US 20050077030A1

(19) United States
(12) Patent Application Publication
Wong
(10) Pub. No.: US 2005/0077030 A1
(43) Pub. Date: Apr. 14, 2005

(54) TRANSPORT LINE WITH GROOVED MICROCHANNELS FOR TWO-PHASE HEAT DISSIPATION ON DEVICES

(76) Inventor: **Shwin-Chung Wong**, Hsinchu (TW)

Correspondence Address:
HungChang LIN
8 Schindler Ct.
Silver Spring, MD 20903 (US)

(21) Appl. No.: **10/936,065**

(22) Filed: **Sep. 9, 2004**

(30) **Foreign Application Priority Data**

Oct. 8, 2003 (TW) 092127907
Mar. 30, 2004 (TW) 093108606
May 3, 2004 (TW) 093112391

Publication Classification

(51) **Int. Cl.**[7] **F25B 21/02**
(52) **U.S. Cl.** **165/104.26**; 165/104.11

(57) **ABSTRACT**

Grooved microchannels are used to enhance the capillary action in the transport line of two-phase heat dissipation devices, such as loop heat pipes, capillary pump loops, or spray cooling devices, or others. Efficient heat dissipations achieved by enhancing the capillary pumping force for the liquid flow without significantly increasing the friction force. The effective cross-sectional area of the liquid line is made smaller than that of the condensation section, either by inserting a plug or shrinking the liquid line, to provide additional pumping force for the coolant recycling.

