(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 June 2006 (29.06.2006)

PCT

(10) International Publication Number
WO 2006/067378 A1

(51) International Patent Classification:
F28F 1/22 (2006.01)

(21) International Application Number:
PCT/GB2005/004771

(22) International Filing Date:
13 December 2005 (13.12.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0428029.3 22 December 2004 (22.12.2004) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

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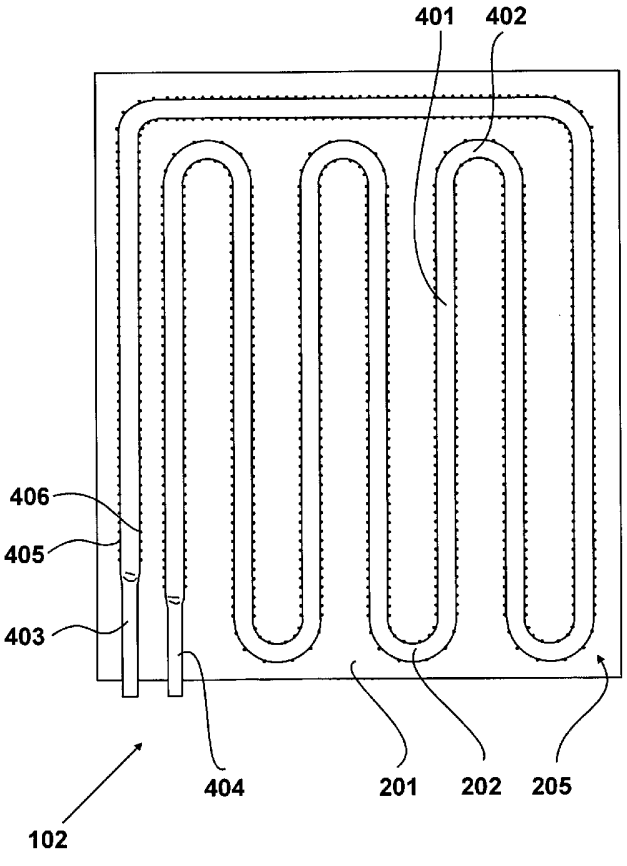
(54) Title: A HEAT EXCHANGER



(57) Abstract: A heat exchanger (102) for use in a refrigeration unit (101), comprising a metal plate (201) and a metal tube (202) for containing refrigerant (203). The metal plate (201) has a first face (204) and a second face (205), and the tube (202) is attached to said first face (204) of the metal plate by a plurality of spot welds (405,406). The spot welds are laser spot welds and said welds extend through only a portion of the thickness of the plate (201), such that the second face (205) of the plate is undisturbed by the welds.

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FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A Heat Exchanger

Background of the Invention

The present invention relates to a heat exchanger for use in a refrigeration unit, a method of manufacturing a heat exchanger for a refrigeration unit, and a refrigeration unit comprising a heat exchanger.

It is well known for refrigeration units, such as domestic refrigerators, to have heat exchangers which comprise of a metal tube which carries a refrigerant. The heat exchanger could typically be an evaporator within which refrigerant evaporates and thereby absorbs latent heat of evaporation, or it could be a condenser within which the refrigerant re-condenses back into liquid form. It is also known for the tube of the heat exchanger to be attached to a metal plate. In instances where the heat exchanger is used as an evaporator, the metal plate is used to conduct heat from a refrigeration cavity, where items are stored, to the tube containing the refrigerant. It is also known to attach the metal tube to the plate by brazing.

A problem with such a brazed evaporator is that it is relatively costly to make due to the materials required and the number and duration of the manufacturing processes involved.

Brief Summary of the Invention

According to a first aspect of the present invention, there is provided a heat exchanger for use in a refrigeration unit, said heat exchanger comprising: a metal plate having a first face and a second face; and a metal tube for containing refrigerant attached to said first face of said metal plate by a plurality of spot welds, wherein said spot welds are laser spot welds and said welds extend through only a portion of the thickness of said plate.

According to a second aspect of the present invention, there is provided a method of manufacturing a heat exchanger for a refrigeration unit, comprising the steps of: obtaining a metal plate having a first face and a second face; and attaching a metal tube for containing refrigerant to said first

face of said metal plate by a plurality of spot welds, wherein said spot welds are made by a laser and said welds extend through only a portion of the thickness of said plate.

According to a third aspect of the present invention there is provided a refrigeration unit having a heat exchanger, said heat exchanger comprising: a metal plate having a first face and a second face; and a metal tube for containing refrigerant attached to said first face of said metal plate by a plurality of laser spot welds.

Brief Description of the Several Views of the Drawings

Figure 1 shows a refrigeration unit **101** incorporating a refrigeration evaporator **102**;

Figure 2 shows a simplified cross-section of the evaporator **102** mounted within refrigeration unit **101;**

Figure 3 shows a simplified cross-sectional view of an alternative refrigeration unit **301**;

Figure 4 shows a plan view of the evaporator **102;**

Figure 5 shows a perspective view of the evaporator **102;**

Figure 6 shows a flow chart illustrating a method for manufacturing the evaporator **102**;

Figure 7 shows schematically apparatus for welding the tube to the plate at step **606** of *Figure 6;*

Figure 8 shows positioning apparatus **106** and laser focus heads **105A** and **105B** laser spot welding a tube **202** on a plate **201;**

Figure 9 shows positioning rollers that are located within the positioning head **804** of *Figure 8*;

Figure 10 shows a portion of the tube **202** and plate **201** and illustrates the position of welds **1001;**

Figure 11 shows a cross-section of a portion of the evaporator **102** after application of the protective layer **1101;**

Figure 12 shows an alternative evaporator **1202** to the evaporator **102**;

Figure 13 shows a further alternative evaporator **1302**; and

Figure 14 shows a further alternative evaporator **1402.**

Written Description of the Best Mode for Carrying out the Invention

Figure 1

Figure 1 illustrates a refrigeration unit **101** incorporating a refrigeration evaporator **102**. Refrigeration evaporator **102** is mounted to the rear wall of inner refrigeration cavity walling **103** within the refrigeration cavity **104**, so that one side of the refrigeration evaporator **102** is visible within refrigeration cavity **104**, when refrigeration unit door **105** is open. Refrigeration cavity **104** is typically used to temporarily store and preserve perishable items, for example, consumable food goods. The evaporator **102** has the appearance of a plane sheet of material with a smooth unmarked surface.

Refrigeration unit **101** is fitted with removable shelves **106** and **107** within the refrigeration cavity **104** to maximise the available storage space.

In the present embodiment, the refrigeration unit is a domestic refrigerator. However, in alternative embodiments, the refrigeration unit is a refrigerator used commercially for storing and displaying items for sale, for example in a shop. In other alternative embodiments, the refrigeration unit is a freezer.

Figure 2

A simplified cross-section of the evaporator **102** mounted within refrigeration unit **101** is shown in *Figure 2*. The evaporator **102** is mounted against the rear wall of inner refrigeration cavity walling **103** within the refrigeration cavity **104** such that the evaporator **102** is visible when the refrigeration unit door **105** is open. The evaporator **102** comprises a metal plate **201** which has a front face **204** that is visible to users of the refrigeration unit **101**. The metal plate also has a rear surface **205** that is welded to a tube

202 through which passes a refrigerant fluid **203**. Due to the manner by which the tube **202** is welded to the plate **201**, the front face of the plate **201** is unmarked and flat.

During use, heat from the refrigeration cavity **104** is absorbed by the plate **201**. The heat is conducted through the plate to the tube **202**, and through the wall of the tube to the refrigerant fluid **203** causing it to evaporate. Thus, the evaporator is used to transport heat away from the cavity **104**. Because the evaporator is located within the refrigeration cavity **104**, and in direct contact with the air within said cavity, the efficiency of refrigeration unit **101** is enhanced.

Figure 3

An alternative refrigeration unit **301** is shown in a simplified cross-sectional view in *Figure 3*. The refrigeration unit **301** differs from refrigeration unit **101** in that the evaporator **102** of refrigeration unit **301** is located within the rear wall of the inner refrigerator cavity walling. Consequently, it is concealed from users of the unit **301**, even when the door **105** of said unit is open.

The arrangement of *Figure 3* is less efficient than that of *Figures 1 and 2*, because heat must pass through a first layer **302** of the inner cavity walling before being absorbed by the evaporator **102**. However, it is to be noted that the same type of evaporator **102** is useable in either location.

Figures 4 and 5

The evaporator **102** is shown in detail in the plan view of *Figure 4* and the perspective view of *Figure 5*.

The tube **202** has a meandering shape providing good coverage of the plate **201**, in that all locations on the plate **201** are within a predetermined distance from the tube **202**. In the present embodiment, the tube **202** has a serpentine shape having several substantially straight portions, such as portion **401**, connected by 180 degree bends, such as bend **402**. However,

meandering shapes other than serpentine are envisaged which provide the required coverage of the plate.

A middle portion of the tube **202** has a flat face which is located against the rear face **205** of the plate **201**, and a second flat face **501** parallel to the first face. Two smaller portions **403** and **404** at each end of the tube **202** have a circular cross-section allowing them to be easily connected to other circular cross-section tubes within the cooling circuit of the refrigeration unit **101**.

