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F4S S2M1 S2M3 S2M5
U1S S1969

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(continued on next page)

(54) Abstract Title: **A heat exchanger**

(57) A heat exchanger (301) comprising a first tube (107) for fluid transmission and a second tube (108) for fluid transmission within a heat transfer system that uses a working fluid which undergoes compression and evaporation. The first tube is placed in thermal contact with the second tube for a portion (109,110) of the respective lengths of the first tube and the second tube so as to allow an exchange of heat between the fluid within said tubes.

The first tube (107) is preferably constructed from steel alloy which has alloyed components to reduce the hardness of the steel to facilitate tube bending within a heat transfer system, thereby allowing the first tube to be constructed from the steel within the heat transfer system, in preference to copper.

The first tube (107) may form the suction tube of a refrigeration system ie the tube running from the evaporator to the compressor. The second tube (108) may comprise the capillary tube of the refrigeration system.

The steel alloy may include carbon, manganese, phosphorus, sulphur and titanium.

The suction tube (107) may be provided with a zinc coating.

The first tube may be constructed of iron alloy.

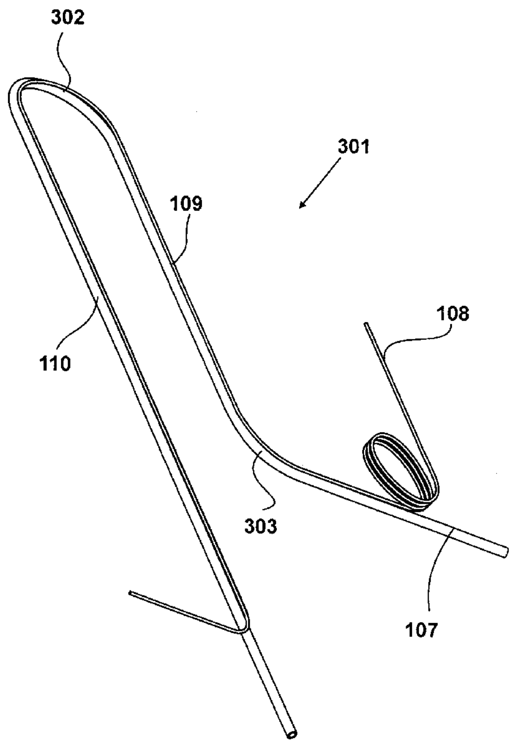

Figure 3

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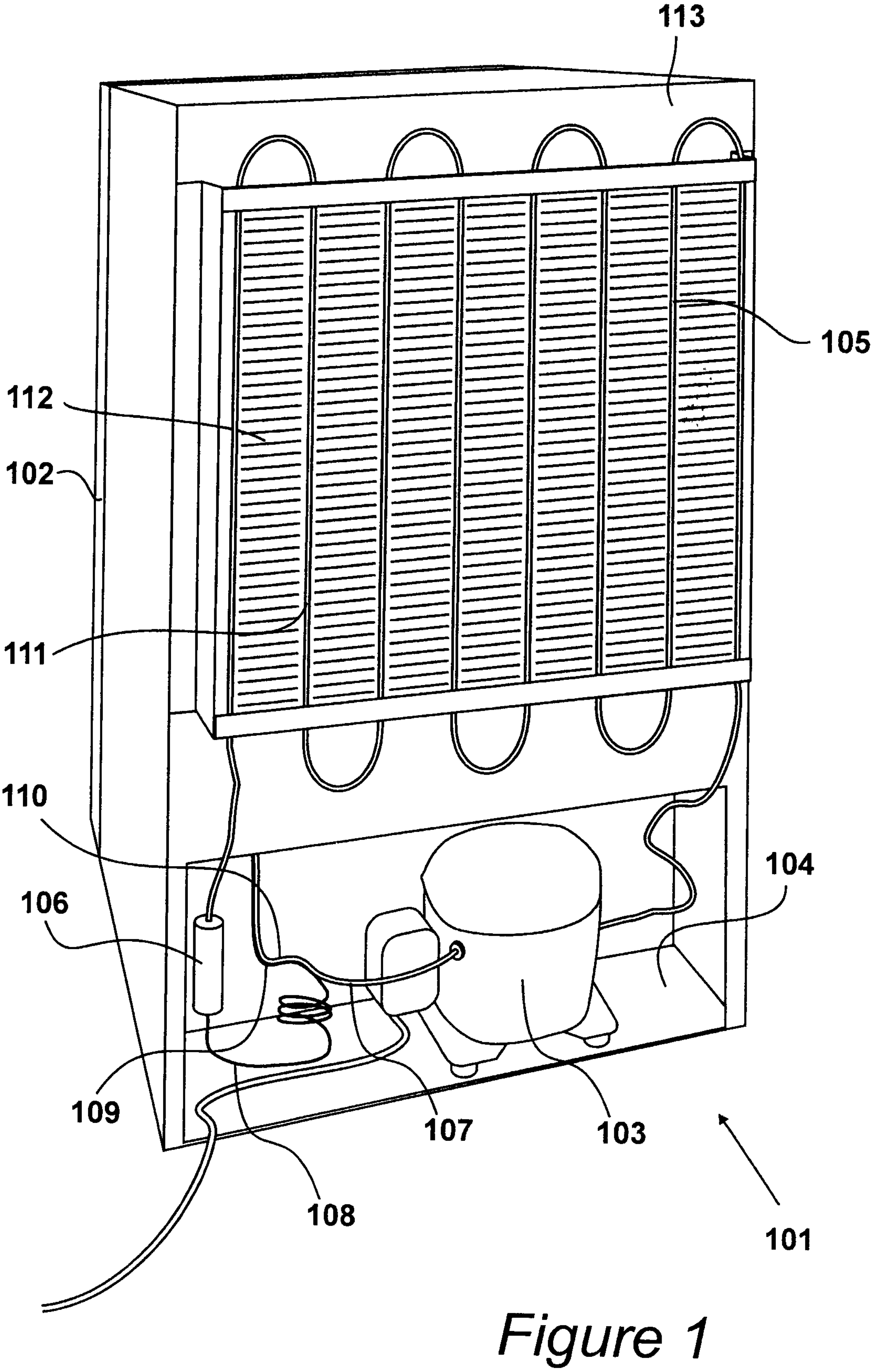

