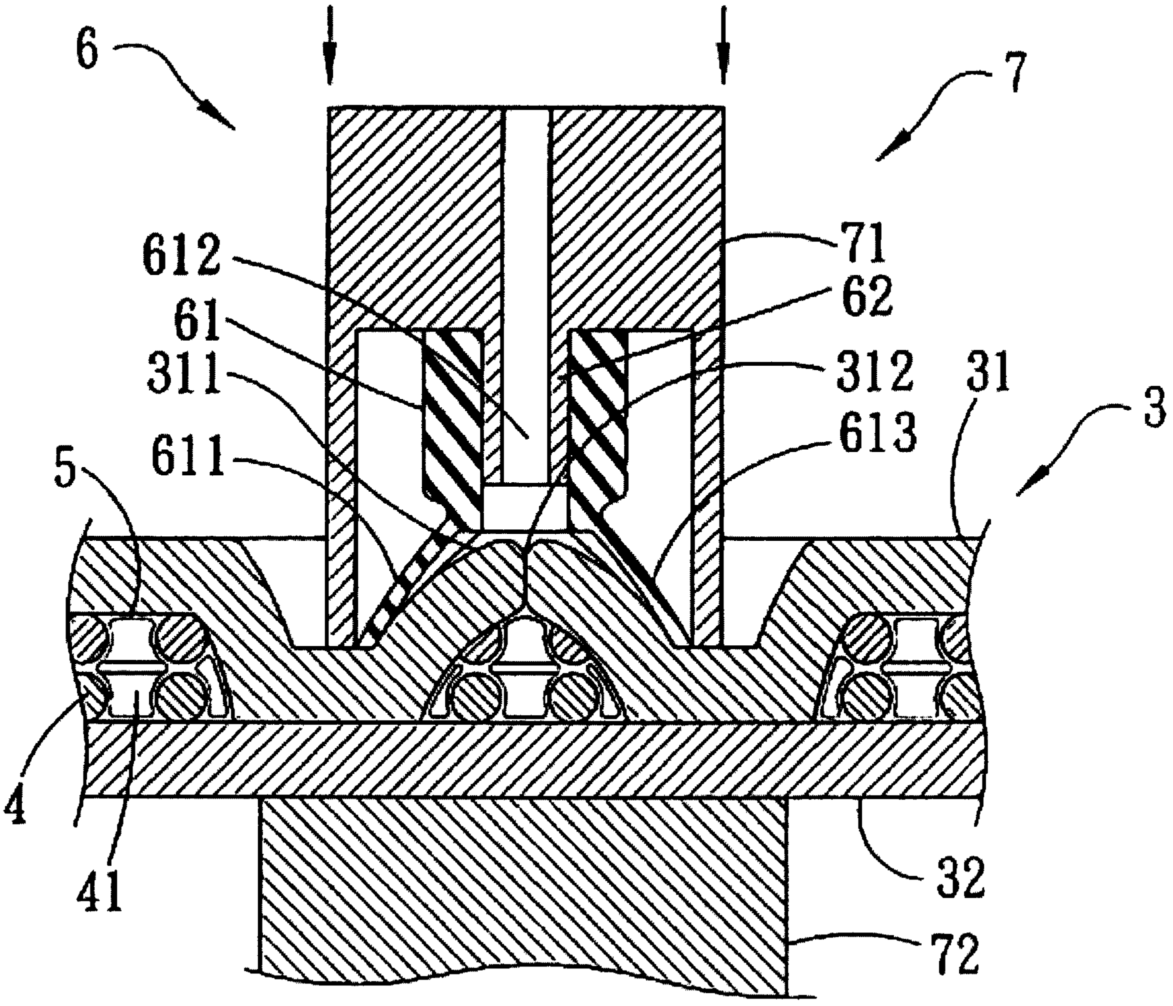



FIG12

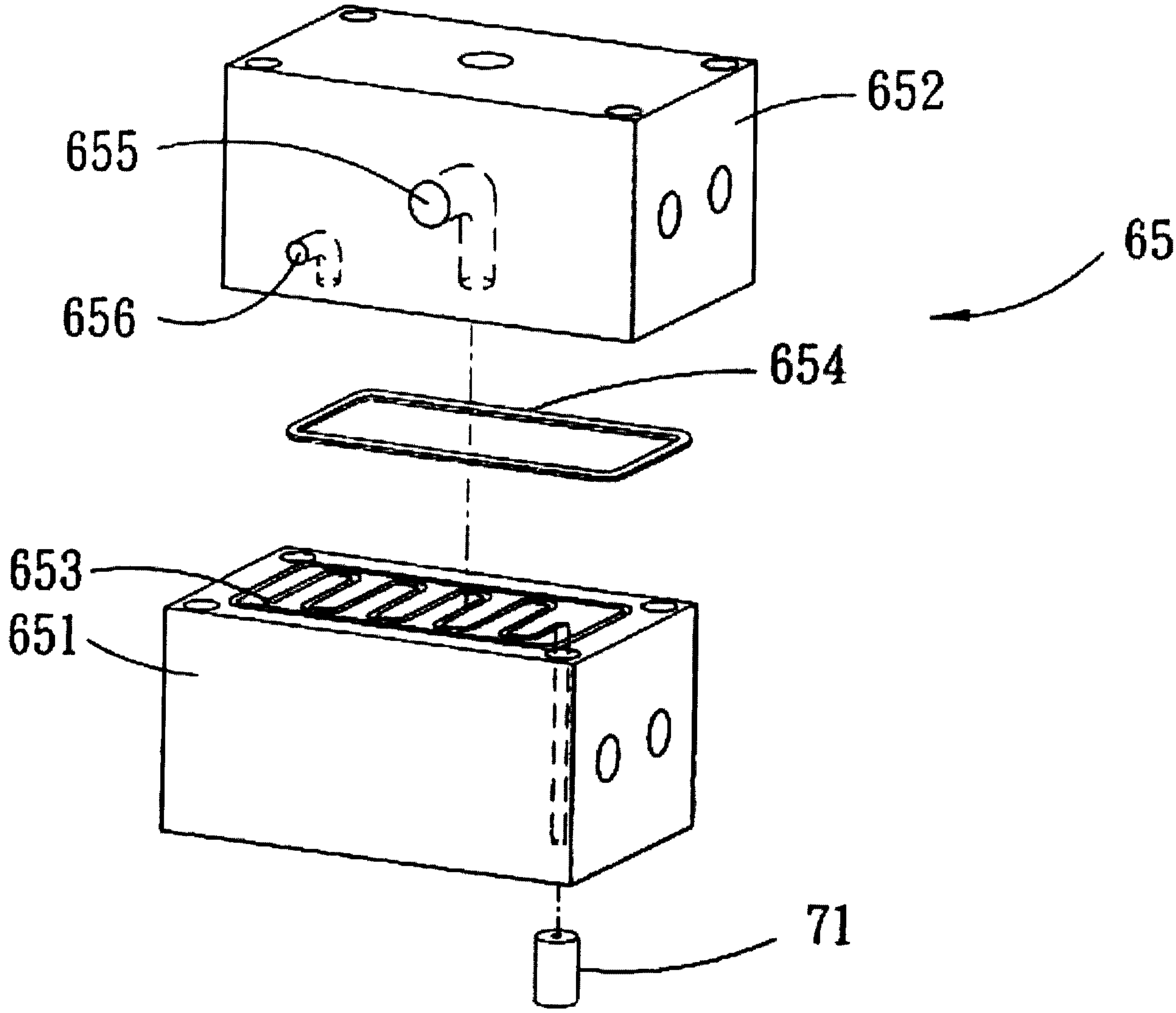



FIG 13

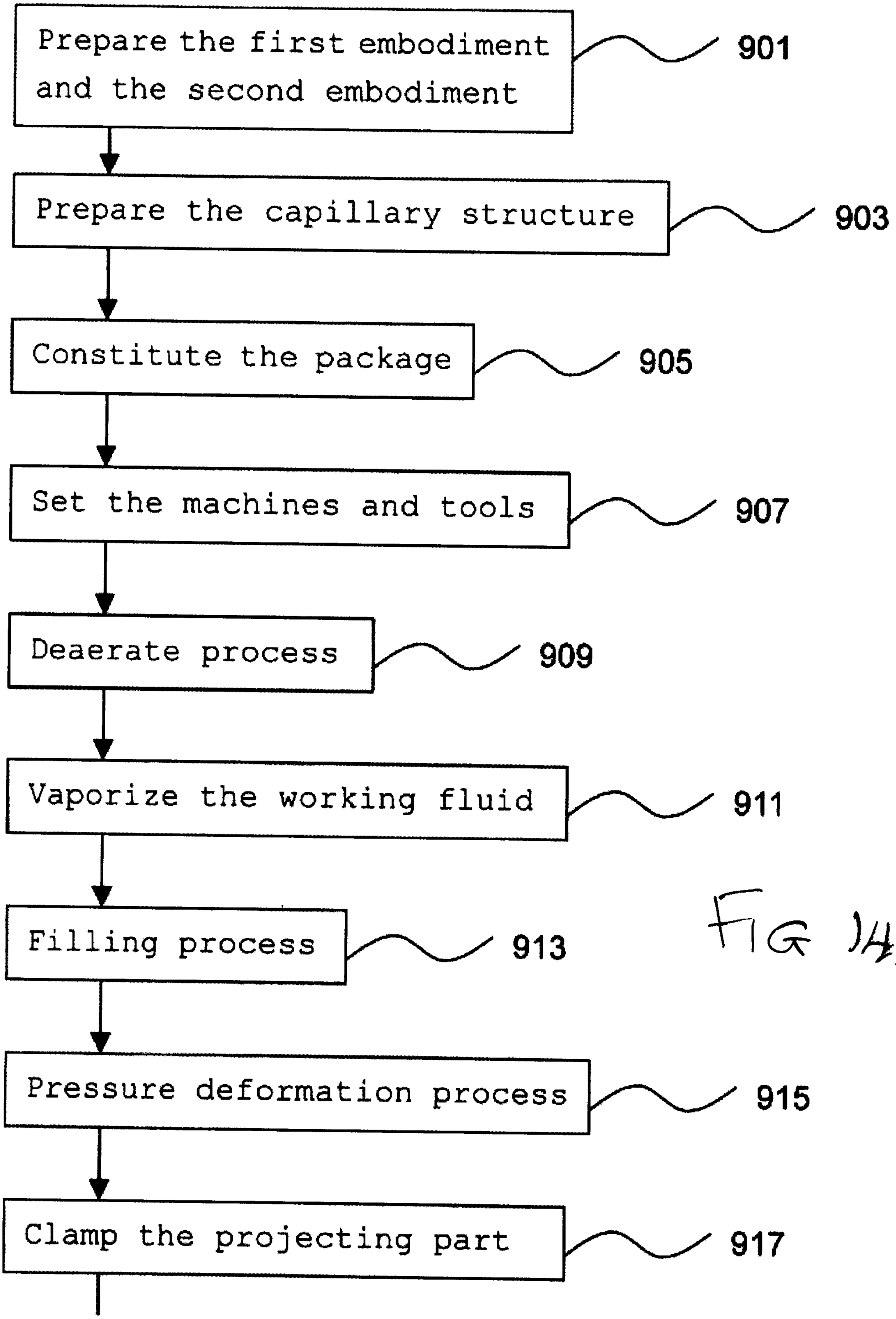

Prepare the first embodiment and the second embodiment
901
Prepare the capillary structure
903
Constitute the package
905
Set the machines and tools
907
Deaerate process
909
Vaporize the working fluid
911
Filling process
913
Pressure deformation process
915
Clamp the projecting part
917