The tube **202** is rigidly attached to the plate **201** by laser spot welds, such as welds **405** and **406**, which weld the metal of the tube directly to the metal of the plate. In the present embodiment, the laser spot welds are spaced along the tube **202**, both along the straight portions, such as portion **401**, and along the bends, such as bend **402**. The distance between the spot welds along the straight portions is 5 millimetres but this distance is extended to up to 25 millimetres in some alternative embodiments and reduced to less than 5 millimetres in others. It will be understood that the increased number of welds ensures the integrity of the plate/tube unit, although it does also increase the production time and cost. However, if the spot welds are arranged too closely and are performed too rapidly, then over heating of the plate can produce undesirable distortions of the plate that would be detrimental to its appearance.

The cross-sectional shape of the tube within its central portion and the position of the spot welds is described below in further detail with respect of *Figures 8, 9 and 10.*

The plate **201** and the tube **202** are made from aluminium alloy, or alternatively aluminium. These materials have good thermal conductivity and therefore provide the evaporator with high efficiency. In addition, they facilitate successful, reproducible, laser welding, and have good resistance to corrosion during use.

The plate **201** of the present embodiment has a thickness of 1.5 millimetres but thinner plates down to around 0.5 millimetre may be used in

order to reduce the material cost. It will be understood that reducing the plate gauge reduces the thermal conductivity of the plate along the plane. To compensate for this, the tube coverage of the plate may be increased. However, the additional tube length required to increase tube coverage of the plate will increase its cost. In practice, therefore, the actual plate thickness and tube coverage that is used may depend upon a number of variants including plate and tube material costs, efficiency requirements, evaporator dimensions, etc.

The tube **202** has a wall thickness of approximately 0.5 millimetres. Tubes with a larger wall thickness may be used but this will increase the cost of the tube.

In one alternative, low cost, embodiment the tube is made from aluminium coated steel tube. Other types of metal tube and metal plates may also be used provided they permit laser welding, and they have the required thermal conductivity and resistance to corrosion.

Figure 6

A method for manufacturing the evaporator **102** is illustrated by the flow chart of *Figure 6*. Initially at step **601** aluminium alloy sheet is cut to desired dimensions using a guillotine and then levelled. At step **602**, aluminium tube having a circular cross-section is straightened and cut to the required length. The tube is then bent to the required shape at step **603**. For example, the tube is bent to form the serpentine shape shown in *Figure 4*. The bent tube obtained at step **603** is then processed by a press, for example a hydraulic press, at step **604** to provide the required cross-section of its central portion. Thus, at step **604** the tube is deformed such that it is provided with a pair of substantially parallel flat faces over a central portion while leaving the end portions **403** and **404** cylindrical.

The plate produced by step **601** is then secured to a welding table at step **605**, and the tube produced at step **604** is temporarily secured to the

plate in the required position, ready for welding. At step **606** the tube is laser spot welded to the plate.

Finally at step **607** the tube and plate are painted in order to resist moisture or ice entering any space left between the tube and the plate. Before the painting takes place the tube and plate are cleaned and degreased to ensure adhesion of the paint.

In an alternative embodiment, the aluminium alloy sheet used at step **601** is pre-coated on one side with a polymer layer, such as a layer of polyester. The tube is then located and welded on the non-coated side of the plate at steps **605** and **606**. In this embodiment, it is envisaged that the painting step **607** will be omitted, and consequently degreasing is also not required.

In further alternative embodiments, extruded tubing having at least one flat side is used at step **602** in place of cylindrical tubing. Consequently, the step **604** of processing the tube to provide the required cross-section is omitted, and the tube is bent at step 603 such that the flat side produced by extrusion remains planar. The flat side produced during the extrusion of the tube is then located and welded against the plate at steps **605** and **606**. For example, in one embodiment, the tube is extruded such that it has a rectangular cross-section, while in another embodiment the tube is extruded such that it has two flat parallel planes and curved side walls. Thus, in the latter case the tube has a cross-section similar to that of the cylindrical tube after process step **604**.

Figure 7

Apparatus for welding the tube to the plate at step **606** of *Figure 6* is shown schematically in *Figure 7*. The apparatus includes a laser **701** suitable for producing pulses of laser light to produce the spot welds between the tube **202** and the plate **201**, and a suitable power supply **702** for the laser **701**. The laser **701** has an associated time share device **703** which receives the laser

beam from the laser and switches it between two output ports. In the present embodiment the laser **701** is a JK700 series laser produced by GSI Lumonics, UK, which is supplied with suitable power supply **702** and time share device **703**.

A fibre optic link **704A**, **704B** is connected between each of the output ports of the time share device **703** and a respective laser focus head **705A**, **705B**. The fibre optic links **704A** and **704B** are configured to receive the laser beam from the laser time share device **703** and deliver it to the laser focus heads **705A** and **705B**. The laser focus heads are configured to receive the laser beam from the respective fibre optic link and focus it on the work piece to produce a spot weld. The fibre optic links and laser focus head may also be obtained from GSI Lumonics.

In order to apply the laser beam at the required positions of welds, the apparatus also includes a positioning apparatus **706** which controls the positioning of the laser focus heads **705A** and **705B** with respect to the tube **202** and plate **201**. A control unit **707** in the form of a programmed computer controls the positioning apparatus **706** and laser **701** in order to co-ordinate the positioning of the laser focus heads **705A**, **705B** and welding of the evaporator **102**.

In alternative apparatus to that of *Figure 7*, the time share device is replaced by a beam splitting device which shares the energy of the laser beam thereby instantaneously providing a laser beam to each of the fibre optic links.

Figure 8

Positioning apparatus **706** and laser focus heads **705A** and **705B** are shown laser spot welding a tube **202** on a plate **201** in *Figure 8*. The plate **201** is rigidly fixed to a table **801** by clamps **802**, while a clamp **803** holds one end of the tube **202** in position on the plate **201**.

The laser focus heads **705A** and **705B** are fixed to a positioning head **804** whose linear position is adjustable by a moveable gantry **805** and angular

position is adjustable by a rotation positioning device **806**. The positioning head **804** includes rollers which apply forces to position the tube **202** at a location adjacent to where the laser beams are currently focused.

During operation, under the control of the control unit **707**, the laser beam focussing heads are initially positioned adjacent to the clamped end of the tube **202** and then they are moved along the tube on a path defined by its intended position and shape. As the focus heads **705A** and **705B** are moved, the rollers in the positioning head **804** ensure the correct positioning of the tube **202**. Meanwhile, under the control of unit **707**, the laser periodically produces a laser beam to produce a weld. The time share device **703** deflects the laser beam first to one focus head and then the other and consequently spot welds are produced along each side of the tube.

The laser welds disturb only the rear surface of the plate leaving the front surface, that is viewable by a user of the refrigeration unit **101**, unmarked by the welding process.

In the present embodiment, the tube **202** and plate **201** remain stationary while the laser focus heads **705A** and **705B** are moved into position by the positioning apparatus for welding. However, in an alternative embodiment the tube and plate assembly is fixed to a X-Y positioning table which moves the tube and plate in a horizontal plane and with respect to the laser focus heads. Thus, in the main embodiment and this alternative embodiment, the positioning apparatus positions the laser focus heads with respect to the tube and plate, but this may be achieved by moving the laser focus heads and/or the tube and plate assembly.

Figure 9

Positioning rollers that are located within the positioning head **804** are shown in *Figure 9*. The positioning head **804** includes a pair of rollers **901** and **902** that are mounted at a fixed position with respect to the focus heads but they are able to rotate around vertical axes **903** and **904**. The gap between the

two rollers **901** and **902** is sufficient to allow the tube **202** to fit between them.

A third roller **905** is mounted such that it is able to rotate about a horizontal axis **906** parallel to the plane of the axes **903** and **904**.

During operation, the roller **905** applies downward force to the tube **202** to ensure it is pressed up against the plate **201**. The rollers **901** and **902** apply sideways forces to the tube to ensure its correct positioning before laser beams **907** and **908** produce spot welds **909**. As shown in *Figure 9*, the three rollers **901**, **902** and **905** are positioned such that the laser beams **907** and **908** produce new welds between the previous welds and the rollers. I.e. the rollers move along the tube in advance of the laser beam.

The laser focus heads **705A** and **705B** are arranged such that the laser beams **907** and **908** are oriented at an angle of between 15 and 20 degrees to the plane of the plate **201**.

Figure 10

A portion of the tube **202** and plate **201** are shown in *Figure 10* which illustrates the position of welds **1001**. As described above, the tube **202** is produced by applying pressure to a cylindrical tube to create a pair of parallel faces, and therefore the tube **202** has a first flat face **1002** and a second flat face **501** parallel to the first face.

The first face **1002** of the tube is located against the rear face **205** of the plate **201** and therefore a tube to plate interface **1003** (shown hatched) is produced. Spot welds **1001** are then produced along the tube **202** on each side of the interface **1003** by laser beams **907** and **908**.

Figure 11

A cross-section of a portion of the evaporator **102** is shown in *Figure 11*, after application of the protective layer **1101** at step **607**.

It is possible that a gap or gaps could exist between the tube **202** and the plate **201**. If water entered such a gap and solidified it could potentially

affect the configuration of the tube to plate interface and reduce the thermal conductivity between tube and plate.

The protective layer **1101** extends over the plate **201** and the tube **202** such that the tube to plate interface **1003** is sealed from the atmosphere. Consequently, if any gap does exist between the tube and the plate, the layer **1101** provides a barrier against water entering said gap.

In the present embodiment the layer **1101** is a layer of paint, applied by spraying on powder paint, but other methods of application such as dipping are envisaged.