Figure 1

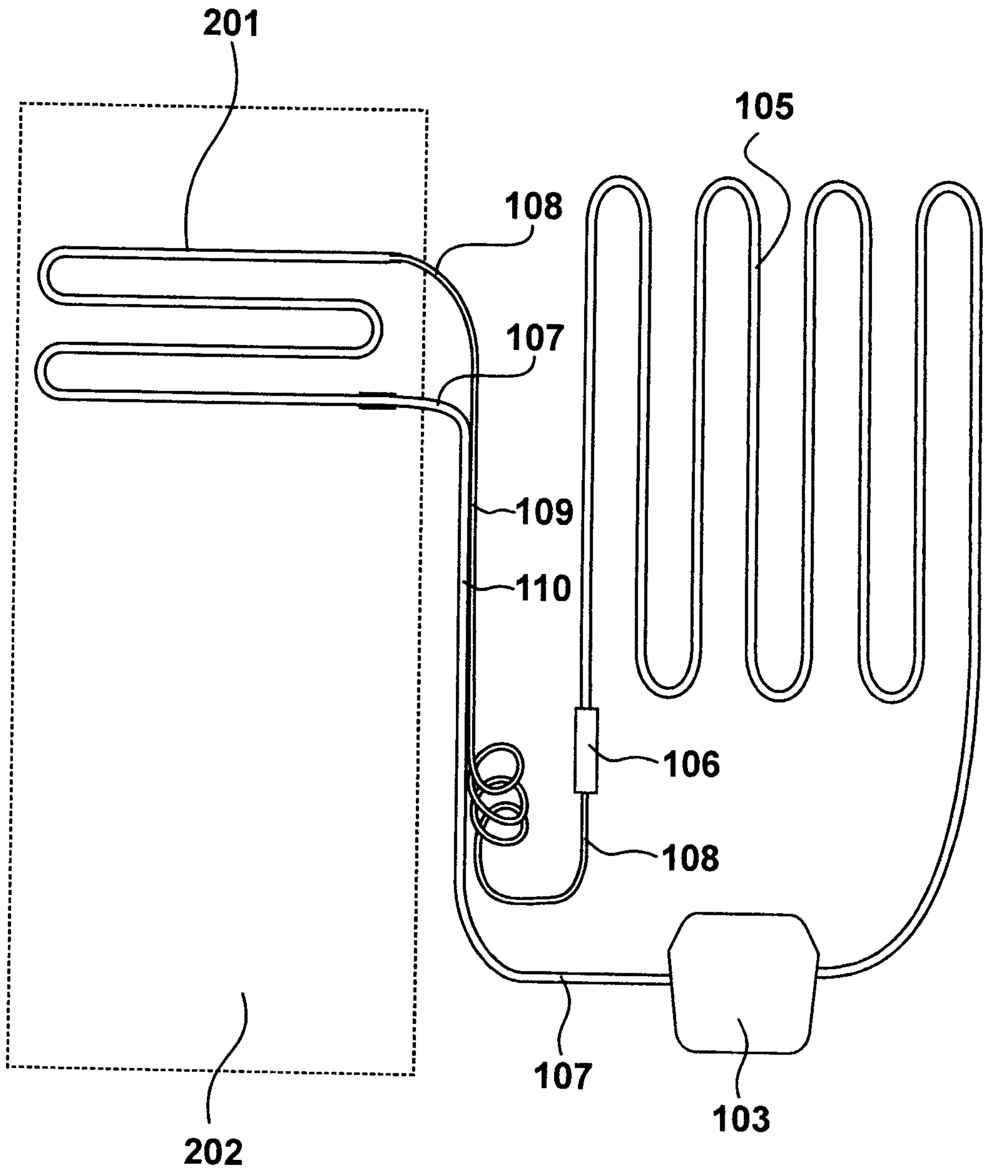

Figure 2

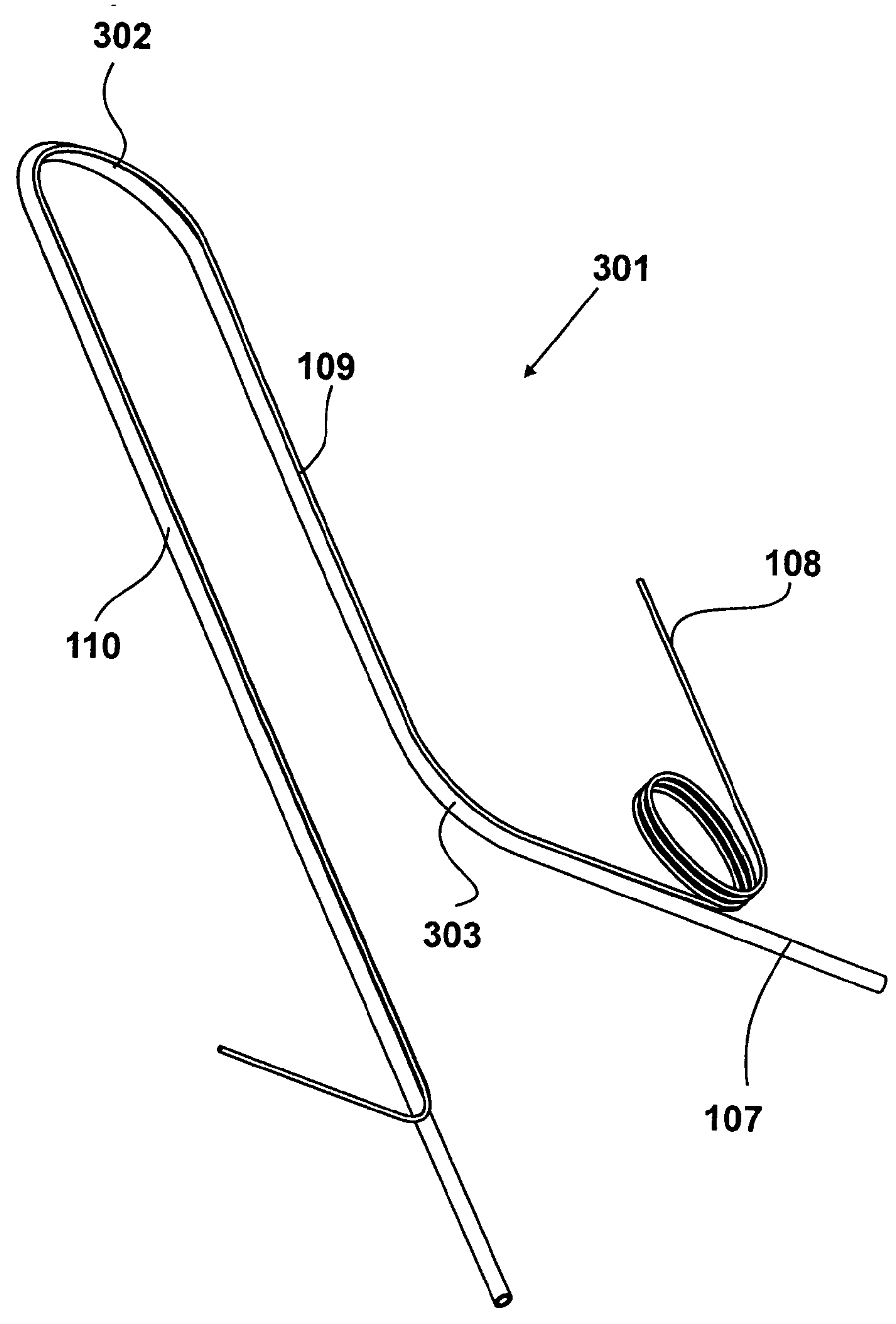

Figure 3

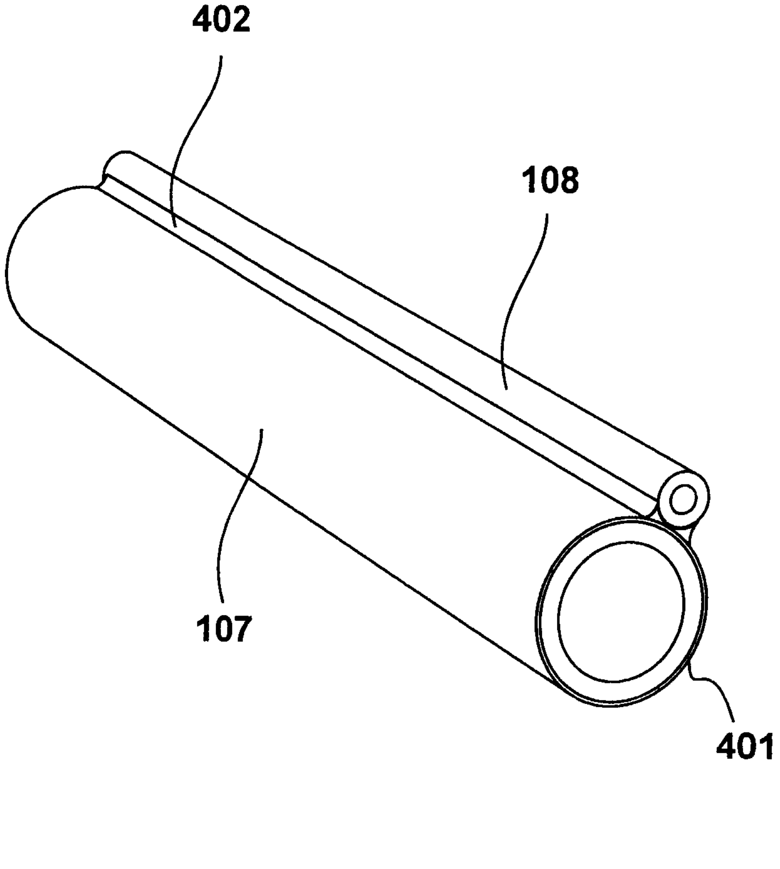

Figure 4

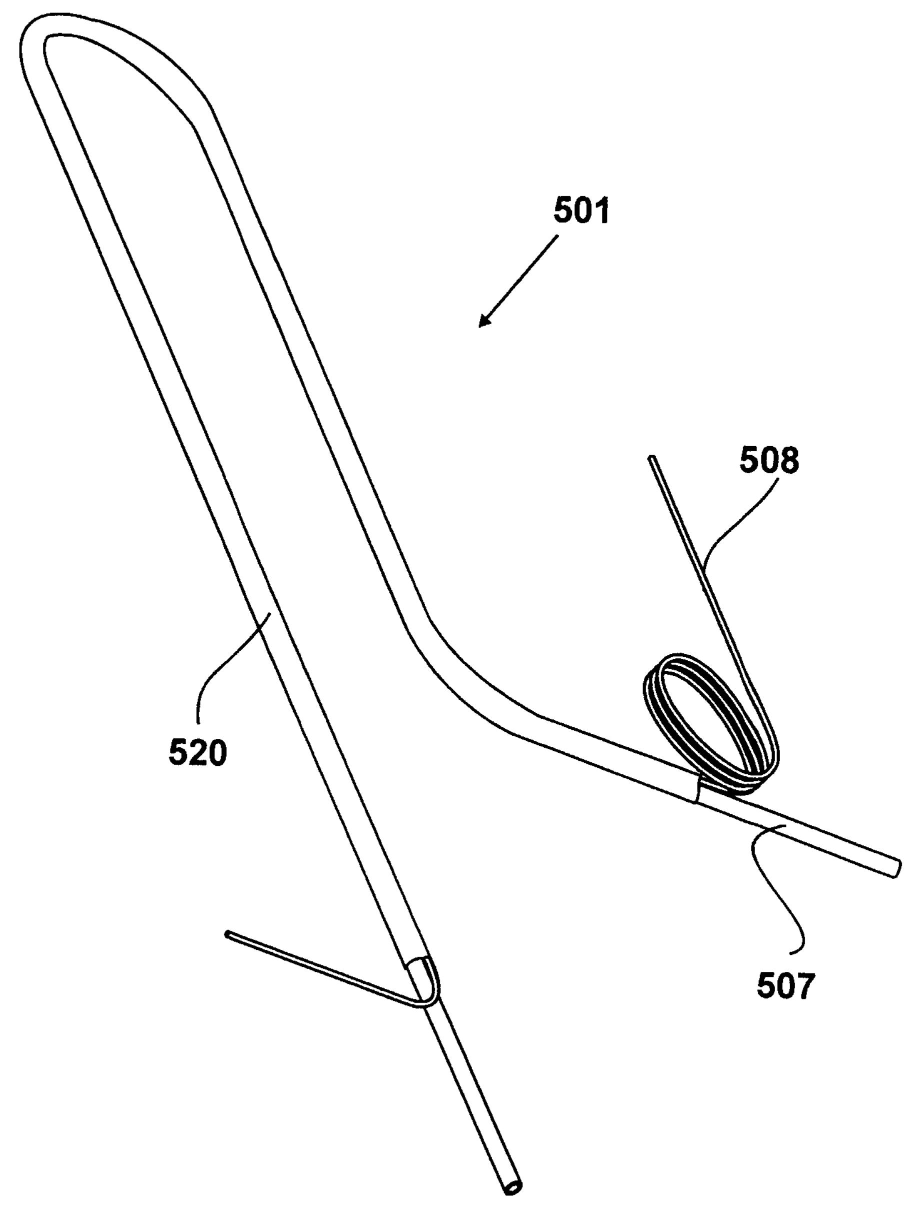

Figure 5

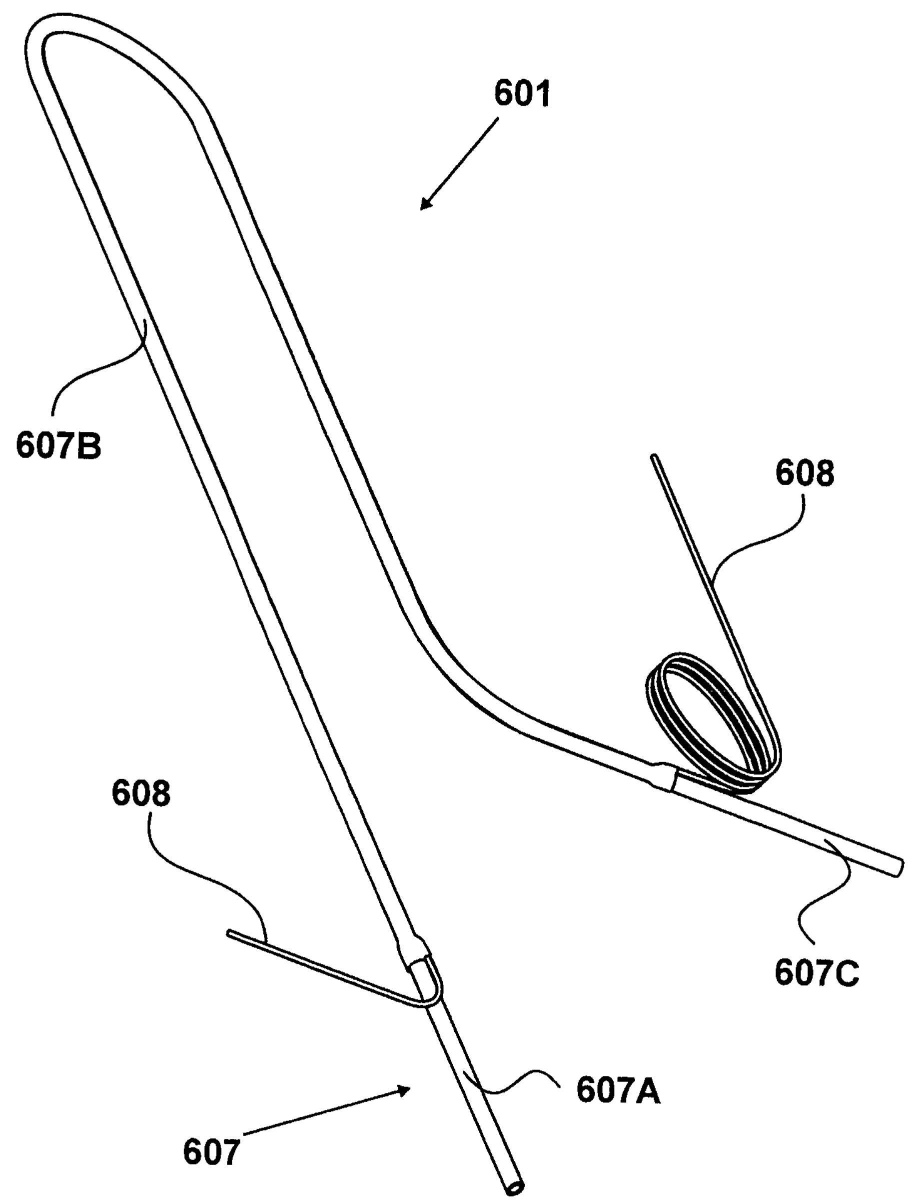