FIG 14

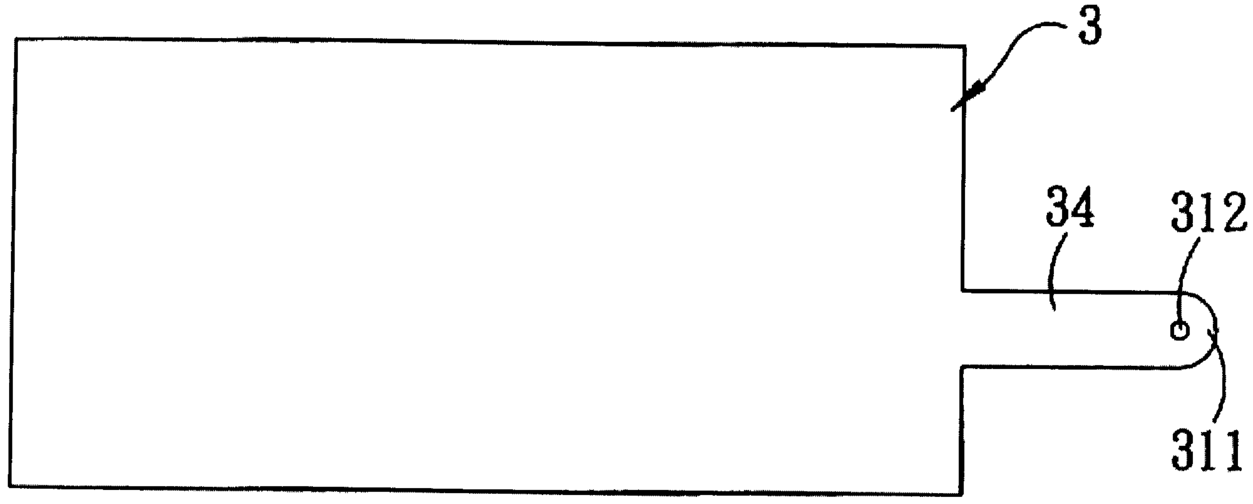



FIG 15

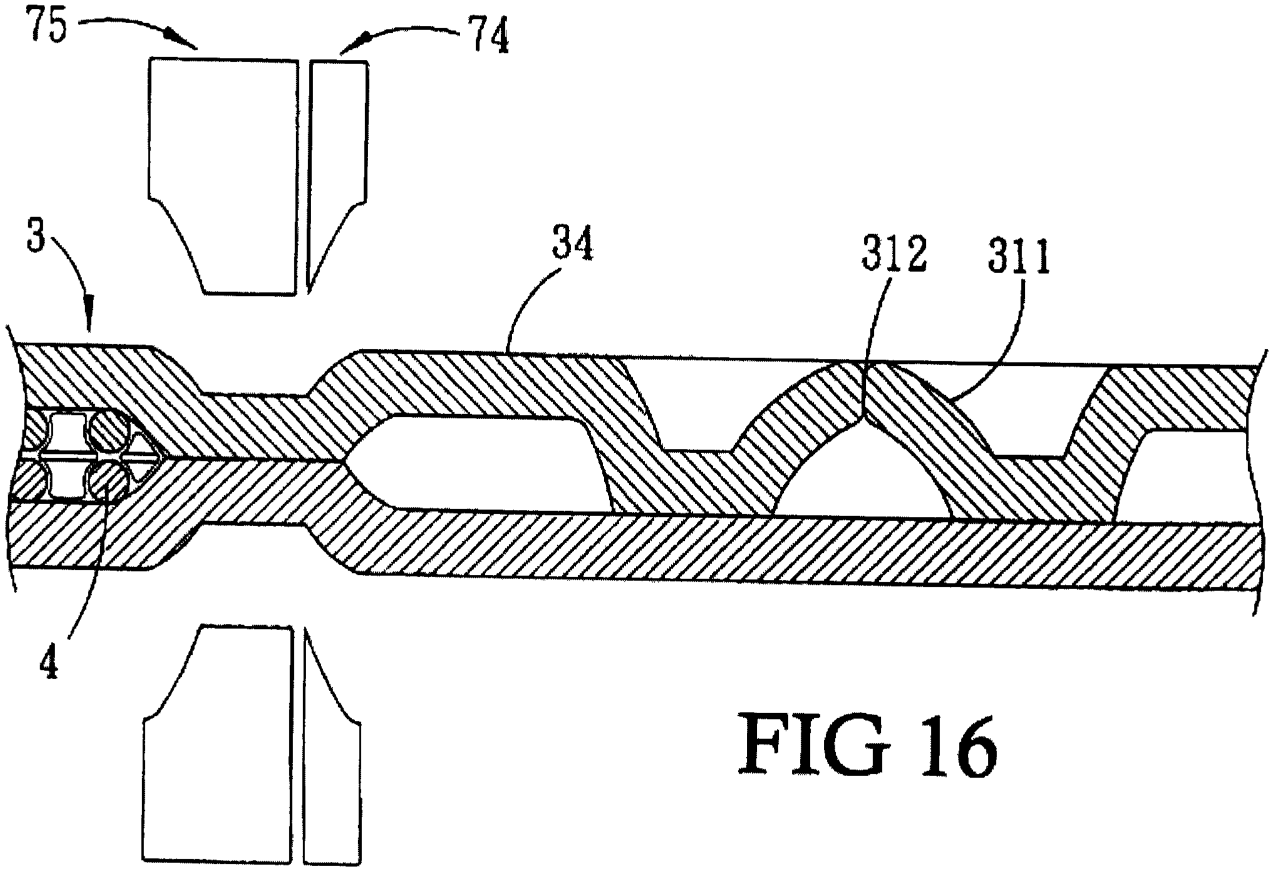



FIG 16

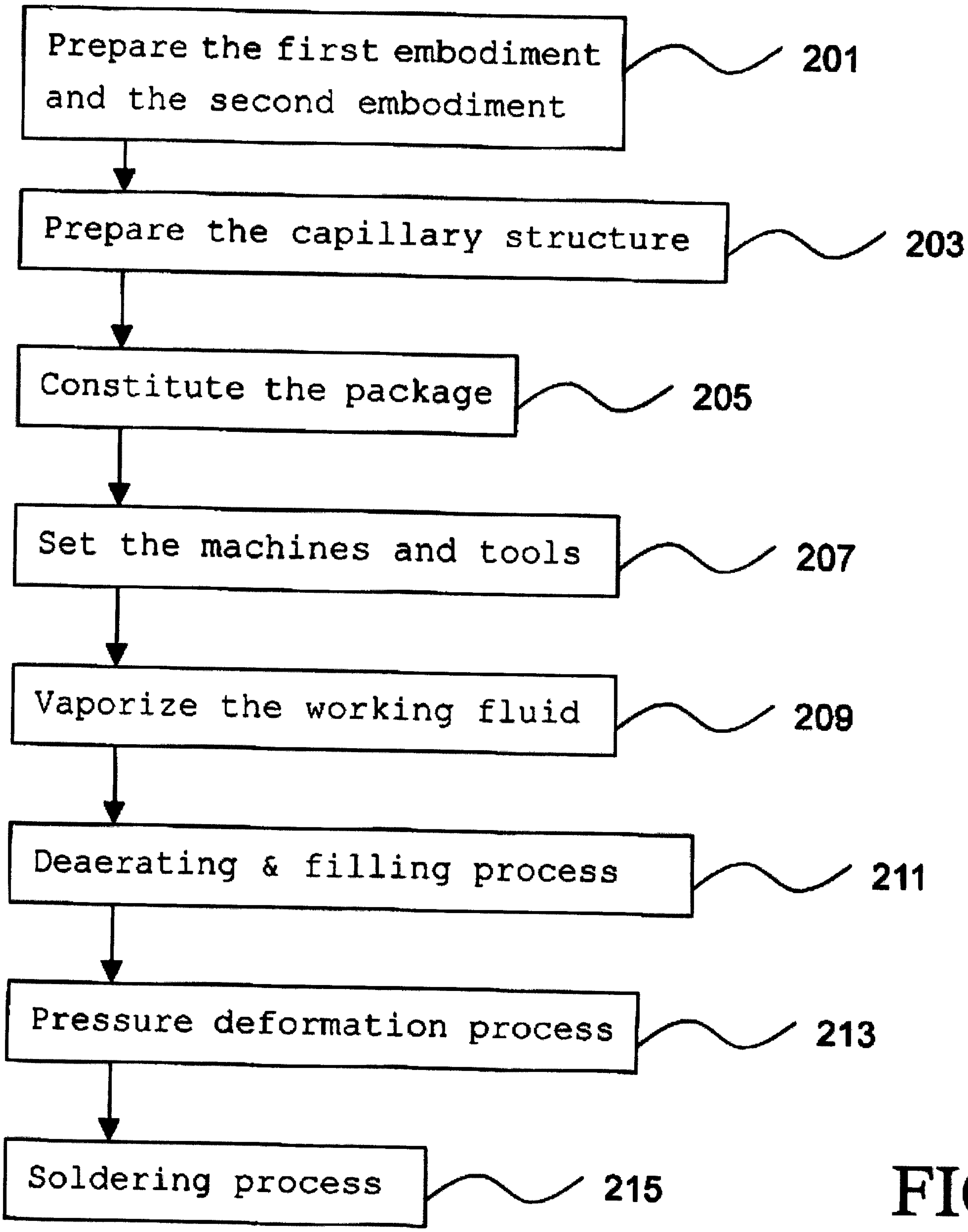

Prepare the first embodiment and the second embodiment
201
Prepare the capillary structure
203
Constitute the package
205
Set the machines and tools
207
Vaporize the working fluid
209
Deaerating & filling process
211
Pressure deformation process
213
Soldering process
215