Figure 12

An alternative evaporator **1202** to the evaporator **102** is shown in *Figure 12*. The evaporator **1202** is manufactured in a similar way to evaporator **102** and has the same type of tube **1203** laser spot welded to a plate **1204** as those of evaporator **102**. However, the laser welds only extend along the straight portions of the tube **1203** and not around the bends, such as bends **1205** and **1206**. Consequently, the welding apparatus may be simplified.

Figure 13

A further alternative evaporator **1302** is shown in *Figure 13*. Like evaporator **1202**, the tube **1303** is only welded to the plate **1304** along straight portions of the tube. However, the tube has been bent at step **603** in such a way that the 180 degree bends have been replaced by two 90 degree bends of smaller radius of curvature, such as bends **1305** and **1306**, separated by a substantially straight portion, such a portion **1307**.

Figure 14

A further alternative evaporator **1402** is shown in *Figure 14*. This evaporator differs from evaporator **102** in that its tube was not processed at step **604**, and consequently it comprises a tube **1403** with a circular cross-

section that is laser welded to a plate **1404**.

In the present embodiment, the tube **1403** is laser spot welded to the plate **1404** in the same manner as described for evaporator **102**. However, due to the very narrow width of the interface between the tube **1403** and plate **1404**, it is envisaged that welding may only be performed along one side of the interface.

In each of the above described embodiments, the heat exchanger takes the form of an evaporator for use within a refrigeration unit such as a refrigerator or freezer. However, in alternative embodiments, heat exchangers manufactured in a similar way to the above described evaporators are used as condensers that are mounted on the outside of a refrigeration unit.

Claims

1. A heat exchanger for use in a refrigeration unit, said heat exchanger comprising: a metal plate having a first face and a second face; and a metal tube for containing refrigerant attached to said first face of said metal plate by a plurality of spot welds,

wherein said spot welds are laser spot welds and said welds extend through only a portion of the thickness of said plate.

2. A heat exchanger according to claim **1**, wherein at least a portion of the length of said tube has a substantially flat face positioned against said first face of said plate.

3. A heat exchanger according to claim **2**, wherein said tube has a second substantially flat face parallel to the substantially flat face positioned against the plate.

4. A heat exchanger according to claims **2** or claim **3**, wherein said tube has portions adjacent to each of its ends which have a circular cross-section for connecting to other tubes in the refrigeration unit.

5. A heat exchanger according to claim **1**, wherein said tube has a circular cross-section.

6. A heat exchanger according to any one of claims **1** to **5**, wherein said tube and said plate comprise of aluminium or aluminium alloy.

7. A heat exchanger according to any one of claims **1** to **6**, wherein said tube is positioned against said plate to provide a tube/plate interface and said spot welds are spaced along said tube on either side of said interface.

8. A heat exchanger according any one of claims **1** to **7**, wherein at least a portion of the length of said tube has a substantially flat face positioned against said first face of said plate to provide a tube/plate interface and said spot welds are spaced along said tube on either side of said interface.

9. A heat exchanger according to any one of claims **1** to **8**, wherein said heat exchanger has a protective layer extending over said first face of said plate and a portion of said tube welded to said plate, whereby said protective layer provides a barrier against water entering a gap between said tube and said plate.

10. A heat exchanger according to any one of claims **1** to **9**, wherein said tube has a plurality of bends separated by substantially straight portions, and said spot welds extend along said straight portions only.

11. A heat exchanger according to any one of claims **1** to **9**, wherein said tube has a plurality of bends separated by substantially straight portions, and said spot welds extend along said straight portions and along said bends.

12. A refrigeration unit comprising a heat exchanger according to any one of claims **1** to **11** and a refrigeration cavity for storing items, wherein said heat exchanger is an evaporator located within said refrigeration cavity.

13. A refrigeration unit comprising a heat exchanger according to any one of claims **1** to **11**, wherein said heat exchanger is a condenser mounted on the outside of the refrigeration unit.

14. A method of manufacturing a heat exchanger for a refrigeration unit, comprising the steps of:

obtaining a metal plate having a first face and a second face; and

attaching a metal tube for containing refrigerant to said first face of said metal plate by a plurality of spot welds,

wherein said spot welds are made by a laser and said welds extend through only a portion of the thickness of said plate.

15. A refrigeration unit having a heat exchanger, said heat exchanger comprising:

a metal plate having a first face and a second face; and

a metal tube for containing refrigerant attached to said first face of said metal plate by a plurality of laser spot welds.

16. A refrigeration unit according to claim **15**, wherein at least a portion of the length of said tube has a substantially flat face positioned against said first face of said plate.

17. A refrigeration unit according to claim **16**, wherein said tube has a second substantially flat face parallel to the substantially flat face positioned against the plate.

18. A refrigeration unit according to any of claims **15** to **17**, wherein at least a portion of the length of said tube has a substantially flat face positioned against said first face of said plate to provide a tube/plate interface and said spot welds are spaced along said tube on either side of said interface.

19. A refrigeration unit according to any one of claims **15** to **18**, wherein said tube and said plate comprise of aluminium or aluminium alloy.

20. A refrigeration unit according to any one of claims **15** to **19**, wherein said refrigeration unit comprises a refrigeration cavity for storing items and said heat exchanger is configured as an evaporator for cooling said refrigeration cavity.