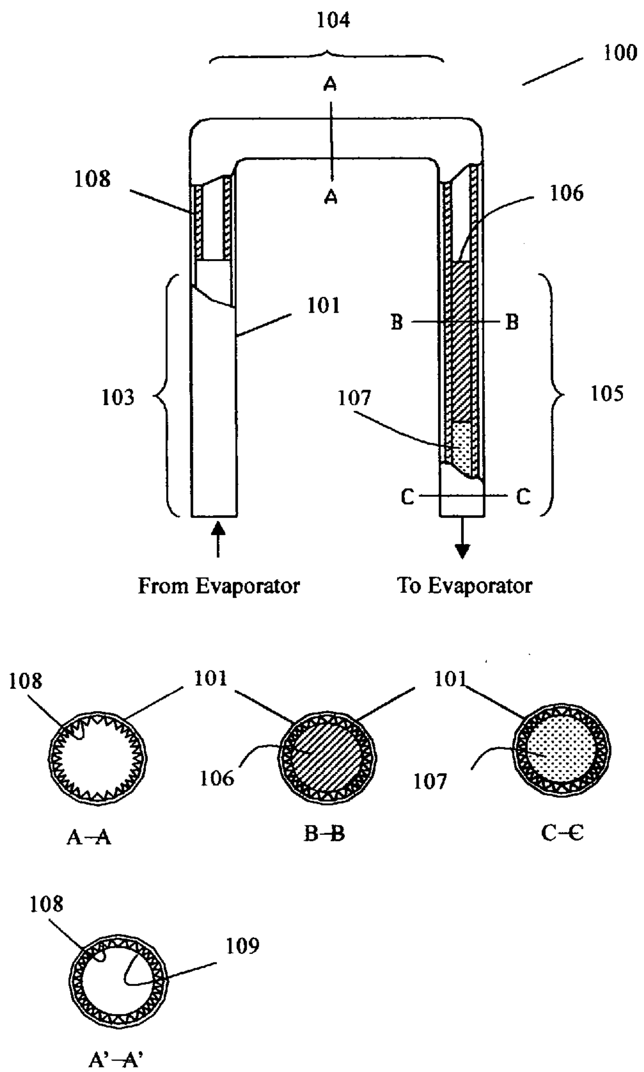


Fig. 1. Prior Art

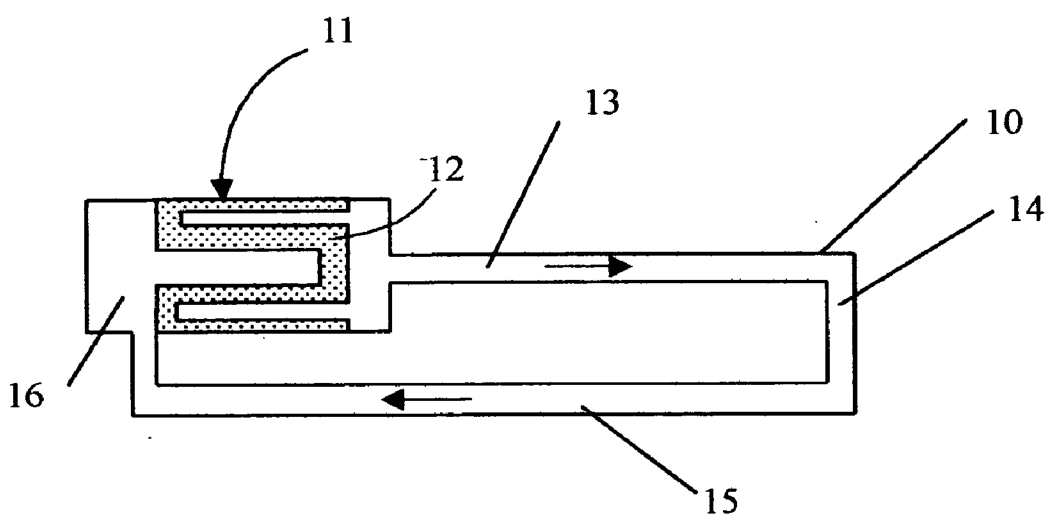


Fig. 2. Prior Art

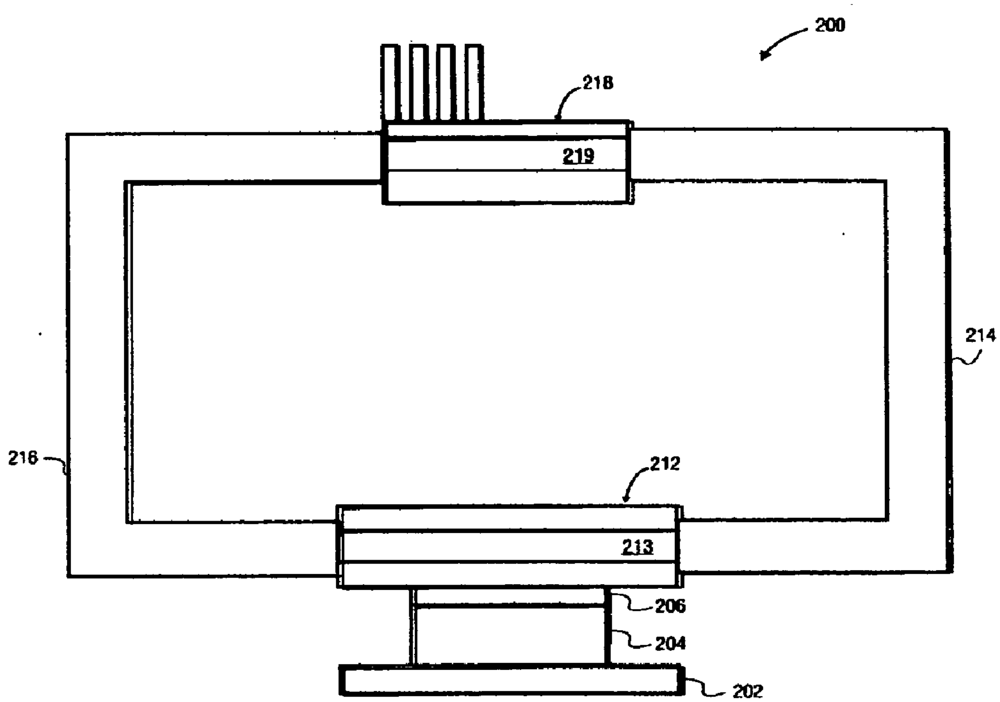


Fig. 3.

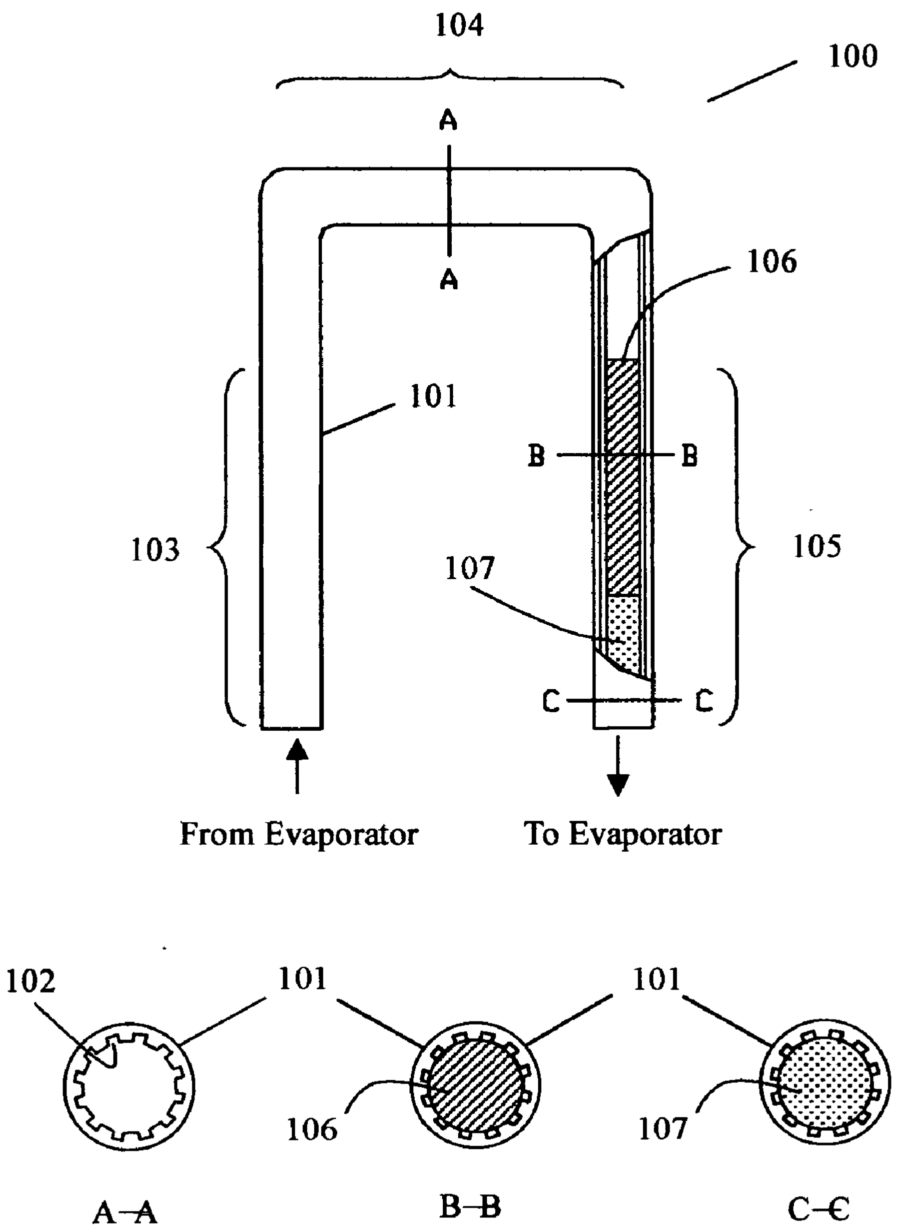

104
100
A
A
106
101
B
B
103
105
107
C
C
From Evaporator
To Evaporator
102
101
101
106
107
A–A
B–B
C–C

Fig. 4.