FIG 17

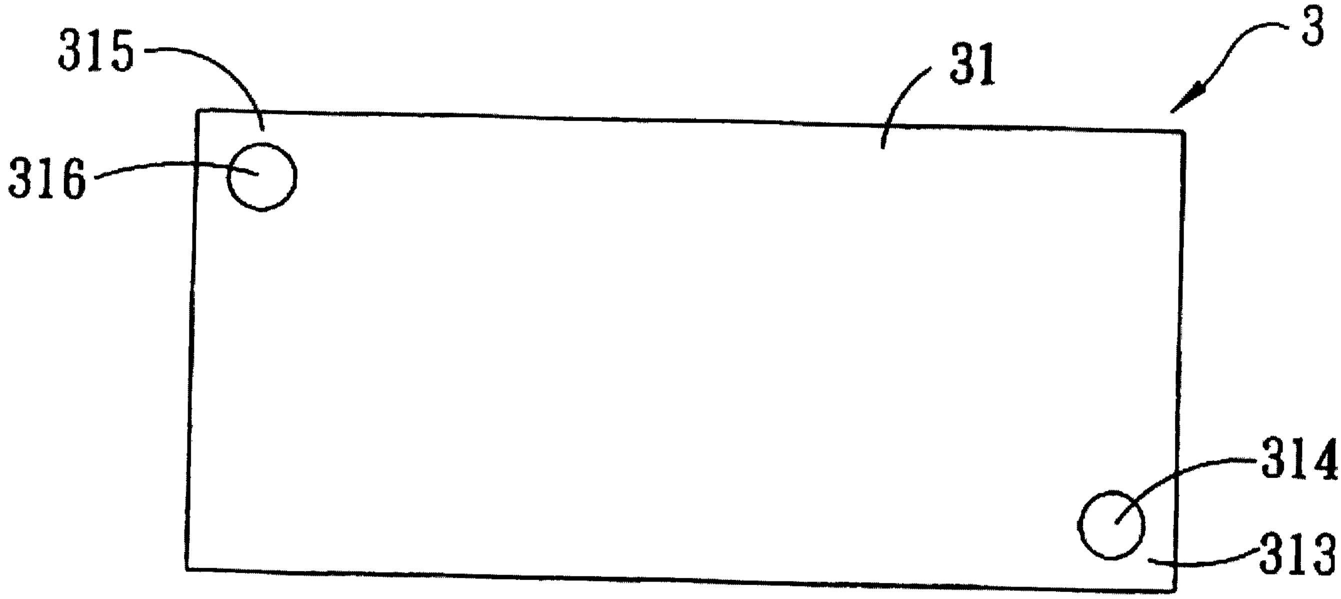
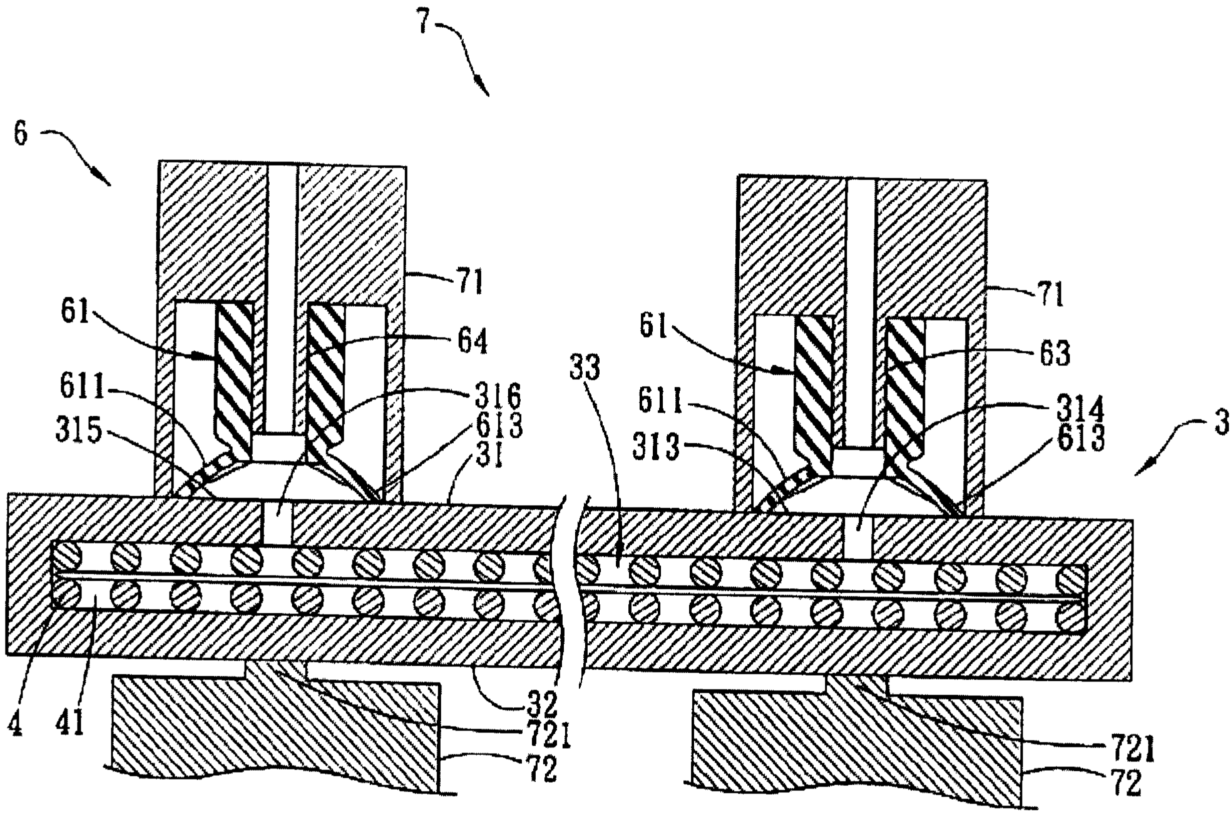
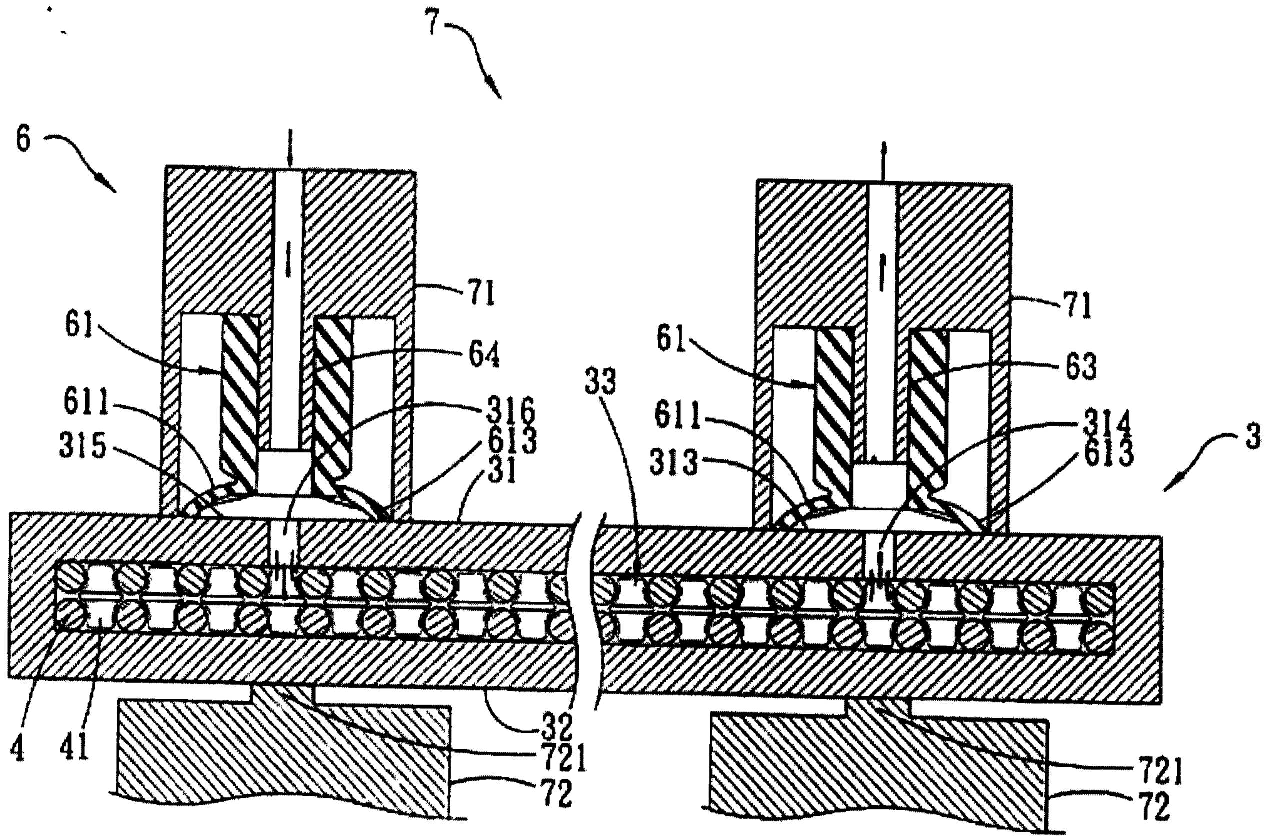



FIG18



7
6
71
61
64
611
316
315
613
31
33
611
313
314
613
3
63
61
71
4
41
32
721
72
721
72


FIG 19


7
6
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61
64
611
316
315
613
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33
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61
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611
314
313
613
3
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41
32
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72
721
72