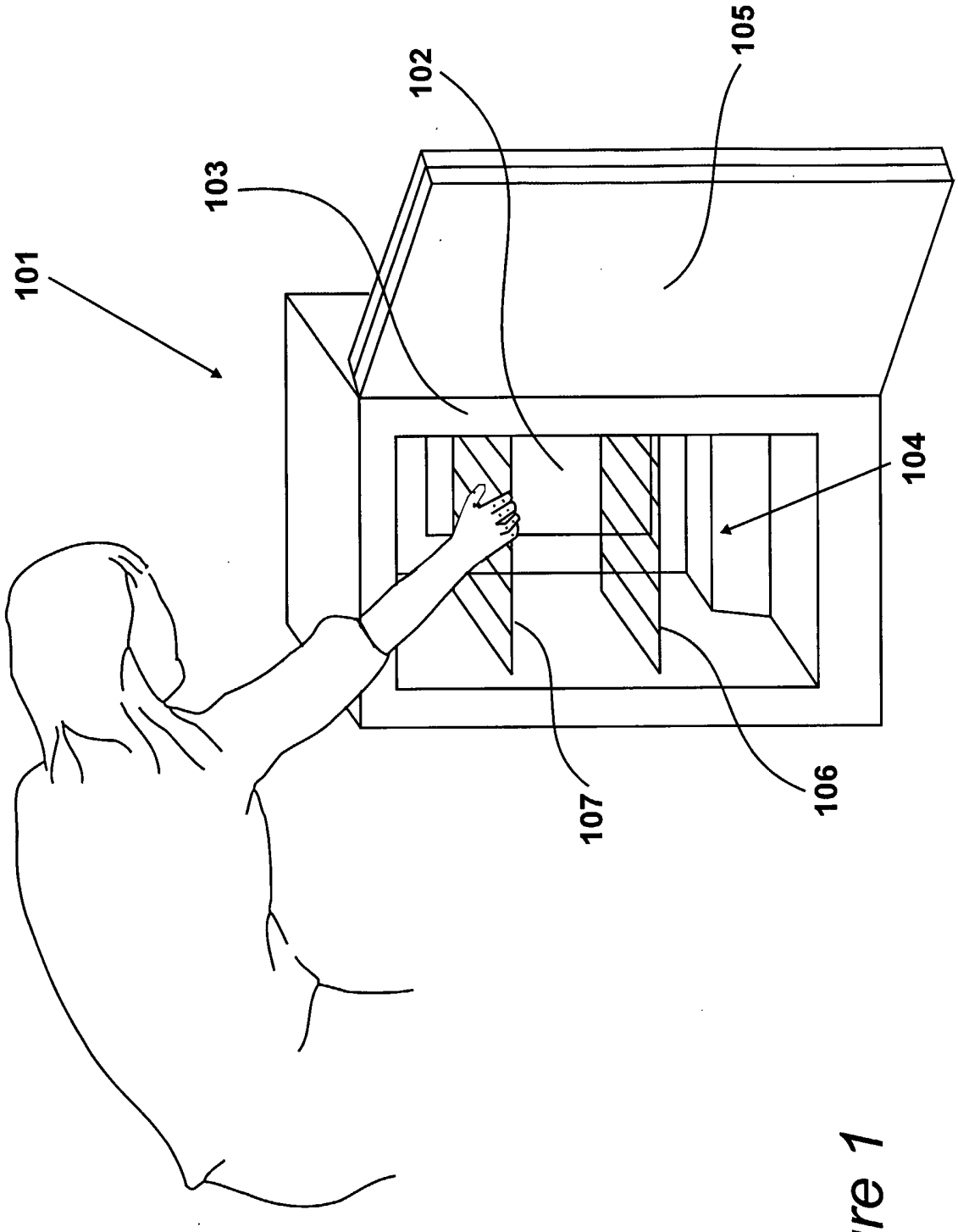

Figure 1

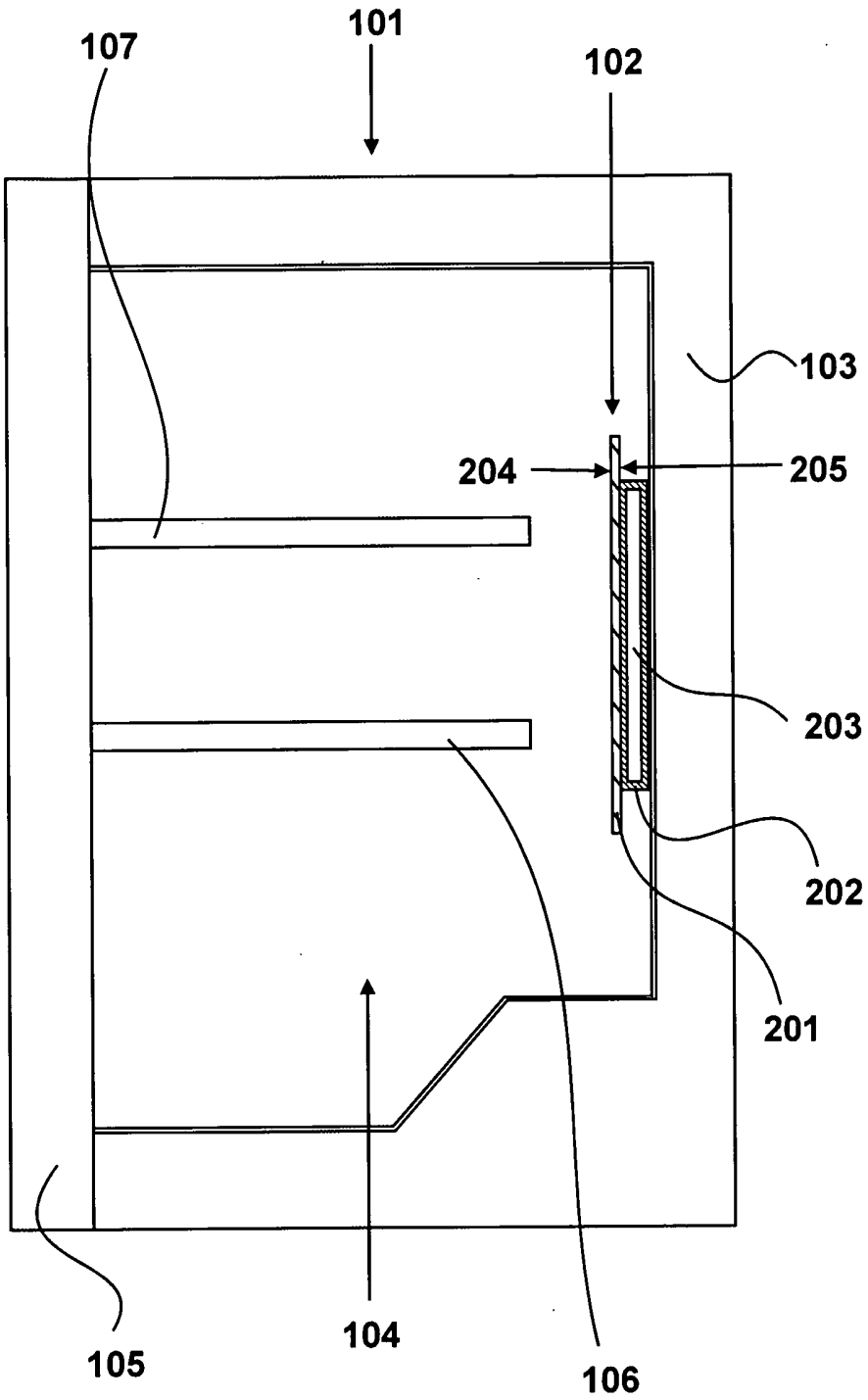

Figure 2

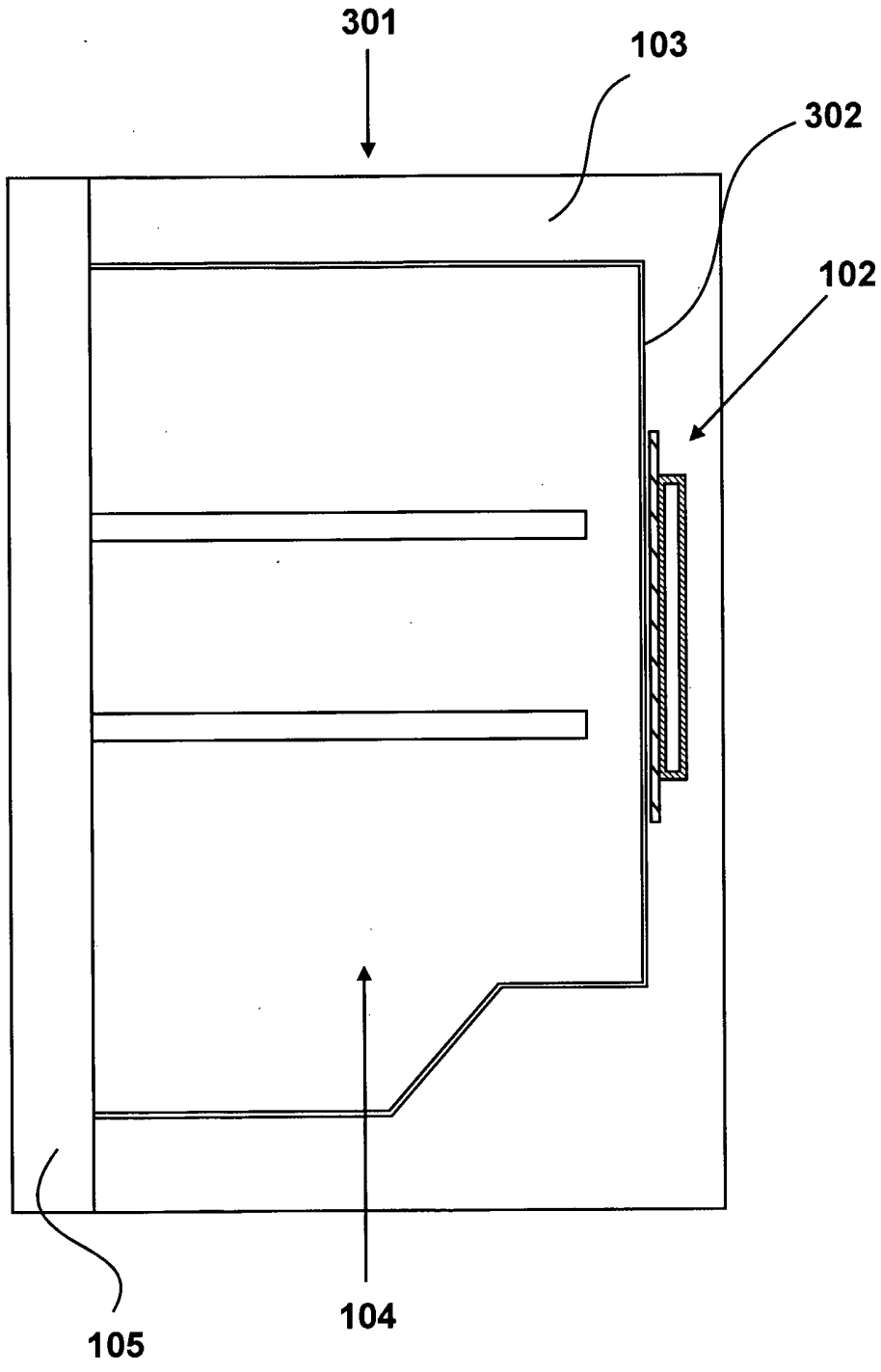

Figure 3

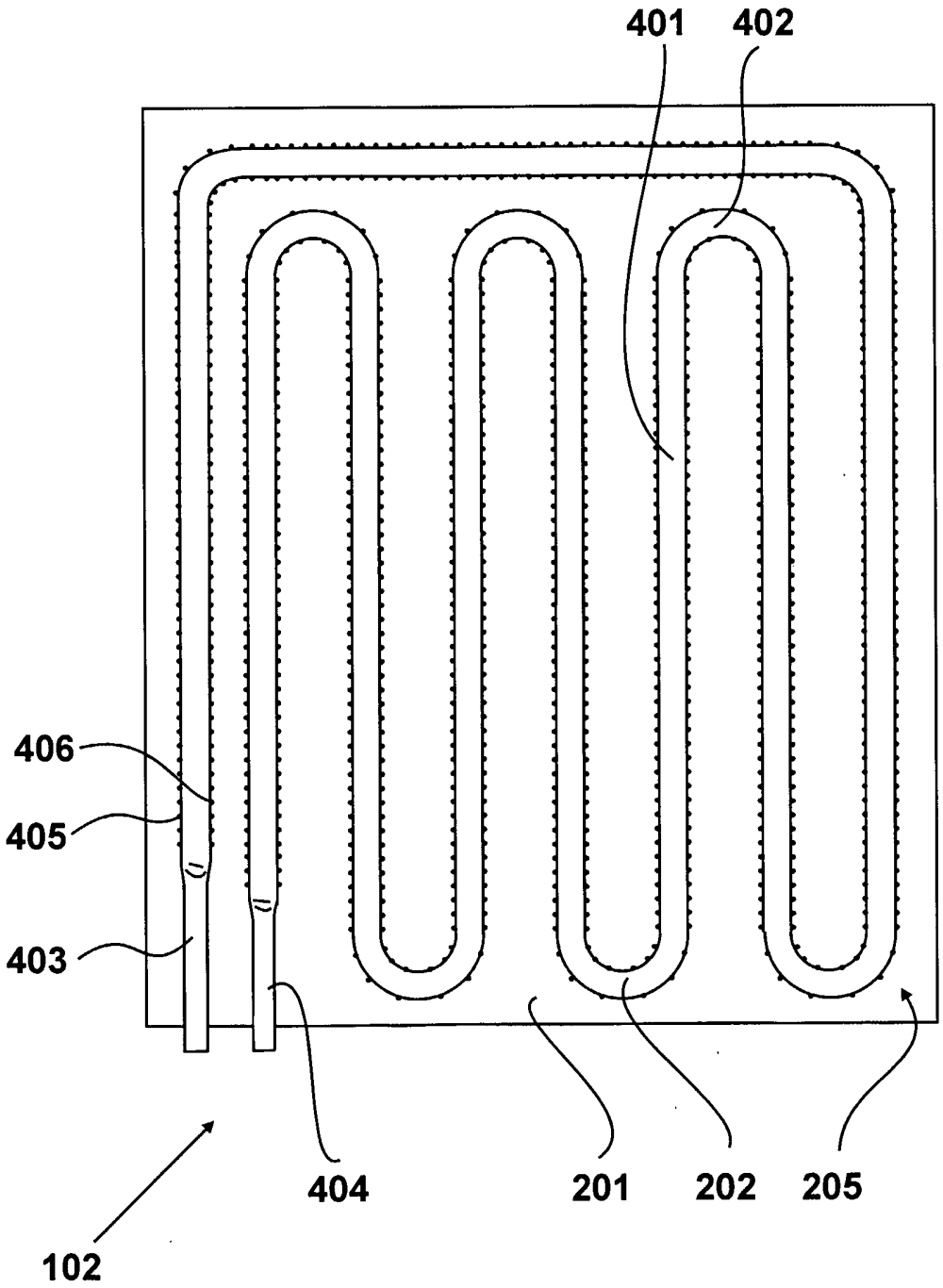

Figure 4

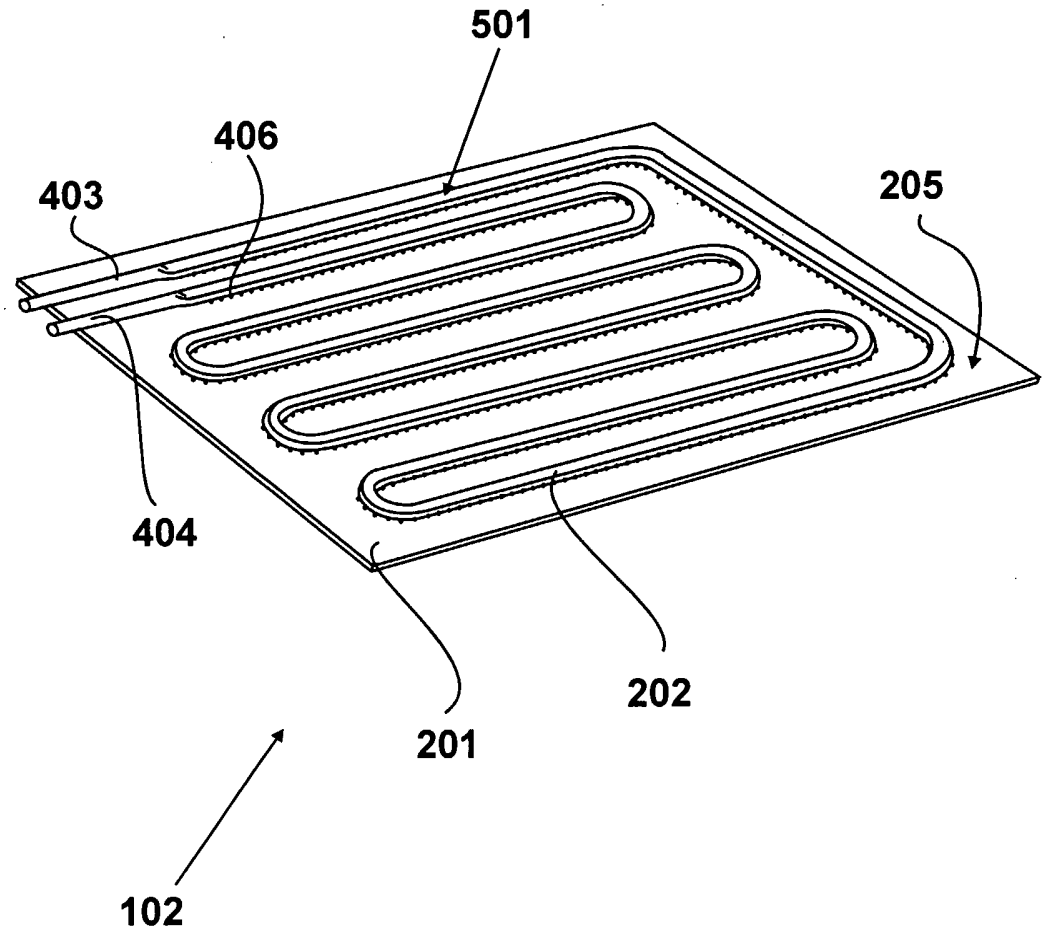

Figure 5

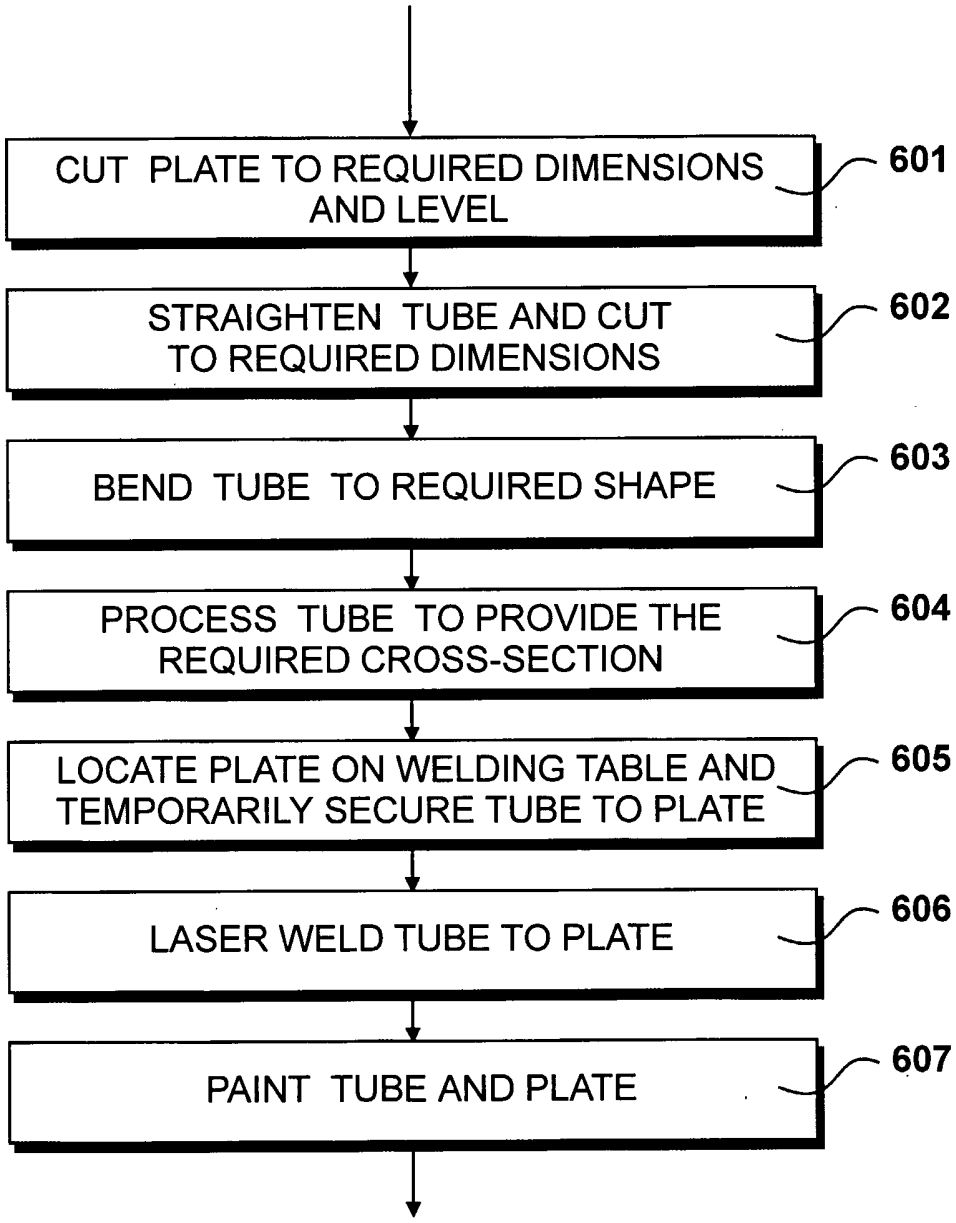
CUT PLATE TO REQUIRED DIMENSIONS AND LEVEL
601
STRAIGHTEN TUBE AND CUT TO REQUIRED DIMENSIONS
602
BEND TUBE TO REQUIRED SHAPE
603
PROCESS TUBE TO PROVIDE THE REQUIRED CROSS-SECTION
604
LOCATE PLATE ON WELDING TABLE AND TEMPORARILY SECURE TUBE TO PLATE
605
LASER WELD TUBE TO PLATE
606
PAINT TUBE AND PLATE
607