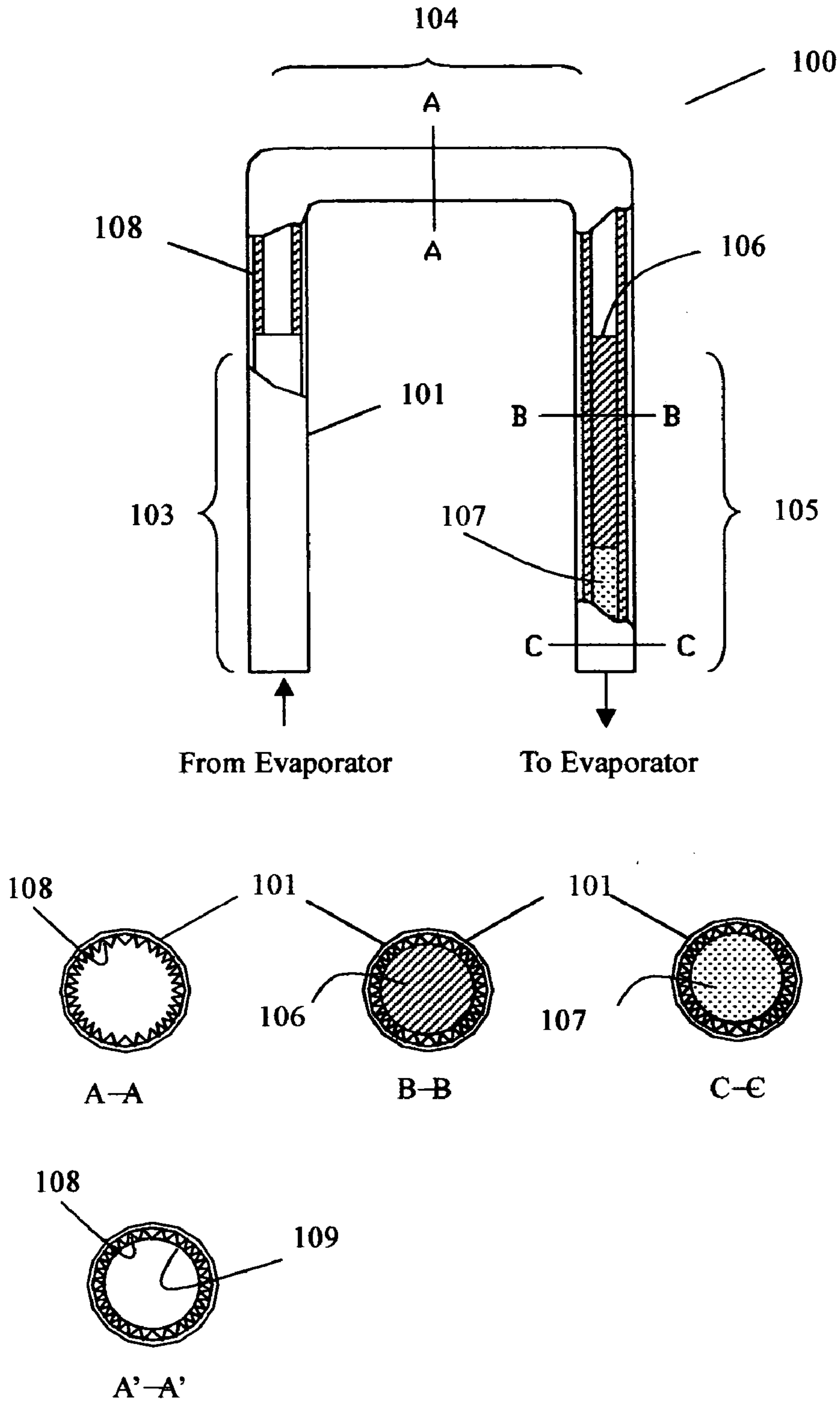

104
100
A
A
108
106
101
B
B
103
107
105
C
C
From Evaporator
To Evaporator
108
101
101
106
107
A-A
B-B
C-C
108
109
A'-A'

Fig. 5.