FIG20

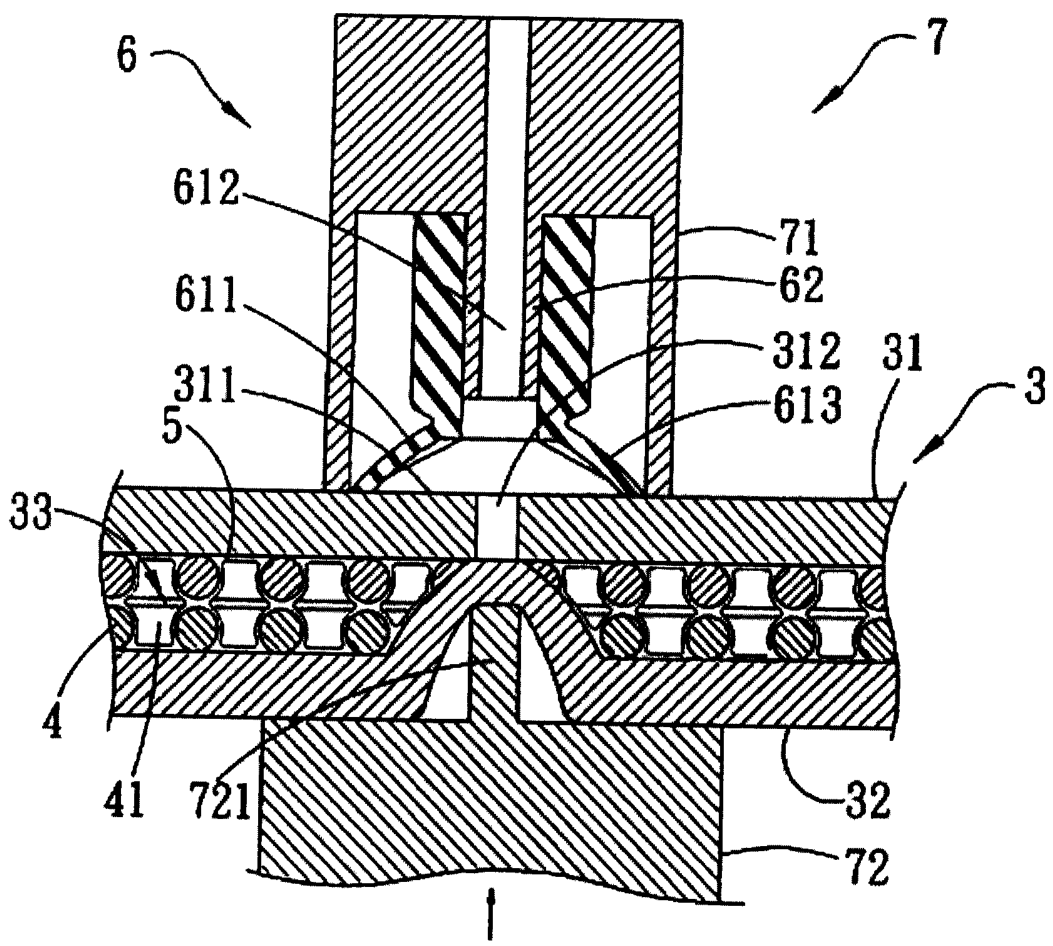


FIG 21

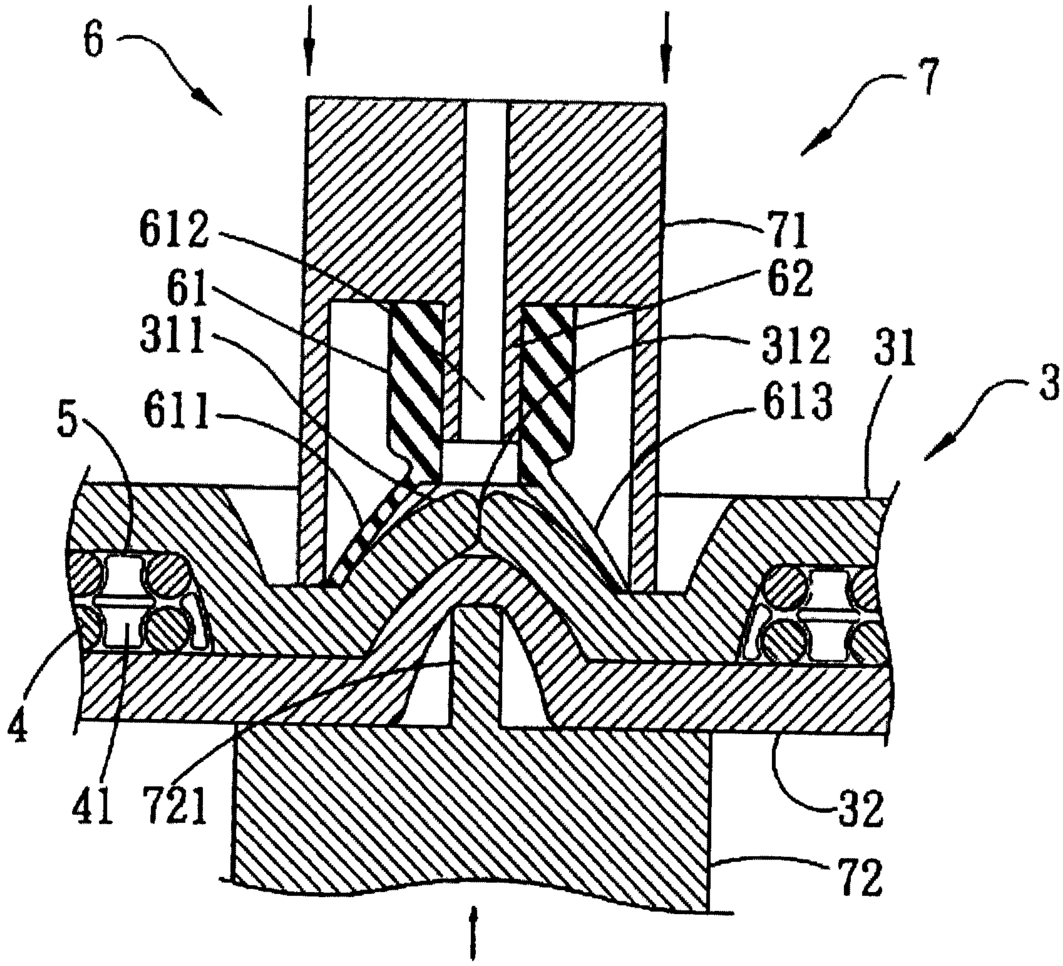


FIG 22

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# PLANAR HEAT PIPE MANUFACTURING METHOD

## BACKGROUND OF THE INVENTION

The present invention relates to a planar heat pipe manufacturing method, and more particularly, to a planar heat pipe manufacturing method having a sucking disk to keep air tight through the use of a pressure deformation sealing process.

A heat pipe is one of the best heat conduction components used in 3C electronic devices, and is therefore usually applied to a heat source, such as a microprocessor of a notebook computer, a host of a play station, or a communication host, which are all not allowed to be installed with large sized heat conduction fins. The heat pipe is used to conduct heat generated by the above heat sources to a heat conductor comprising heat conduction fins. The heat pipe is cheap, and has a lifespan as long as tens of years, for the heat pipe is a kind of passive heat conduction components. Different from copper or aluminum heat conduction components, which have constant conductivities, the heat pipe has a variable conductivity. The longer a length of the heat pipe is, the larger the heat conductivity of the heat pipe becomes. Moreover, the heat conductivity of a conventional heat pipe is tens or more than tens of thousands times as large as the heat conductivity of copper.

Please refer to Fig.1. A conventional planar heat pipe 1 comprises a hollow package 11, a capillary structure 12 installed in an inner surface of the package 12, and working fluid 13 accommodated in the package 11. The package 11 comprises an endothermic end 111 and a radiating end 112 installed opposite to the endothermic end 111. A pressure inside the package 11 is equal to a saturated vapor pressure of the working fluid 13, which is in a stable equilibrium state when a liquid state and a gas state exist concurrently. Additionally, the capillary structure 12 comprises a plurality of capillaries 121 infiltrated in the working fluid 13.

When the endothermic end 111 is heated and a temperature of the endothermic end 111 is increased, the stable equilibrium state of the working fluid 13 near the endothermic end 111 is destroyed, causing the liquid working fluid 13 neighboring the endothermic end 111 to be evaporated gradually. At this moment, the endothermic end 111 has a vapor pressure higher than that of the radiating end 112, so a great volume of gas working fluid 13 is driven to flow from the endothermic end 111 to the radiating end 112. Since the temperature of the radiating end 112 is still low, the radiating end 112 is capable of congealing the gas working fluid 13 neighboring the radiating end 112 flew from the endothermic end 111. The excess congealed working fluid 13 flows along the capillaries 121 back to the endothermic end 111. A heat radiation cycle to radiate heat from the endothermic end 111 to the radiating end 112 is therefore completed.

Since the heat radiation cycle is realized by destroying the stable equilibrium state of the working fluid 13, the heat radiation cycle can still function and radiate considerable quantity of heat continuously, even though the temperatures of the two ends of the package 11 differ from each other slightly.