Figure 6

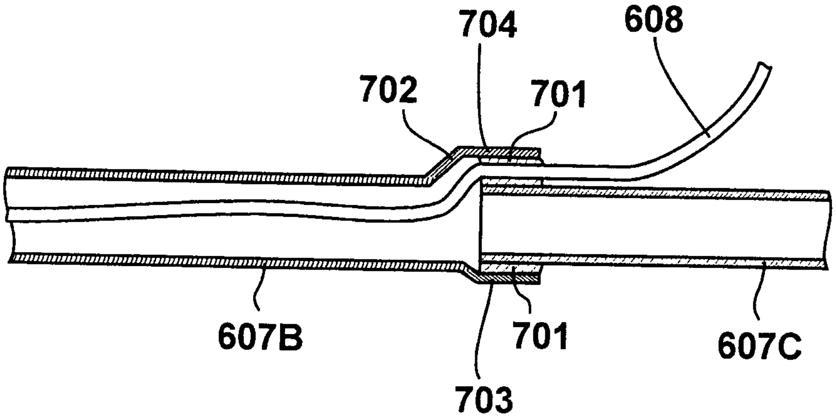

Figure 7

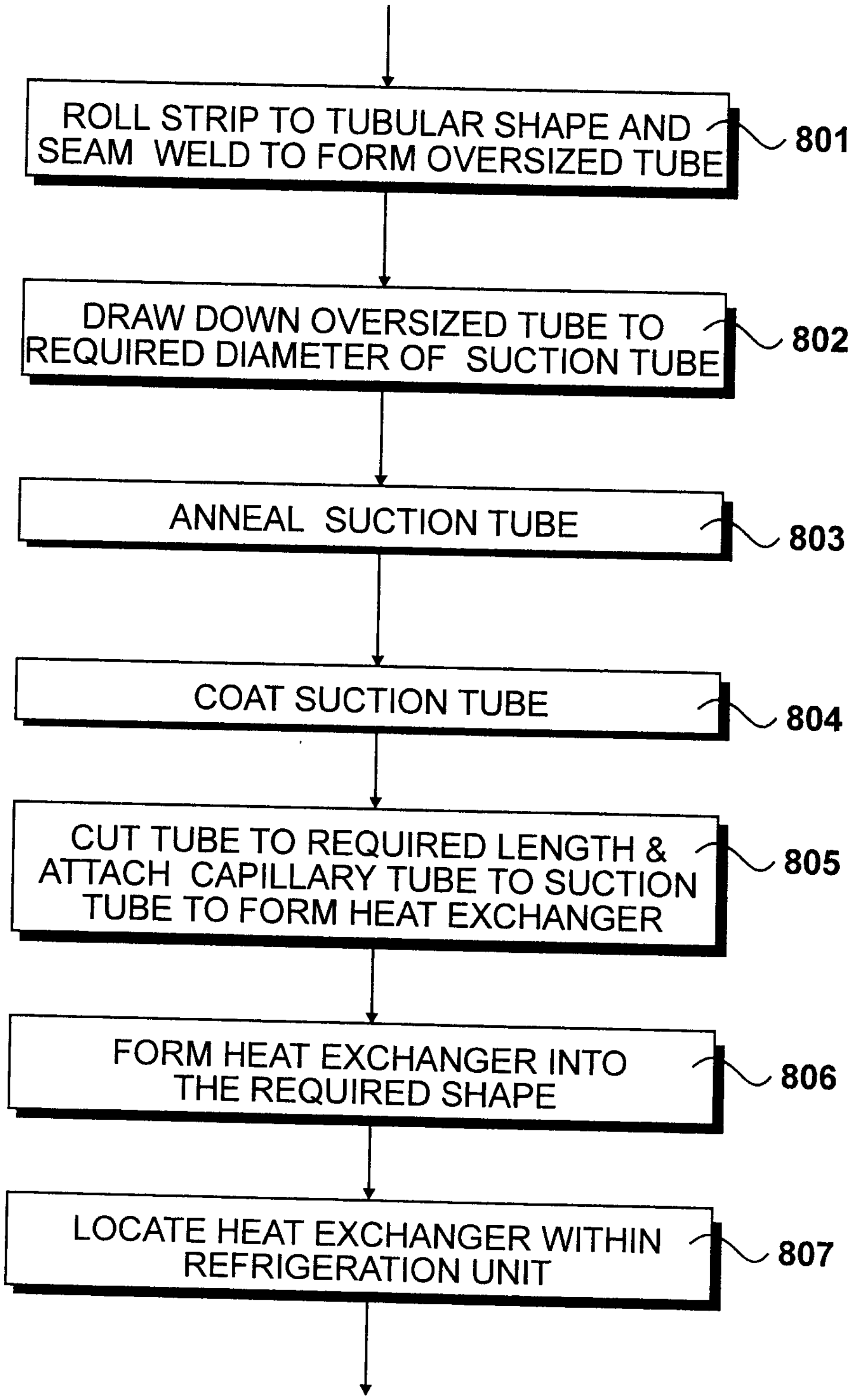
ROLL STRIP TO TUBULAR SHAPE AND SEAM WELD TO FORM OVERSIZED TUBE
801
DRAW DOWN OVERSIZED TUBE TO REQUIRED DIAMETER OF SUCTION TUBE
802
ANNEAL SUCTION TUBE