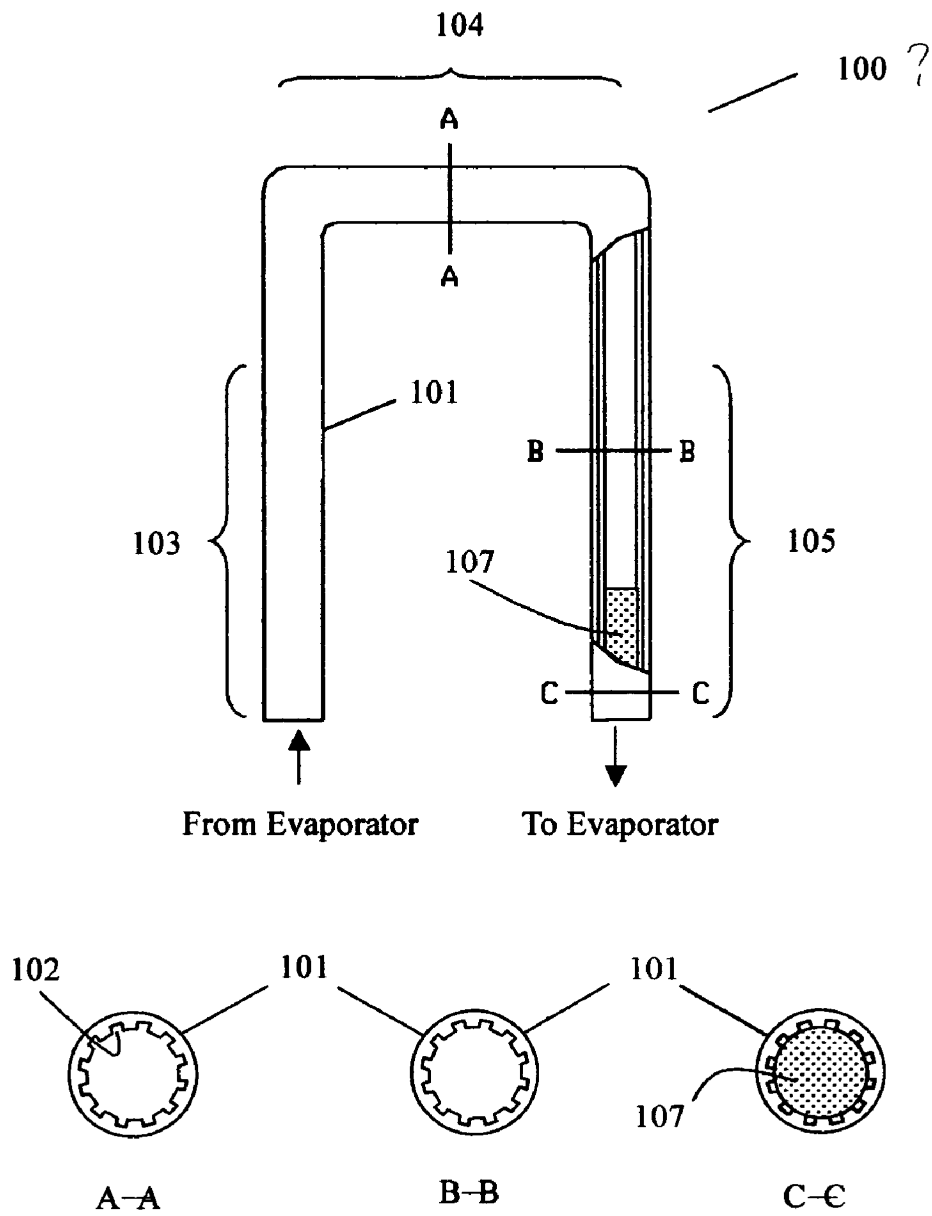

104
100 ?
A
A
101
103
B
B
105
107
C
C
From Evaporator
To Evaporator
102
101
101
107
A-A
B-B
C-C

Fig. 6.

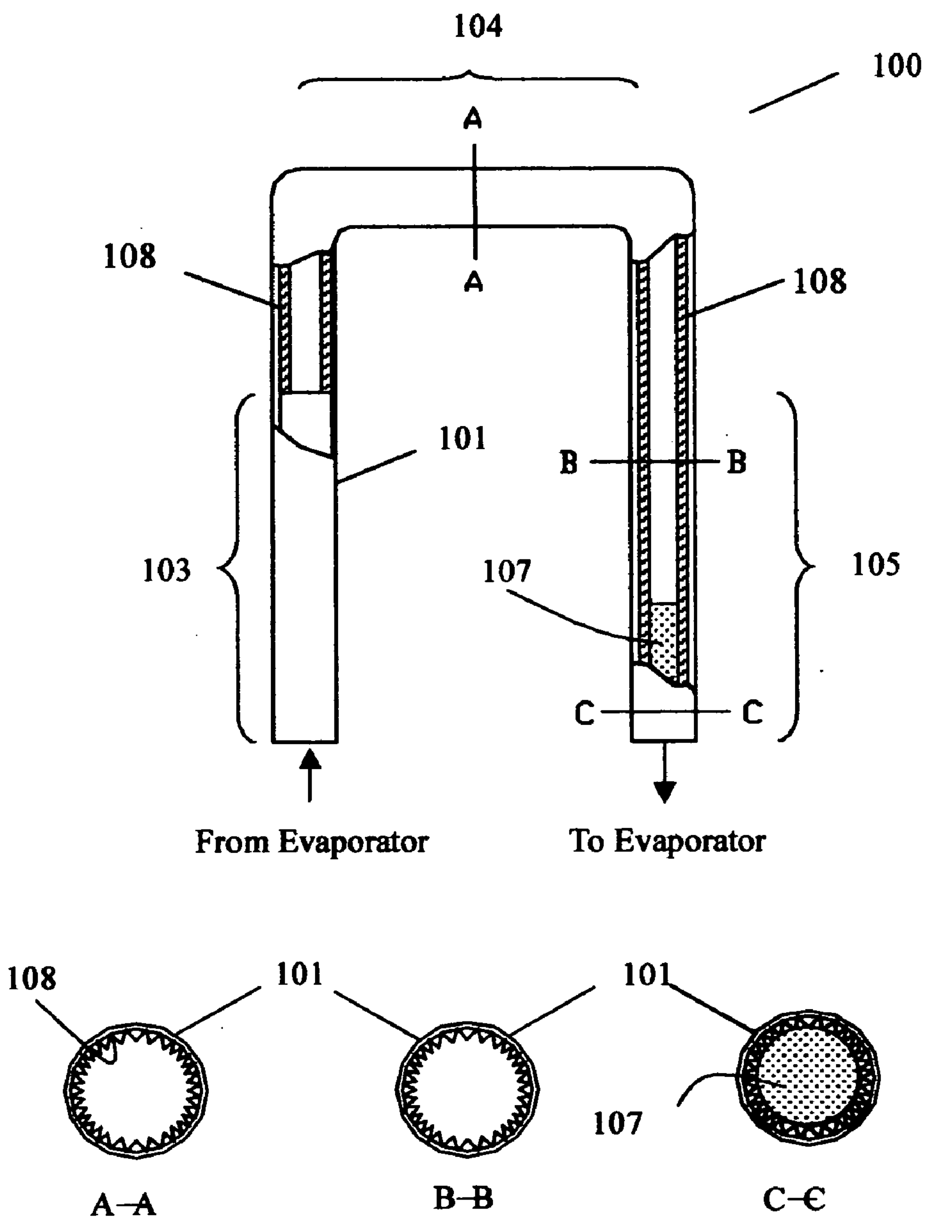

104
100
A
A
108
108
101
B
B
103
105
107
C
C
From Evaporator
To Evaporator
108
101
101
107
A–A
B–B
C–C

Fig. 7.