Although it is not difficult to understand the working principles of a heat pipe, and everyone can obtain materials for a heat pipe from a hardware store and make up a heat pipe for a short-term use by himself, in real industry applications it is very difficult to manufacture a durable heat pipe for a long-term use. In early years, the manufacturing techniques to manufacture a heat pipe are not mature, the manufacturing efficiency being low and the quality of finished products being poor, for in the heat pipe manufacturing system flaws hardly seen by human's eyes are generated inevitably. Though a heat pipe produced by such a heat pipe manufacturing system looks the same as those heat pipes of good quality, an air tightness of the heat pipe is likely to be destroyed after a long-term use. Therefore, maintaining the air tightness inside of the package 11 becomes a key issue to determine whether or not the above heat radiation cycle can be executed successfully. When an outer surface of the package 11 is damaged, a pressure difference between an inner part and an outer part of the package 11 causes air to flow into the package 11 easily, and the stable equilibrium state inside of the package 11 is therefore destroyed. In consequence, most heat pipes lose their original efficiencies gradually as time goes on.

In the following paragraphs, a flow chart shown in Fig.2 is used to illustrate the method to manufacture the conventional planar heat pipe 1.

Please also refer to Fig.1 and Fig.3. The method shown in Fig.2 starts from step 191. In step 191, a planar hollow package 11 made of ductile materials is provided. The package 11 comprises a capillary structure 12. In general, both the package 11 and the capillary structure 12 are made of copper or aluminum. The capillary structure 12 can be formed on the inner surface of the package 11 by a stamping process, or is an individual metal network installed at a time when the package 11 is formed.

In step 192, a through hole 113 is formed on a side surface of the package 11. A way to form the through hole 113 is to have two slots opposite to each other reserved when manufacturing the package 11, or to drill the package 11 in addition after the package 11 is done completely. However, both of the slot-reserved and the drilling-in-addition techniques cannot function independently without an auxiliary biting motion provided by a biting device, which is likely to destroy the integrity of the package 11, for the package 11 is small. If the package 11 is lack of the integrity, the vacuum degree of the package 11 is low, and the quality of the heat pipe 1 is poor.

In step 193, a steel pipe 14 is jointed into the through hole 113. In order to operate in accord with the following steps, a joint between the steel pipe 14 and the through hole 113 has to have good enough air tightness. However, in practice conventional jointing methods, such as a soldering method or a bonding method, still produce small air holes, which will make an impact on the air tightness. Moreover, this step still has the clamping problem occurred in last step.

In step 194, a working fluid filling process can be performed through the use of the steel pipe 14. In a conventional heat pipe, water is selected as a working fluid 13. In some other heat pipes, methyl alcohol, or acetone, is selected as the working fluid 13. Different kinds of working fluid correspond to different working temperatures, beyond which the heat radiation cycle cannot be performed successfully, for the working fluid 13, if staying in a high temperature environment or a low temperature environment, is either in a liquid state or in a gas state all the time, and cannot perform a phase-changing process. For example, a working temperature of the heat pipe ranges from 24℃ to 94℃ if the working fluid 13 is pure water, while the working temperature of the heat pipe ranges from 46℃ to 125℃ if the working fluid 13 is methyl alcohol.