Figure 6

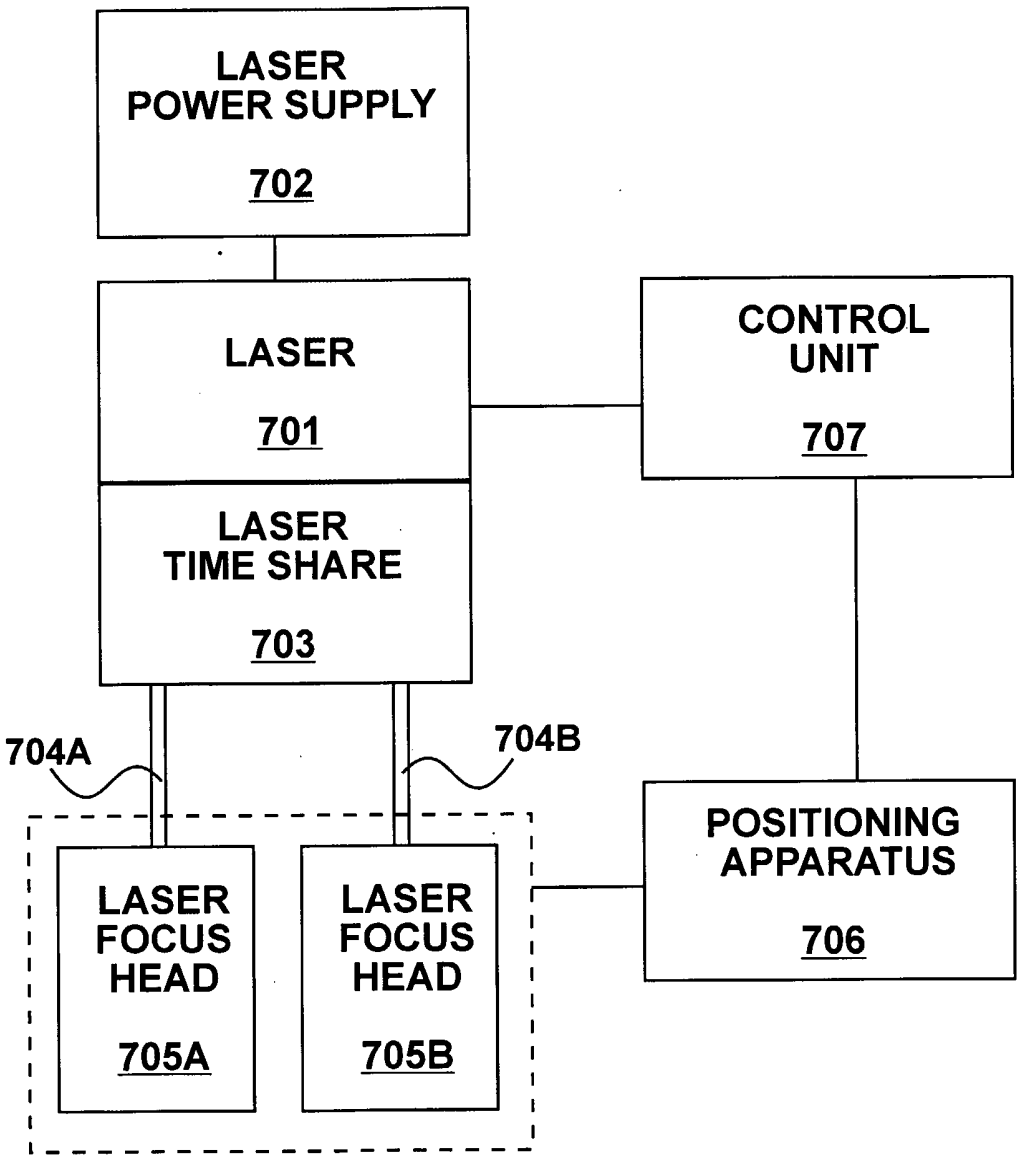
LASER
POWER SUPPLY
702
LASER
701
LASER
TIME SHARE
703
CONTROL
UNIT
707
704A
704B
LASER
FOCUS
HEAD
705A
LASER
FOCUS
HEAD
705B
POSITIONING
APPARATUS
706