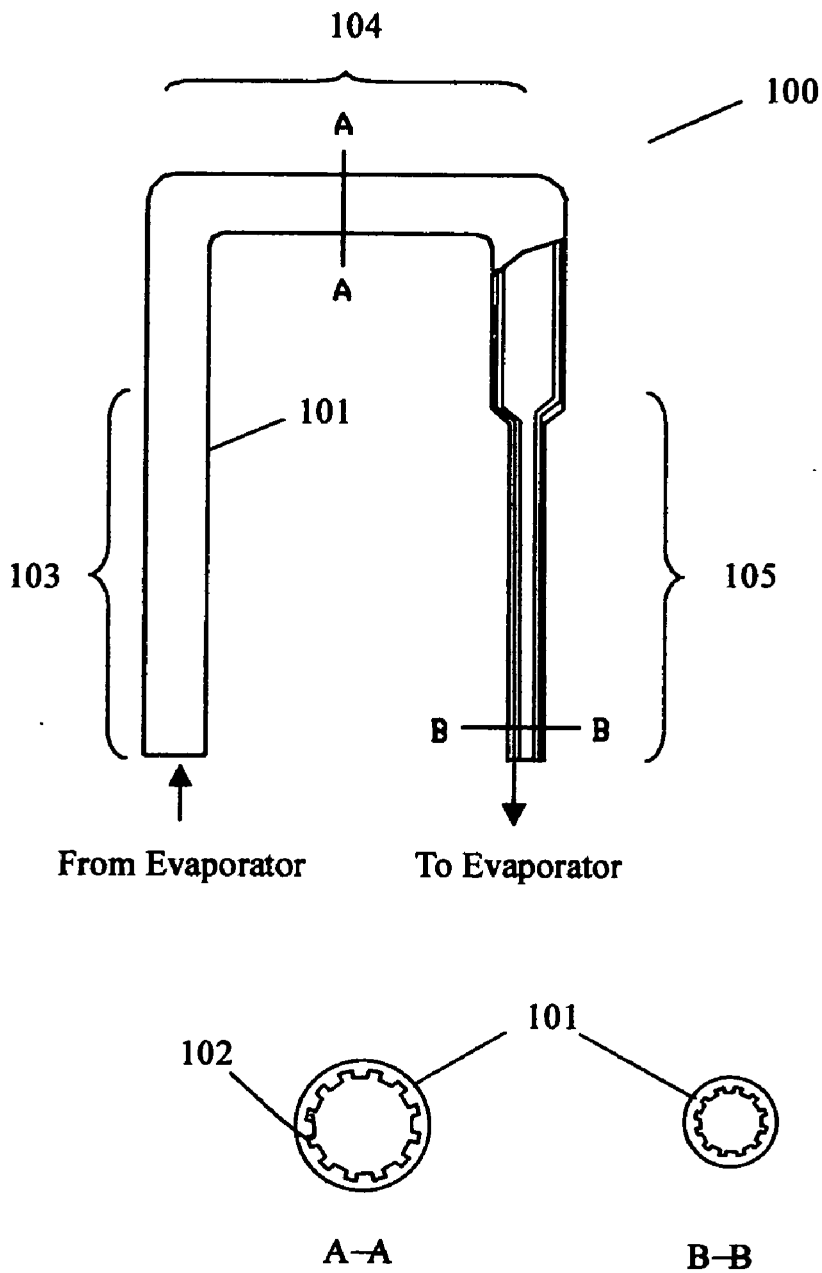

104
100
A
A
101
103
105
B
B
From Evaporator
To Evaporator
101
102
A-A
B-B

Fig. 8.

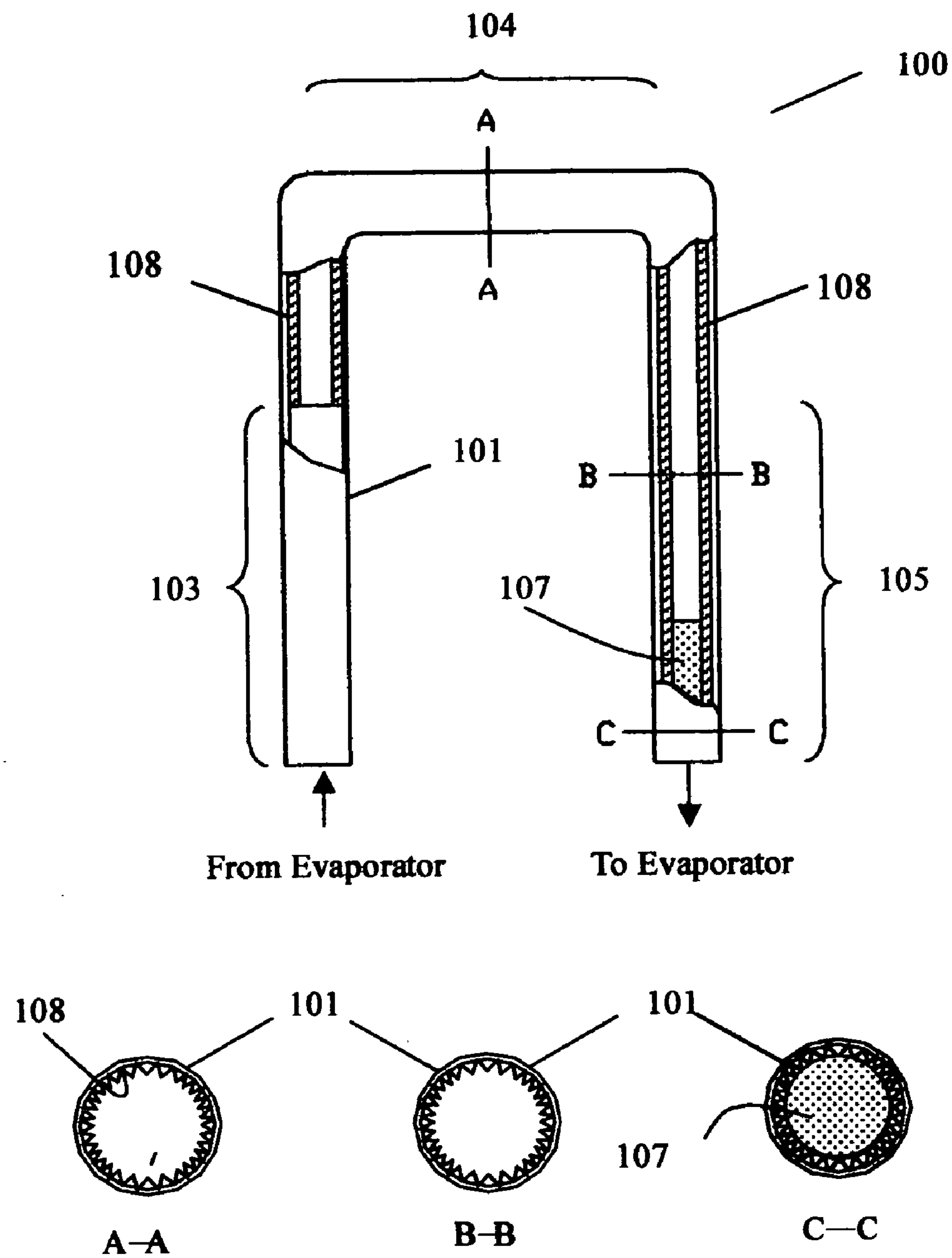
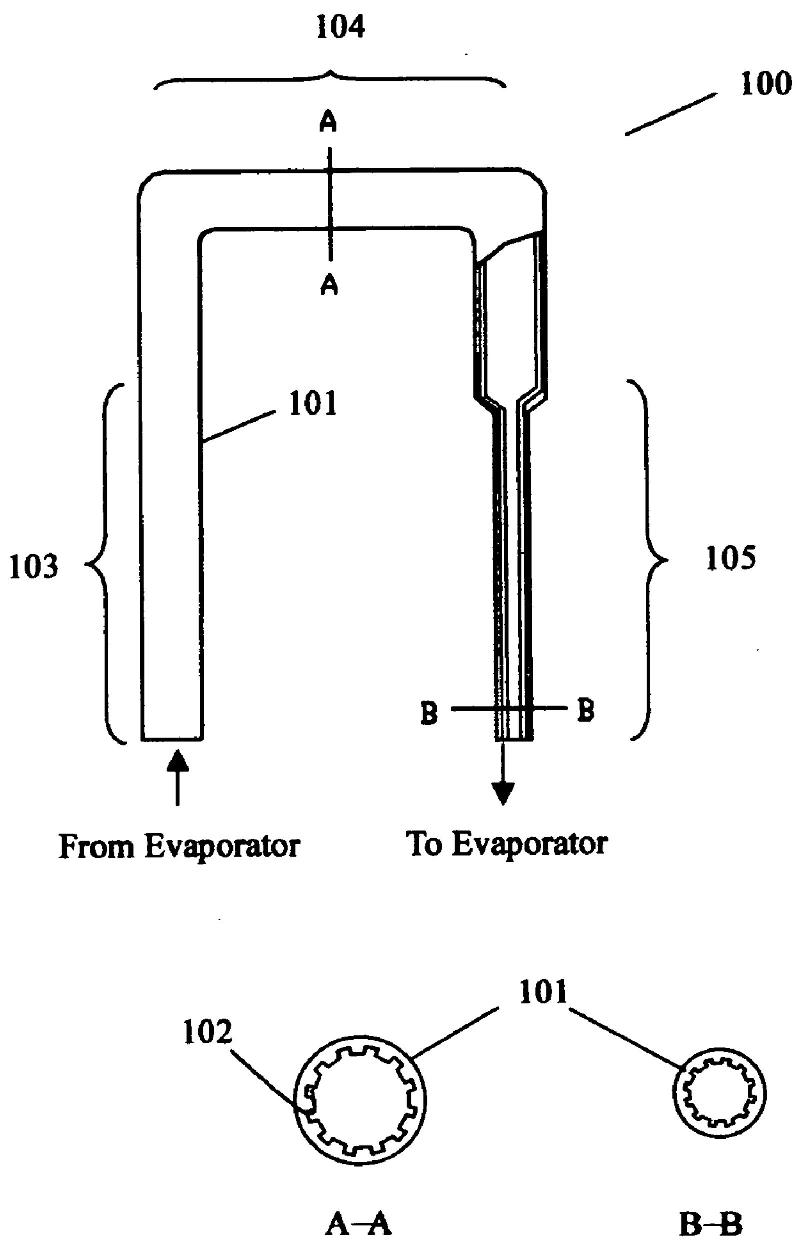