In order to ensure that the heat radiation cycle can be performed successfully, a working pressure of the package 11 had better to be kept equal to a vapor pressure of the working fluid 13, that is enabling the working fluid 13 to reach the stable equilibrium state. Then, a deaerating process is performed in step 195 to deaerate gas except the gas working fluid 13 in the package 11. In general, as long as a pressure of the package 11 is equal to the vapor pressure of the working fluid 13, the gas except the gas working fluid 13 is determined having been expelled to a region outside of the package 11 completely.

Please refer to Fig.4 and Fig.5. In step 196, a clamping device is used to clamp an end of the steel pipe 14. In step 197, a clipping device is used to clip a flat sealed end 141 formed in step 196. Thus far, the package 11, as shown in Fig.3, has been sealed completely. Note that for the time being the air tightness of the package 11 completely relies on a packing mechanism performed by sheet metal of two sides of the flat sealed end 141. According to such a scenario, when the clamping device releases the flat sealed end 141, gas is leaked out from the package 11.

Therefore, in step 198 the last step, a seaming device is used to spot weld a flat sealed end surface 142 of the flat sealed end 141, to air tighten the package 11 completely.

In order to maintain the air tightness of the package 11 during steps 196 to 198, a clamping process, a clipping process, and a spot welding process have to be performed completely all at a time. Therefore, steps 196 to 198 have to be performed and completed in a single table. However, such a table costs high, consumes more power, and is not cost-effective.

It can be seen from the above procedures that the flow chart of manufacturing the planar heat pipe 1 is not ideal. Not only the quality of the planar heat pipe 1 is not good all the time during the procedures, most of the steps, when executed, are likely to destroy the integrity of the package 11 indirectly, and decrease the lifespan and working efficiency of the planar heat pipe 1. Moreover, the manufacturing process described above is uneconomical.

## SUMMARY OF THE INVENTION

It is therefore a primary objective of the claimed invention to provide a planar heat pipe manufacturing system to manufacture a planar heat pipe having a guaranteed quality.

Another objective of the claimed invention is to provide a planar heat pipe manufacturing system to manufacture a planar heat pipe having an integrity not destroyed by a clamping mechanism performed by a clamping device during a manufacturing process.

Another objective of the claimed invention is to provide a planar heat pipe manufacturing system to manufacture a planar heat pipe having good enough air tightness during a manufacturing process.

Another objective of the claimed invention is to provide a planar heat pipe manufacturing system to maintain air tightness with a sucking disk.

An embodiment of the planar heat pipe manufacturing method of the present invention includes the following steps of (A) forming a planar hollow package made of a ductile material, the package comprising a cavity, (B) providing a substantially flat surface installed on the package, and an opening formed on the surface for connecting the cavity, (C) mounting a sucking disk onto the opening, the sucking disk comprising a deformation part and a through hole penetrating through the deformation part, a sucking ring being formed at an outer region of the deformation part, (D) deaerating air inside the cavity via the through hole, (E) filling working fluid into the cavity of the package via the through hole, and (F) compressing the package along a direction perpendicular to the surface to deform and extend part of the package to seal the hole.

Additionally, another embodiment of the planar heat pipe manufacturing method of the present invention includes the following steps of (I) forming a planar hollow package made of a ductile material, the package comprising a cavity, (J) providing a substantially flat first surface and second surface installed on the package, and forming a deaerating hole installed on the first surface and a filling hole installed on the second surface, both of the deaerating hole and filling hole connected to the cavity, (K) mounting two sucking disks onto the deaerating hole and the filling hole respectively, each of the sucking disk comprising a deformation part and a through hole penetrating through the deformation part, a sucking ring being formed at an outer region of the deformation part, (L) deaerating air inside the cavity via a through hole installed on the deaerating hole, (M) filling working fluid into the cavity of the package via a through hole installed on the filling hole, and (N) compressing the package along directions perpendicular to the first surface and the second surface respectively to deform and extend part of the package to seal the deaerating hole and the filling hole.

These and other objectives of the claimed invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a cross sectional view of a planar heat pipe according to the prior art.

Fig.2 is a flow chart diagram of manufacturing the planar heat pipe shown in Fig.1.

Fig.3 is an explosive view of a package and a conventional steel pipe.

Fig.4 is a cross sectional view of the steel pipe shown in Fig.3.

Fig.5 is a cross sectional view similar to Fig.5.

Fig.6 is a flow chart of a planar heat pipe manufacturing method of a first preferred embodiment according to the present invention.

Fig.7 is an explosive view of the planar heat pipe shown in Fig.6.

Fig.8 is a cross sectional view of the planar heat pipe shown in Fig.6.

Fig.9 is a cross sectional view of the planar heat pipe, a deaerating & filling device, and a sealing device.

Fig.10 is a cross sectional diagram similar to Fig.9.

Fig.11 is a cross sectional diagram similar to Fig.9.

Fig.12 is a cross sectional diagram similar to Fig.9.

Fig.13 is an explosive view of a vaporizing device of the first embodiment.

Fig.14 is a flow chart of a planar heat pipe manufacturing method of a second preferred embodiment according to the present invention.

Fig.15 is a top view of an assembly planar heat pipe of the second preferred embodiment.

Fig.16 is a cross sectional view of the planar heat pipe, a clamping device, and a clipping device of the second preferred embodiment.

Fig.17 is a flow chart of a planar heat pipe manufacturing method of a third preferred embodiment according to the present invention.

Fig.18 is a top view of an assembly planar heat pipe of the third preferred embodiment.

Fig.19 is a cross sectional view of the planar heat pipe, a deaerating & filling device, and a sealing device of the third preferred embodiment.

Fig.20 is a cross sectional diagram similar to Fig.18.

Fig.21 is a cross sectional diagram similar to Fig.18.

Fig.22 is a cross sectional diagram similar to Fig.18.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The premise and other related technique contents, characteristics, and virtues of the present invention would be presented clearly in accord with detailed descriptions of two preferred embodiments of reference figures.

Before the present invention is described, note that similar components are assigned the same numbers in the following paragraphs.

Please refer to Fig.6. A first embodiment of a planar heat pipe manufacturing method of the present invention comprises steps 801 to 817.

Please refer to Fig.7. In step 801, a first component 31 and a second component 32 are manufactured through the use of a current metal manufacturing method. An appearance of the first component 31 is complementary to an appearance of the second component 32. Under consideration for efficiency and economy, these two components can be made of copper or aluminum. Under other considerations, the first component 31, and the second component 32 as well, can be made of ductile materials of good heat conductivity. The first component 31 comprises an opening 312 penetrating through two sides opposite to each other, and provides a substantially flat surface 311 encircling the opening 312.

In step 803, a capillary structure 4 is manufactured through the use of a current metal manufacturing method. The capillary structure 4 can be made of copper, aluminum, or any other materials of good heat conductivity. Of the first preferred embodiment, the capillary structure 4 is a metal network, which comprises a plurality of capillaries 41 in communication with each other. The capillaries 41 described here are fine holes capable of inducing liquid to form a capillarity effect. That is, when a part of the capillary structure 4 contacts with liquid, the liquid can be diffused through the capillaries 41 to the remaining part of the capillary structure 4. Such a diffusion process has nothing to do with a direction of gravity. Therefore, the actual size of the capillaries 41 depend on the materials of the capillary structure and the liquid applied in coordination with the capillary structure 4.

Please refer to Fig.8. In step 805, the first component 31 and the second component 32 are combined to form a hollow package 3 through the use of a current combining technique, such as a bonding technique or a soldering technique. The package 3 comprises a cavity 33. The opening 312 is connected to the cavity 33. In the process of combining the first component 31 and the second component 32, the capillary structure 4 is installed between the first component 31 and the second component 32. After the package 3 is finished, the capillary structure 4 is disposed in the cavity 33, and has two opposite sides contacting with an inner surface of the package 3 respectively. Heat can be conducted from the package 3 to the capillary structure 4, and vice versa.

Moreover, the above-mentioned steps 801 to 805 are only the preferred embodiment. In practice, in step 803 the capillary structure 4 can also be formed between the first component 31 and the second component 32 through the use of another current techniques, such as a stamping technique or a seal cutting technique. Combining the first component 31 and the second component 32 in step 805 can acquire a similar structure.

Please refer to Fig.9. After the package 3 and the capillary structure 4 are finished, a deaerating & filling process and a sealing process are performed in coordination with a deaerating & filling device 6 and a sealing device 7. The deaerating & filling device 6 comprises a sucking disk 61, a deaerating & filling pipe 62, and a vacuum-pumping device (not shown). The sucking disk 61 has a virtue similar to that of a vacuum lifter used for job transfer, job air tightness test, job displacement direction detection, stickers sticking automatically, and materials packing & sack opening. The vacuum pumping device, and the vacuum lifter as well makes the use of a pressure difference to absorb an object. The sealing device 7 comprises a first loading element 71, a second loading element 72, and a driving device (not shown). The first loading element 71, and the second loading element 72 as well, is made of pressure resistant materials of high rigidity. The driving device (not shown) does works by oil pressing, water pressing, or through the use of a servomotor.