Figure 7

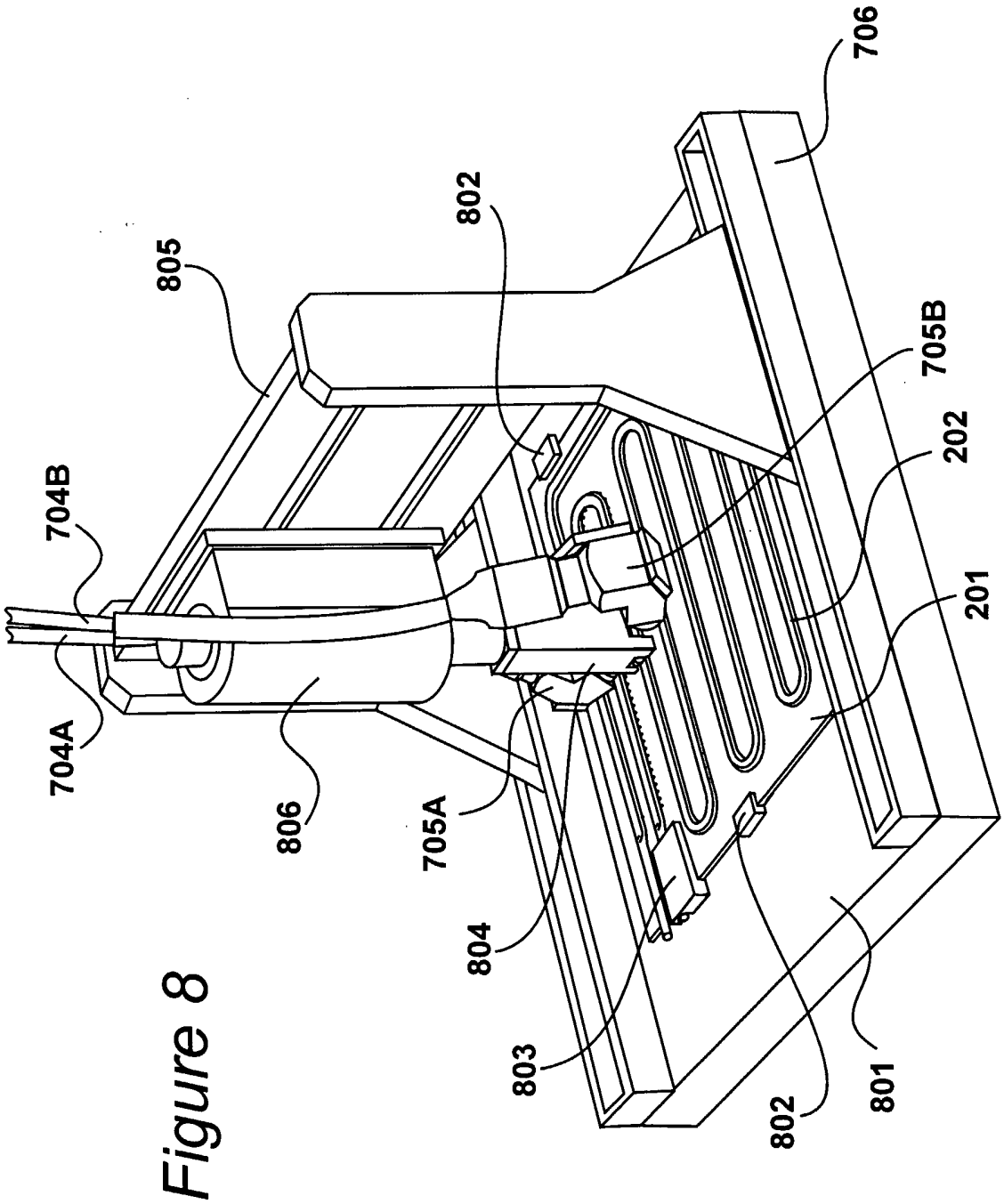

Figure 8

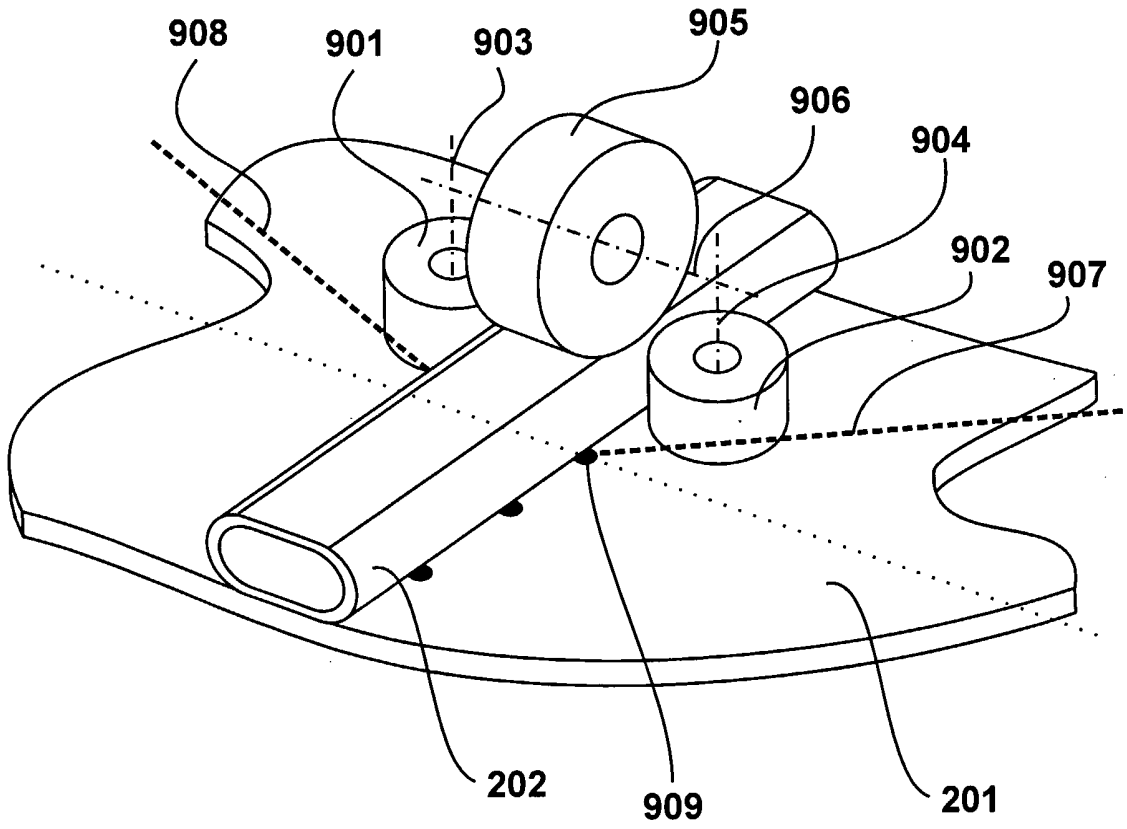

Figure 9

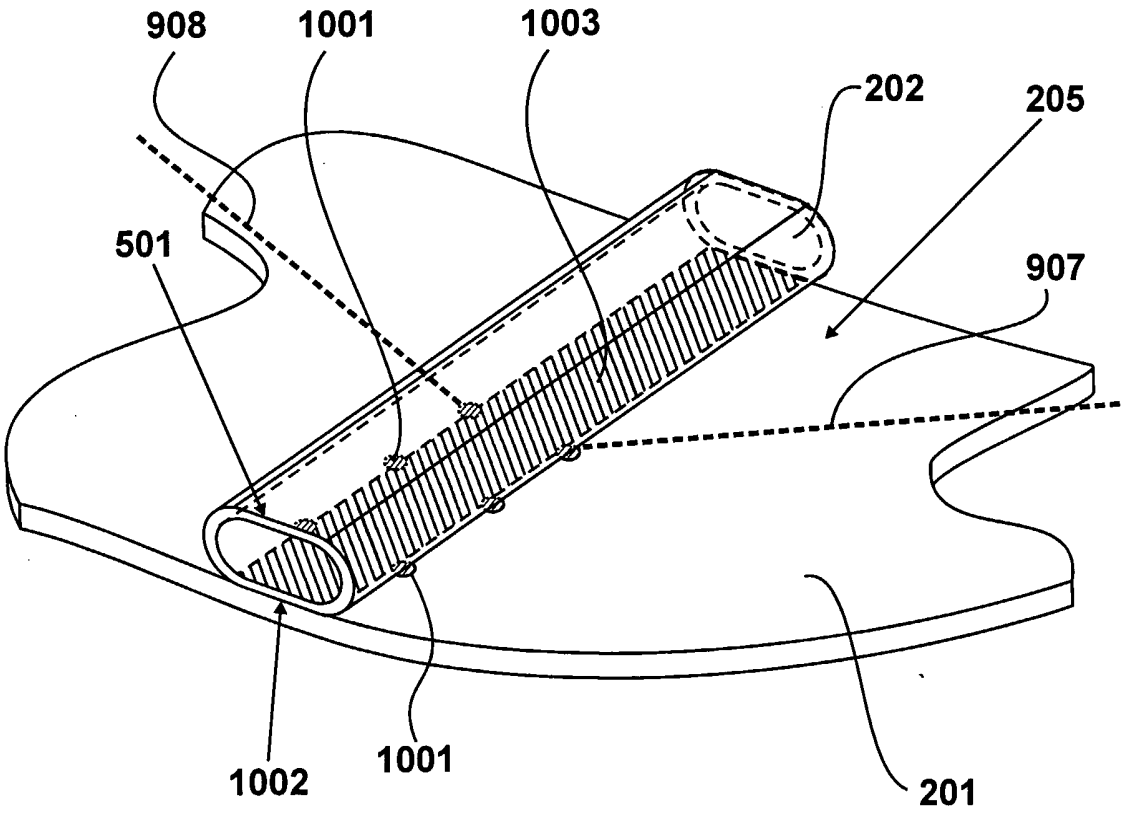

Figure 10

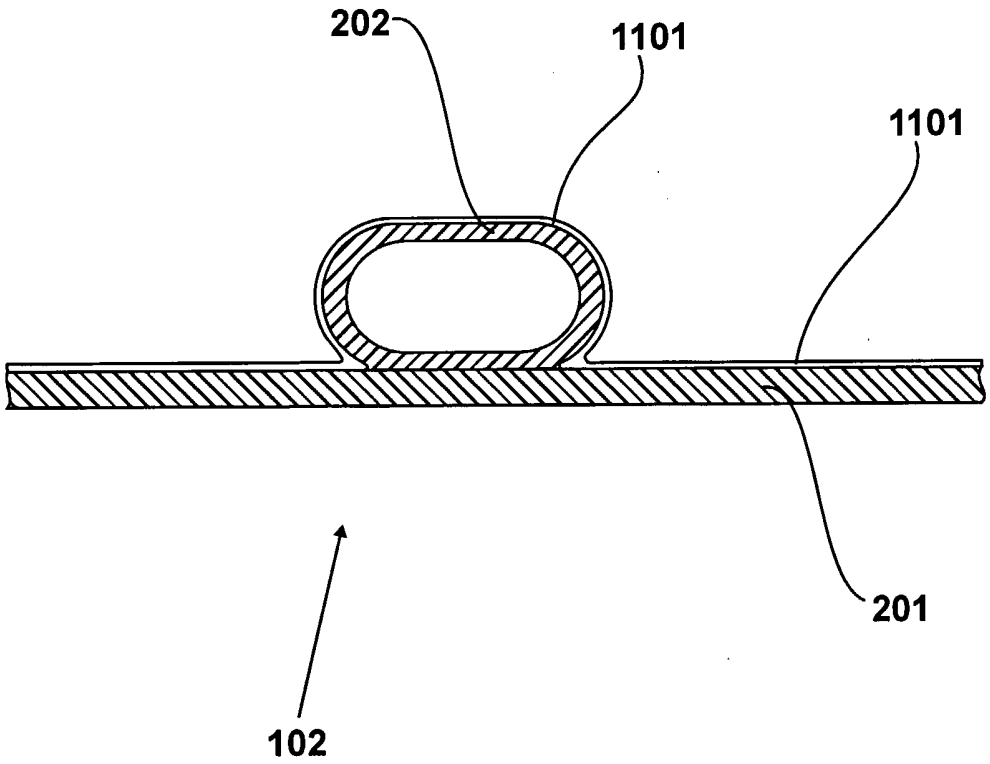

Figure 11

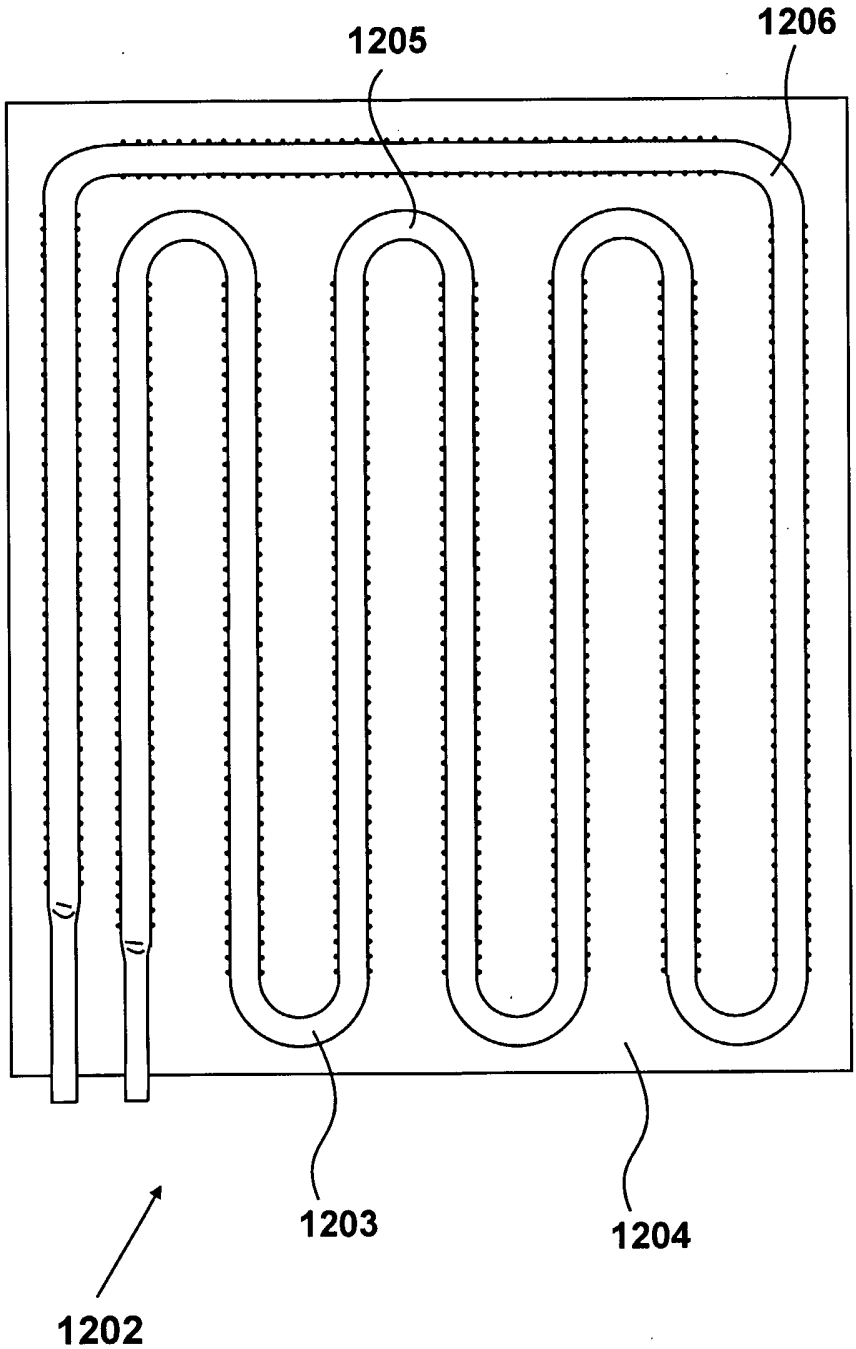

Figure 12

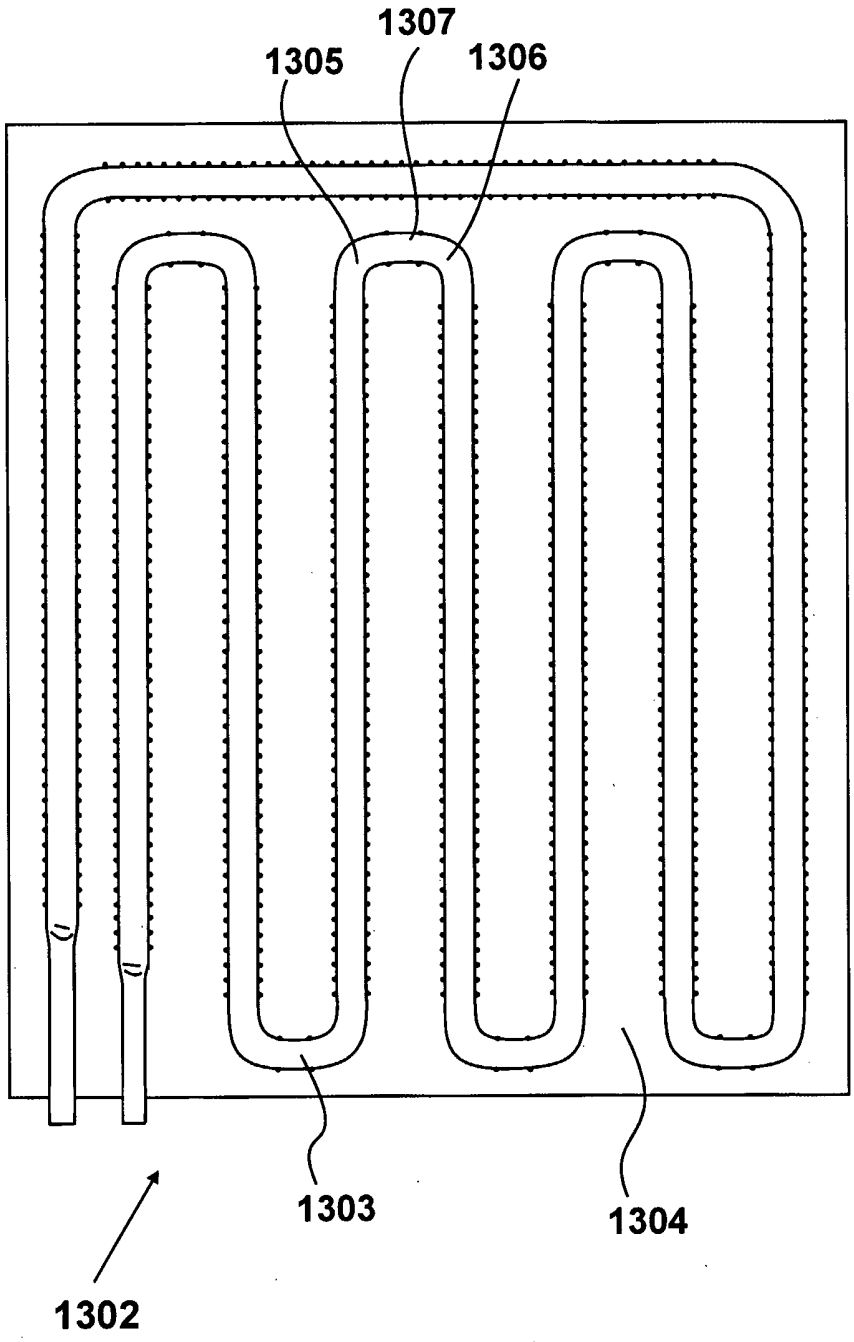

Figure 13

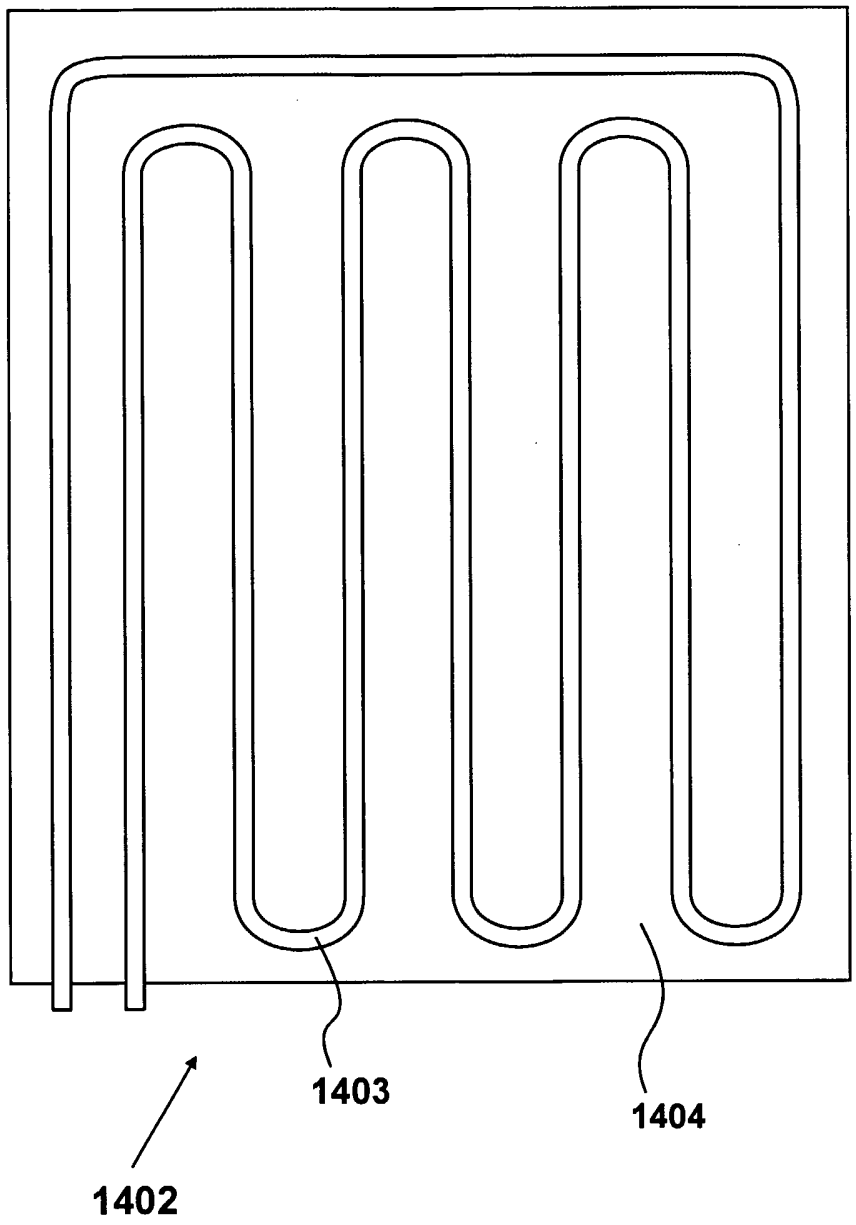

Figure 14

INTERNATIONAL SEARCH REPORT

International application No
.../GB2005/004771

A. CLASSIFICATION OF SUBJECT MATTER
F28F1/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F F25B B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 906 045 A (KIM ET AL) 25 May 1999 (1999-05-25) column 1, line 62 - column 2, line 1figure 3	1,5,6, 13-15,19
Y	EP 0 057 091 A (ROBERT BION & COMPANY LIMITED; BION ROBERT & CO LTD) 4 August 1982 (1982-08-04) abstract, figure 1	1,6, 13-15
Y	FR 2 608 747 A (PHILIPS GLOEILAMPENFABRIEKEN NV) 24 June 1988 (1988-06-24) calim 1, figure 1	1,5,6, 13-15
Y	EP 1 362 662 A (LASAG AG) 19 November 2003 (2003-11-19) paragraph [0002]; figure 1	1,5, 13-15

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 March 2006	07/04/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Martinez Rico, C

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INTERNATIONAL SEARCH REPORT

International application No
.../GB2005/004771

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	GR 1 004 729 B1 (TRAVASAROS KONSTANTINOS SPYRIDONA) 22 November 2004 (2004-11-22) the whole document	1,5, 13-15

INTERNATIONAL SEARCH REPORT

nformation on patent family members

International application No
../GB2005/004771

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		WO 03095138 A1	20-11-2003
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		US 2005145680 A1	07-07-2005