104
100
A
A
108
108
101
B
B
103
107
105
C
C
From Evaporator
To Evaporator
108
101
101
107
A-A
B-B
C—C

Fig. 9.


104
100
A
A
101
103
105
B
B
From Evaporator
To Evaporator
102
101
A–A
B–B

TRANSPORT LINE WITH GROOVED MICROCHANNELS FOR TWO-PHASE HEAT DISSIPATION ON DEVICES

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention related to two-phase heat dissipation devices, particularly to the transport line of loop heat pipes, capillary pump loops, spray cooling devices or others. The two-phase heat dissipation device is sued for heat removal of heat generating devices, such as the central processing unit (CPU) or other integrated circuit (IC) chips.

[0003] 2. Brief Description of Related Art

[0004] As electronic technology advances, more electronic function is performed in a smaller area on a semiconductor chip. More electronic function is invariably accompanied with temperature increase which may damage the chip. To maintain a safe temperature, it is necessary to remove the heat generated in the chip at the chip mount.

[0005] A widely used method for cooling the chip mount is to utilize the two-phase heat transfer during phase transition between liquid phase and vapor phase of a coolant. In this method, a vaporization section vaporizes the coolant and carries away a large amount of heat energy, and the vapor fills the originally evacuated space. In the condensation section, the vapor condenses into liquid for recycling and releases a large amount of heat energy. The heat pipe is a commonly applied heat dissipation device in this category. However in the traditional heat pipe, the vapor and the recycling liquid move in opposite directions. This impedes the recycling capillary pumping action and tends to limit the maximum heat dissipation capability of the heat pipe.

[0006] **FIG. 1** shows a prior art to remedy this problem, using a loop heat pipe (LHP). The LHP comprises sequentially an evaporator **11**, a wick **12**, a vapor conduit **13**, a condensation section **14**, a liquid line **15**, and a compensation chamber **16**. The principle of operation is similar to that of a traditional heat pipe except that the vapor and the liquid flow in single way along a guiding loop. The operation still depends on the capillary action. The liquid compensation chamber is used to compensate the dispersion of the liquid in the loop to avoid the evaporator drying out.