Before the deaerating & filling process and the sealing process are performed, in step 807 the sucking disk 61, the first loading element 71, and the second loading element 72 are installed on a surface of the package 3. The sucking disk 61 comprises a deformation part 611 in the form of a bell jar mounted on the opening 312, and a through hole 612 penetrating through the deformation part 611 for insertion of the deaerating & filling pipe 62 and in communication with the opening 312. A sucking ring 613 is formed in an outer ringed region of the deformation part 611 for adhering to the surface 311. Moreover, the sucking disk 61 is made of flexible silicon. However, in practical application, the sucking disk 61 can be made of other flexible materials such as acrylonitile rubber (NBR). The first loading element 71 encircles the sucking disk 61, and has one end against the surface 311. The second loading element 72 has one end against the package 3 and is located opposite to the surface 311. The second loading element 72 comprises a projecting part 721 against an end surface of the package 3. The projecting part 721 is located at a position corresponding to the opening 312.

Before the deaerating & filling process is described in detail, note that in the first preferred embodiment a popular deaerating & filling sequence is introduced here for description, the sequence comprising step 809, step 811, and step 813. However, a practical application is not limited to the popular sequence. That is, the practical application can have another sequence of step 811, step 813, and step 809.

Please refer to Fig.10. In step 809, a deaerating process is performed by taking the advantage of a characteristic of the sucking disk 61 able to be air tightened to the surface 311. Through the use to the vacuum-pumping device (not shown) to reduce the pressures of the deaerating & filling pipe 62 and the cavity 33, the air inside of the cavity 33 can be expelled to a region outside of the cavity 33. At this moment, the deformation part 611 is deformed and absorbed to the surface 311, so as to achieve the efficiency of air tightness.

Please refer to Fig.11 and Fig.13. Both of step 811 and step 813 are used to perform the filling process in coordination with the deaerating & filling device 6. Since for the time now the pressures of the deaerating & filling pipe 62 and the cavity 33 are very low, when a pipe line carrying working fluid 5 manufactured in advance is connected to the deaerating & filling pipe 62, the working fluid 5 is compressed and flows into the cavity 33. In many practical applications, because the package 3 is very thin (0.8 mm in thickness), the working fluid 5 flew into the cavity 33 is piled and adhered to the capillaries 41 away from the opening 312. The surface tension generated by the capillaries 41 is large enough to resist a pressure difference generated in step 809. This interrupts the filling process to fill the working fluid 5. In order that the working fluid 5 can be filled into the cavity 33 successfully, the deaerating & filling device 6 further comprises a vaporizing device 65 for vaporizing the working fluid 5. The vaporizing device 65 comprises a first heat conduction element 651, a second heat conduction element 652, a vaporizing channel 653 formed in the first heat conduction element 651, an airtight seal strip 654 installed between the first heat conduction element 651 and the second heat conduction element 652, a flow-guiding hole 655 installed in the second heat conduction element 652 for guiding the working fluid 5 to flow to the vaporizing channel 653, and an operating hole 656 installed in the second heat conduction element 652 in communication with the vaporizing channel 653 and the vacuum pumping device (not shown).

The working fluid 5 can be pure water, methyl alcohol, or other liquids. For the convenience of description, the pure water, as the working fluid 5, is described in the following paragraphs. Therefore, in step 811, both the first heat conduction element 651 and the second heat conduction element 652 are heated up to 200℃, and the vaporizing channel 653 is used to prolong the period when the working fluid 5 is stayed in the first heat conduction element 651 and the second heat conduction element 652, so as to vaporize the working fluid 5 completely. Next in step 813, the working fluid 5 is poured through the flow-guiding hole 655, and the working fluid 5 flows into the cavity 33 due to a pressure difference. Since the package 3 is still at room temperature, the gas working fluid 5 flew into the cavity 33 is congealed through the conduction of the excess heat to the package 3 and the capillary structure 4, and is adhered to the capillaries 41. Because the sucking disk 61 used in step 807 is made of silicon, which is high temperature (250℃) resistant, in the filling process the air tightness of the entire system can be maintained.

In other practical applications, that is when the package 3 is thick (8 mm in thickness), the phenomenon of piled and adhered working fluid 5 will not happen, so the vaporizing device 65 and step 811 can be omitted, and the working fluid 5 is filled directly in step 813.

Additionally, in step 813, a plunger pump controls a filling quantity of the working fluid 5. However, under a circumstance that the filling quantity of the working fluid 5 is required as precise as possible, a peristaltic pump is used to replace the plunger pump.

Please refer to Fig.22. In step 815, the first loading element 71 and the second loading element 72 combine to perform a pressure deformation process. The pressure deformation process means, at room temperature, to proceed a plastic deformation on blank, but without breaking the blank, with external pressure. A detailed description of the pressure deformation process will be described in following three embodiments. A first embodiment of the pressure deformation process, when maintaining at the air tightness described previously, makes the use of the driving device (not shown) to drive the first and the second loading elements 71, 72 to move closer to each other to compress the package 3, and to deform parts of the first loading element 71 and the second loading element 72 corresponding to the surface 311. The first loading element 71 enables an area mounted onto the opening 312 to generate a downward inward compression deformation, while the projecting part 721 enables a part on the second component 32 corresponding to the opening 312 to deform upward and to form a convex deformation. The projecting part 721 further compresses a convex part toward a center of the opening 312, so as to seal, together with the downward inward compression deformation, the opening 312 completely.

Please refer to Fig.12. A second embodiment of the pressure deformation process, when maintaining at the air tightness described previously, drives only the first loading element 71 to move toward the second loading element 72 to compress the package 3 under a support provided by the second loading elements 72, making a part of the package 3 located on the surface 311 to be deformed completely and be compressed toward the center of the opening 312 to seal the opening 312. Note that, since the second loading element 72 is not in operation, the projecting part 721 of the second embodiment can be omitted. Moreover, an objective of the second embodiment is to drive the first loading element 71 to move only, the pressure is smaller, and the second embodiment is suit for thin packages especially.

Please refer to Fig.21. A third embodiment of the pressure deformation process, when maintaining at the air tightness described previously, drives the second loading element 72 only to move toward the first loading element 71, and, under a support provided by the first loading element 71, makes the use of the projecting part 721 to compress the package 3, and deforming a part of the second component 32 corresponding to the surface 311 completely and compressing toward the center of the opening 312 to seal the opening 312. Moreover, an objective of the third embodiment is to drive the second loading element 72 to move only, since a convex point has a small unit area and a corresponding large applied pressure, and the third embodiment is suit for thick packages 3 especially.

When the sealed opening 312 can maintain an air tightness to a certain extent, the deaerating & filling device 6, the first loading element 71, and the second loading element 72 can all be removed. In step 817, the opening 312 is soldered to be air tightened forever, which can be achieved by the use of a spot welding technique or a soldering technique. The spot welding technique puts epoxy resin, silicon gel, or UV gel onto the opening 312 to attain a goal of air tightness forever. One of the soldering techniques hot welds the opening 312 with solder paste or silver tin, that is, to paste the solder paste or the silver tin in the opening 312 and send the opening 312 into a reflow or heat the opening 312 with a heating gun, so as to melt and adhere the solder paste or the silver tin to the opening 312 and to air tighten the opening 312 forever. Another of the soldering techniques solders the opening 312 with a supersonic soldering machine or a laser finisher. As known for those skilled, the techniques applied to metal soldering are not limited to the above techniques. Those techniques described above are the preferred embodiment and do not limit other possible implementing methods.

Note that step 817 can be independent from the heat pipe manufacturing system of the present invention, and can be realized by modern soldering mechanisms and techniques, therefore overcoming current problems such as consuming too much power, and speeding the whole manufacturing flow chart.

Please refer to Fig.14. A heat pipe manufacturing method of a second embodiment of the present invention comprises steps 901 to 923, wherein steps 901, 903, 907, 909, 911, 913, and 915 are similar to steps 801, 803, 805, 807, 811, 813, and 815 respectively, further description of these steps hereby omitted. Only the steps different from the steps in the first embodiment are described in the following paragraphs.

Please refer to Fig.15. In step 905, the finished package 3 further comprises a projecting part 34. Both of the opening 312 and the surface 311 are installed on the projecting part 34. The projecting part 34 can be formed in step 901 or be installed further through the use of a specific process after step 905 when the package 3 is formed.