803
COAT SUCTION TUBE
804
CUT TUBE TO REQUIRED LENGTH & ATTACH CAPILLARY TUBE TO SUCTION TUBE TO FORM HEAT EXCHANGER
805
FORM HEAT EXCHANGER INTO THE REQUIRED SHAPE
806
LOCATE HEAT EXCHANGER WITHIN REFRIGERATION UNIT
807

Figure 8

	RANGE OF ALLOY CONTENT BY MASS	TYPICAL ALLOY CONTENT BY MASS
CARBON	0.001% - 0.02%	0.02%
MANGANESE	0.10% - 0.25%	0.25%
PHOSPHORUS	0.00% - 0.02%	0.02%
SULPHUR	0.01% - 0.02%	0.02%
TITANIUM	0.06 - 0.3%	0.3%

Figure 9

	Copper tube	Conventional steel tube	Annealed low carbon steel tube
Diameter (mm)	6	6	6
Wall thickness (mm)	0.65	0.70	0.70
Relative force	1.0	2.8	1.85

Figure 10

A Heat Exchanger

Background of the Invention

The present invention relates to heat exchanger in a heat transfer system in which the heat exchanger comprises a first tube for fluid transmission and a second tube for fluid transmission, and the first tube is placed in thermal contact with the second tube for a proportion of their respective lengths so as to allow an exchange of heat between the fluid within said tubes.