[0007] **FIG. 2** shows another prior art disclosed in U.S. Pat. No. 6,381,135. The LHP **200** has an evaporator **212** placed on a heat-generating device **204** on top of a substrate **202**. A thermal interface material **206** is placed between the device **204** and the evaporator **212**. The evaporator **212** comprises a wick **213**, one end of which is connected to a liquid line **214**, which also has a wick (not shown). The second wick need not be the same as the first wick and may be of sintered metal powder, metallic wire mesh, or packed spherical particles. The vapor line **216** is simply a hollow tube. The condenser **218** is a hollow block of metal, which can be mounted with fins to dissipate heat. The condenser **218** may have a third wick **219**, which need not be the same as the first two wicks. The drawback of this structure is that the wicks in the condenser **218** and the liquid line **214** increase the friction to the liquid flow and hence retard coolant recycling. Therefore, the evaporator tends to dry out at high heat dissipation and limit the heat cooling capability. For the reason that the volume flow rate of the vapor far exceeds that of the liquid, the liquid line **214** requires much smaller cross-sectional area than the vapor line **216**. When the liquid section and the vapor section use the same large tubing, the liquid line cannot provide additional capillary force. If both sections use the same small tubing, the vapor speed and the friction in the vapor line becomes excessive.

SUMMARY OF THE INVENTION

[0008] The object of this invention is to provide efficient flow of a coolant in a transport line for loop heat pipes, capillary pump loops or spray cooling devices. Another object of this invention is to provide additional pumping force for the liquid flow without significantly increasing the friction force.

[0009] These objectives are achieved by using grooved microchannels in the liquid line. Grooved microchannels can be optionally made in the inner surface of the condensation section. Further, a plug can be inserted in the liquid line to reduce its effective cross-sectional area to enhance the pumping force. Another way is to shrink the liquid line section to reduce its effective cross-sectional area to enhance the pumping force. The grooved microchannels in the liquid line provide additional pumping force for coolant recycling with limited friction force.

[0010] The grooved microchannels can be constructed on the inner surface of the tube by means of extrusion molding of the tube, or by lining a groove-corrugated wire mesh along the inner wall of the transport line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **FIG. 1** shows a prior art loop heat pipe.

[0012] **FIG. 2** shows a second prior loop heat pipe disclosed in U.S. Pat. No. 6,381,135

[0013] **FIG. 3** shows a first embodiment of the present invention with grooved microchannels along the inner wall of the condensation section and liquid line, and a plug inserted in the liquid line.

[0014] **FIG. 4** shows a second embodiment of the present invention with grooved microchannels covered with a layer of wire mesh along the inner wall of the condensation section and liquid line, and a plug inserted in the liquid line.

[0015] **FIG. 5** shows a third embodiment of the present invention with a groove-corrugated wire mesh lining along the inner wall of the condensation section and the liquid line to form microchannels, and a plug inserted in the liquid line.

[0016] **FIG. 6** shows a fourth embodiment of the present invention with grooved microchannels along the inner wall of the condensation section and liquid line, and without a plug in the liquid line.

[0017] **FIG. 7** shows a fifth embodiment of the present invention with grooved microchannels covered with a layer of wire mesh along the inner wall of the condensation section and liquid line, and without a plug in the liquid line.

[0018] **FIG. 8** shows a sixth embodiment of the present invention with a groove-corrugated wire mesh lining along the inner wall of the condensation section and the liquid line, and without a plug in the liquid line.

[0019] **FIG. 9** shows a seventh embodiment of the present invention with shrunk cross-section of the liquid line.

DETAILED DESCRIPTION OF THE INVENTION

[0020] **FIG. 3** shows the first embodiment of the present invention. The flow path of the transport line **100** has sequential three sections: a vapor line **103**, a condensation section **104**, and a liquid line **105**. The inner wall of the tubing **101** of the condensation section and liquid line is made with grooved microchannels **102**, which can be made by extrusion molding during the fabrication of the tubing **101**. The grooved microchannel has a hydraulic diameter smaller than the 500 μm. The cross-section of the groove can be triangular, rectangular, trapezoidal, wavy, or others. A plug **106** is inserted into the core of the liquid line **105** to reduce its effective cross-sectional area to only the groove microchannels, to enhance the pumping force. The plug **106** can be fabricated with metal, plastic or other heat resistant materials. The bottom corners of the grooved microchannels as shown in A-A section view help to collect the condensed liquid and convey it to the liquid line section. With the grooved microchannels closed by a plug **106** in the liquid line **105**, the liquid can be effectively pumped with capillary action back to the wick (not shown) in the main body of the two-phase heat dissipation device. At the end of the liquid section **105**, a capillary material **107** is optionally inserted. The capillary material **107** provides smoother connection with the wick (not shown) in the main body of the two-phase heat dissipation device. The vapor line section **103** can be a tube only or inserted with a grooved microchannels. The condensation section **104** is inserted with a grooved microchannels, which has a cross-section shown in cross-section A-A; the upper part of the liquid line **105** has a cross-section B-B; and, if the capillary material **107** is inserted, the lower part of the liquid line **105** has a cross-section C-C.

[0021] The grooved microchannels can also be fabricated on the surface of the plug **106**.

[0022] With a reduced effective cross-sectional area in the liquid section **105** by inserting a plug **106** and leaving the grooved microchannels only as a passage for the liquid, additional pumping force is provided for coolant recycling without significantly increasing friction in the liquid flow.

[0023] **FIG. 4** shows a second embodiment of the present invention. This embodiment differs from the first embodiment in that a layer of wire mesh **109** is added to cover the grooved microchannels **102** for at least the condensation section **104**, as shown in cross-section A-A, to improve the pumping ability. The material of the wire mesh can be metals or nonmetals.

[0024] **FIG. 5** shows a third embodiment of the present invention. The grooved microchannels are fabricated with a layer of a corrugated wire mesh to line in along the inner wall of the tubing **101** of the transport line. The vapor section **103** can be a tube only or inserted with a corrugated wire mesh as shown in the cross-section A-A, The condensation section **104** has a cross-section A-A with corrugated wire mesh lining **108**. The liquid line section has a cross-section B-B with corrugated wire mesh enclosing a plug **106** which reduces the effective cross-sectional area for the liquid to flow. The wire mesh is corrugated with a cross-section shape either of triangular, rectangular, trapezoidal, wavy, or other groove shape with equivalent function. The corrugated wire mesh is basically inserted into the condensation section **104** and liquid line **105**. A plug **106** is optionally inserted as a core in the liquid line **105** to reduce its effective cross-sectional area. An additional layer of wire mesh **109** can be optionally placed against the corrugated wire mesh **108** to form closed grooved microchannels in the condensation section **104**, as shown in cross-section A'-A', to improve the pumping ability. The material of the wire mesh can be metals or nonmetals.