Please refer to Fig.16. In step 917, a clamping device 74 is used to clamp the projecting part 34. In step 919, a clipping device 75 is used to clip the projecting part 34 to form a clipped end surface 341 able to maintain air tightness temporarily.

In step 921, the clipped end surface 341 is to be sealed. Detailed implementing ways are similar to step 817 described in the first preferred embodiment, further description hereby omitted.

Further, in the second preferred embodiment, step 919 and step 921 can be implemented through the use of an excimer laser machine (not shown) to emit laser beams of high energy onto the projecting part 34 to cut the projecting part 34 and melt the clipped end surface 341, so as to obtain the effect of air tightness.

Please refer to Fig.17. A planar heat pipe manufacturing method of a third preferred embodiment of the present invention comprises steps 201 to 215.

Please refer Fig. 18. Steps 201, 203, and 205 are similar to steps 801, 803, and 805. A slight difference is that the first component 31 comprises a deaerating hole 314 and a filling hole 316, both of which penetrate through two sides opposite to each other, and provides a substantially flat first surface 313 encircling the deaerating hole 314, and a substantially flat second surface 315 encircling the filling hole 316.

Please refer to Fig.19. After the package 3 is finished, a deaerating & filling process and a sealing process are performed in coordination with a deaerating & filling device

6 and a sealing device 7. The deaerating & filling device 6 comprises two sucking disks 61 installed on the deaerating hole 314 and the filling hole 316 respectively, a deaerating pipe 63 to perform a deaerating process via the deaerating hole 314, a filling pipe 64 to perform a filling process via the filling hole 316, and vacuum pumping device (not shown). The sealing device 7 comprises two first loading elements 71 applied to the deaerating hole 314, two second loading elements applied to the filling hole 316, and a driving device (not shown). Additionally, the sucking disks 61, the first loading elements 71, and the second loading elements 72 all have a structure, a out-shape, and a virtue the same as those of corresponding components of the first preferred embodiment, further description hereby omitted.

Please refer to Fig.20. In the preferred embodiment, since both the deaerating process and the filling process are performed via the deaerating hole 314 and the filling hole 316 respectively; these two processes can be performed at a same time. Similar to the two above-mentioned preferred embodiments, step 209 can be performed before the deaerating & filling process of step 211. Through the use of a vaporizing device 65 (shown in Fig.11) to vaporize the liquid working fluid 5 can improve the filling process, or can omit step 209 and perform step 211 directly. In step 211, the vacuum pumping device (not shown) reduces the pressures of the deaerating pipe 63, the filling pipe 64, and the cavity 33, so as to expel the air inside the cavity 33 to a region outside of the cavity 33. In the meantime, a low pressure of the cavity 33 allows the working fluid 5 to flow into and to be accommodated in the capillaries 41.

In step 213, the first loading element 71 and the second loading element 72 combine to perform a pressure deformation process on the deaerating hole 314 and the filling hole 316 as well. When an air tightness described previously is maintained, the driving device (not shown) is used to drive the first and the second loading elements 71, 72 to move closer to each other to compress and deform parts of the first component 31 and the second component 32 disposed on the first surface 313 and the second surface 315 corresponding to the surface 311, so as to seal the deaerating hole 314 and the filling hole 316.

In step 215, a welding process is performed on the sealed deaerating hole 314 and the filling hole 316. The welding process has an implementing way similar that is step 817, further description hereby omitted.

In summary, taking the advantage of the sucking disk 61 able to maintain air tightness in the deaerating process, the planar heat pipe manufacturing method of the present invention can overcome the drawback of the prior art unable to maintain air tightness in a joint through the use of a welding process or a soldering process. Different from the steel pipe 14, which is cut off or stays on the package 3, the sucking disk 61 can be reused after the clamping process or the pressure deformation process is done. Through the use of the pressure deformation developed from the opening 312 formed on the surface, the heat pipe manufacturing system of the present invention overcomes the problem that the air tightness is not ensured after the clamping force is removed. Therefore, the heat pipe manufacturing system of the present invention is surely capable of achieving the goals and virtues of the invention.

Following the detailed description of the present invention above, those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

CLAIMS

What is claimed is:

1. A planar heat pipe manufacturing method comprising the following steps of:
   (A) Forming a planar hollow package made of a ductile material, the package comprising a cavity;
   (B) Providing a substantially flat surface installed on the package, and an opening formed on the surface for connecting the cavity;
   (C) Mounting a sucking disk onto the opening, the sucking disk comprising a deformation part and a through hole penetrating through the deformation part, a sucking ring being formed at an outer region of the deformation part;
   (D) Deaerating air inside the cavity via the through hole;
   (E) Filling working fluid into the cavity of the package via the through hole; and
   (F) Compressing the package along a direction perpendicular to the surface to deform and extend part of the package to seal the hole.

2. The planar heat pipe manufacturing method as recited in claim 1, wherein step (D) comprises the following sub-steps:
   (D-1) inserting a deaerating & filling pipe into the through hole; and
   (D-2) reducing an inner pressure of the deaerating & filling pipe to perform a deaerating process, when the deformation part is deformed and absorbed to the surface to maintain air tightness.

3. The planar heat pipe manufacturing method as recited in

claim 1, wherein step (E) fills the working fluid into the cavity of the package through the use of a deaerating & filling pipe inserted into the through hole.

4. The planar heat pipe manufacturing method as recited in claim 1 further comprising (G) vaporizing the working fluid.

5. The planar heat pipe manufacturing method as recited in claim 1 further comprising (H) welding the opening to seal the cavity of the package.

6. The planar heat pipe manufacturing method as recited in claim 5, wherein step (H) welds the opening through the use of a spot welding technique.

7. The planar heat pipe manufacturing method as recited in claim 5, wherein step (H) welds the opening through the use of a soldering technique.

8. A planar heat pipe manufacturing method comprising the following steps of:

(I) Forming a planar hollow package made of a ductile material, the package comprising a cavity;

(J) Providing a substantially flat first surface and second surface installed on the package, and forming a deaerating hole installed on the first surface and a filling hole installed on the second surface, both of the deaerating hole and filling hole connected to the cavity;

(K) Mounting two sucking disks onto the deaerating hole and the filling hole respectively, each of the sucking disk comprising a deformation part and a through hole penetrating through the deformation part, a sucking ring being formed at an outer region of the deformation part;

(L) Deaerating air inside the cavity via a through hole installed on the deaerating hole;

(M) Filling working fluid into the cavity of the package via a through hole installed on the filling hole; and

(N) Compressing the package along directions perpendicular to the first surface and the second surface respectively to deform and extend part of the package to seal the deaerating hole and the filling hole.

9. The planar heat pipe manufacturing method as recited in claim 8, wherein step (L) comprises the following sub-steps:

(L-1) inserting a deaerating pipe into the through hole; and

(L-2) reducing an inner pressure of the deaerating pipe to perform a deaerating process, when the deformation part is deformed and absorbed to the first surface to maintain air tightness.

10. The planar heat pipe manufacturing method as recited in claim 8, wherein step (M) fills the working fluid into the cavity of the package through the use of a filling pipe inserted into the through hole.

11. The planar heat pipe manufacturing method as recited in claim 8 further comprising (O) vaporizing the working fluid.

12. The planar heat pipe manufacturing method as recited in claim 8 further comprising (P) welding the deaerating hole and the filling hole to seal the cavity of the package.

13. The planar heat pipe manufacturing method as recited in claim 12, wherein step (P) welds the deaerating hole and the filling hole through the use of a spot welding technique.

14. The planar heat pipe manufacturing method as recited in claim 12, wherein step (P) welds the deaerating hole and the filling hole through the use of a soldering technique.

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**Application No:** GB0513113.1 **Examiner:** Stephen Hart

**Claims searched:** 1 & 8 at least **Date of search:** 5 October 2006

# Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance |
|---|---|---|
| A | | JP 2005016892 A (FURUKAWA) 20.01.05 (see figs 1 - 7, EPODC Abstract and also WPI Abstract Accession No. 2005-085571 [10]), noting deaerating and filling opening 16 on a flat surface of a heat pipe, and an opening and closing unit 22 compressing and caulking the heat pipe to seal the opening. |
| A | | JP 03122496 A (NIPPON) 24.05.91 (see figs 1 - 4 and also EPODOC Abstract). |
| A | | JP 62245086 A (FUJIKURA et al.) 26.10.87 (see figs 1 - 8 and also EPODOC Abstract). |
| A | | JP 61070389 A (TOKYO) 11.04.86 (see figs 1 - 4 and also EPODOC Abstract). |

Categories:

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| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art |
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**Field of Search:**

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC$^X$ :

F4S; F4U

Worldwide search of patent documents classified in the following areas of the IPC

B21D; B23P; F28D

The following online and other databases have been used in the preparation of this search report

Online: WPI, EPODOC