[0025] **FIG. 6** shows a fourth embodiment of the invention. The structure is similar to **FIG. 3** with the same reference numerals denoting the corresponding parts. The only difference is that the plug **106** in the liquid line **105** in **FIG. 3** is removed. The optional capillary material **107** provides smoother connection with the wick (not shown) in the main body of the two-phase heat dissipation device.

[0026] **FIG. 7** shows a fifth embodiment of the invention. The structure is similar to **FIG. 4** with the same reference numerals denoting the corresponding parts. The only difference is that the plug **106** in the liquid line **105** in **FIG. 4** is removed. The optional capillary material **107** provides smoother connection with the wick (not shown) in the main body of the two-phase heat dissipation device. In this embodiment, the layer of wire mesh **109** covers at least the condensation section **104** and the liquid line **105** to improve the pumping ability.

[0027] **FIG. 8** shows a sixth embodiment of the invention. The structure is similar to **FIG. 5** with the same reference numerals denoting the corresponding parts. The only difference is that the plug **106** in the liquid line **105** in **FIG. 5** is removed. The optional capillary material **107** provides smoother connection with the wick (not shown) in the main body of the two-phase heat dissipation device. Again, an additional layer of wire mesh **109** can be placed inside the corrugated wire mesh to form closed microchannels in the condensation section **104** and the liquid line **105** (as shown in section A'-A' of **FIG. 5**) to improve the pumping ability.

[0028] **FIG. 9** shows a seventh embodiment of the present invention. The inner wall of the tubing **101** of the condensation section **104**, and the liquid line **105** has grooved microchannels as shown in cross-section A-A, and the liquid section **105** has a cross-section B-B which is made smaller than that of the condensation section **104** as shown in the cross-section A-A. Also, a layer of wire mesh **109** can be added to cover the grooved microchannels **102** for at least the condensation section **104** (not shown). The shrunk liquid line **105** enhances capillary action for the coolant recycling. In addition, a plug can be inserted in the shrunk liquid line **105** (not shown) to further reduce its effective cross-section area An optional capillary material **107** can be added (as shown in **FIG. 8**) in the end of the liquid line **105**.

[0029] Other embodiments having a smaller effective cross0section area of the liquid line **105** can be made without grooved mnicrochannels on the inner wall of the transport line (not shown). This can be achieved by simply inserting a plug **106** having a size slightly smaller than of the transport line into the liquid line **105**. The small gap between the non-grooved inner wall surface of the evaporator. Alternatively, this can be achieved by shrinking the liquid line **105**. In addition, a plug can be inserted into the shrunk liquid line to further reduce its effective cross-sectional area. Again, a layer of wire mesh **109** can be added to cover the inner surface of at least the condensation section **104**. An optional capillary material **107** can be added in the end of the liquid line **105**.

[**0030**] While the preferred embodiments of the invention have been described, it will be apparent to those skilled in the art, the various modifications may be made in the embodiments without departing from the spirit of the present invention Such modifications are all within the scope of the present invention.

1. A transport line for use in a two-phase dissipation device, comprising:

a vapor line section for flowing a coolant in vapor phase from an evaporator in the main body of said two-phase heat dissipation device, a condensation section for condensing the vapor phase from said vapor section into liquid phase, and a liquid line section for refluxing said liquid phase coolant from said condenser section back to said evaporator; and

grooved microchannels made along the inner wall of said liquid line section to enhance capillary action.

2. The transport line for use in a two-phase heat dissipation device as described in claim 1, further comprising:

grooved microchannels made along the inner wall of said condensation section to enhance capillary action.

3. The transport line as described in claim 2, further comprising a layer of wire mesh covering said grooved microchannels.

4. The transport line as described in claim 1, wherein the cross-section of said transport line is circular.

5. The transport line as described in claim 1, wherein said grooved microchannels have a cross-section selected from the group consisting of: V-shaped, triangular, rectangular, trapezoidal, and wavy.

6. The transport line as described in claim 1, wherein said grooved microchannels are formed by corrugating the inner wall of said section.

7. The transport line as described in claim 1, wherein said grooved microchannels are formed by lining the inner wall of said section with corrugated wire mesh.

8. The transport line as described in claim 7, further comprising a layer of wire mesh placed against said corrugated wire mesh to form closed grooved microchannels.

9. The transport line as described in claim 1, further comprising a capillary material inserted in said liquid line section.

10. The transport line as described in claim 1, further comprising a plug, inserted in said liquid line section to make an effective cross-sectional area smaller.

11. The transport line as described in claim 10 wherein said grooved microchannels are formed on the surface of said plug.

12. The transport line as described in claim 11, further comprising a capillary material inserted in said liquid line section.

13. The transport line as described in claim 1, wherein said liquid line section shrinks to make an effective cross-sectional area smaller.

14. The transport line as described in claim 13, further comprising a plug, inserted in said liquid line section to further make an effective cross-sectional area smaller.

15. The transport line as described in claim 13, further comprising a capillary material inserted in said liquid line section.

16. A transport line for use in a twO-phase heat dissipation device, comprising:

a vapor line section for flowing a coolant in vapor phase from an evaporator in the main body of said tw0-phase heat dissipation device, a condensation section for condensing the vapor phase from said vapor section into liquid phase, and a liquid line section for refluxing said liquid phase coolant from said condenser section back to said evaporator, and the effective cross-sectional area of said liquid line section is smaller than the cross-sectional area of said vapor section.

17. The transport line as described in claim 16, further comprising a later of wire mesh placed against the inner wall of at least said condensation section.

18. The transport line as described in claim 16, wherein the effective cross-sectional area of said liquid line section is made smaller by inserting a plug.

19. The transport line as described in claim 16, wherein the effective cross-sectional area of said liquid line section is made smaller by shrinking said liquid line section.

20. The transport line as described in claim 16, further comprising a capillary material inserted in said liquid line section.

21. The transport line as described in claim 20, wherein the effective cross-sectional area of said liquid line section is made further smaller by inserting a plug.

* * * * *