In domestic refrigerators and freezers, it is usual to have a capillary tube which transmits liquid refrigerant to an evaporator, and a copper suction tube which transmits gaseous refrigerant from the evaporator. It is also known to arrange a portion of the length of the capillary tube and suction tube together to form a heat exchanger. Consequently, refrigerant fluid transmitted from the evaporator is warmed by the fluid transmitted to the evaporator, and similarly fluid transmitted to the evaporator is cooled by the fluid returned from the evaporator.

A problem with such an arrangement is the high cost of the copper used to form the suction tube.

Brief Summary of the Invention

According to a first aspect of the present invention, there is provided, in a heat transfer system using a working fluid that undergoes compression and evaporation, a heat exchanger comprising a first tube for fluid transmission and a second tube for fluid transmission, in which said first tube is placed in thermal contact with said second tube for a proportion of the respective lengths of said first tube and said second tube so as to allow an exchange of heat between the fluid within said tubes, wherein said first tube is constructed from steel alloy; and said steel alloy has alloyed components which reduce the hardness of said steel to facilitate tube bending, thereby allowing said first tube to be constructed from said steel within the heat transfer system, in preference to copper.

According to a second aspect of the present invention, there is provided a heat exchanger comprising a capillary tube for transporting a liquid to an evaporator of a heat transfer system, and a suction tube for transporting fluid from the evaporator, wherein a portion of the length of the capillary tube is secured to a portion of the length of the suction tube such that thermal conduction is provided from the liquid in the capillary tube to the fluid in the suction tube, and wherein the suction tube comprises a iron alloy tube, and at least said portion of the iron alloy tube is coated with a protective coating providing a surface onto which the capillary tube is soldered or brazed.

Brief Description of the Several Views of the Drawings

Figure 1 shows a rear perspective view of a domestic refrigeration unit **101**;

Figure 2 shows schematically the heat transfer system of the refrigerator **101**;

Figure 3 shows a heat exchanger **301** comprising a suction tube **107** and a capillary tube **108** prior to fitting within the refrigeration unit **101**;

Figure 4 shows a section of the soldered portions of the suction tube **107** and capillary tube **108**;

Figure 5 shows an alternative heat exchanger **501**; *Figure 6* shows a further alternative heat exchanger **601**;

Figure 7 shows, in cross-section, a portion of the heat exchanger **601** at the solder joint connecting section **607B** and section **607C** of suction tube **607**;

Figure 8 shows a flow chart of the steps for producing a refrigeration unit containing the heat exchanger of *Figure* 3, 5 or 6;

Figure 9 shows a table of the alloyed elements of the steel alloy from which the suction tube is made; and

Figure 10 shows parameters of tubes used in a bending experiment and the relative forces required to cause the tubes to plastically bend.

Written Description of the Best Mode for Carrying out the Invention

Figure 1

A rear perspective view of a domestic refrigeration unit **101** is shown in *Figure 1*. In the present example, the refrigeration unit is a refrigerator having a door **102** at its front to allow access to a refrigeration cavity. The cavity is configured to provide cold storage for perishable goods such as food, drinks, etc.

The refrigerator **101** has a heat transfer system which pumps heat from the refrigeration cavity to the air surrounding the refrigerator. The heat transfer system comprises an electrically powered compressor **103** located within a lower rear compartment **104** of the refrigerator, a condenser **105** mounted on a rear outer wall **113** of the refrigerator, a drying and filtering unit **106**, and an evaporator (shown as **201** in *Figure 2*) mounted within the refrigeration cavity.

The condenser **105** comprises a meandering tube **111** attached to a louvered panel **112** which assists transportation of heat from the tube **111** to the surrounding air during operation.

In addition, the heat transfer system comprises: a suction tube **107** which has a first end connected to the outlet of the evaporator and a second end connected to the inlet of the compressor **103**; and a capillary tube **108** which has a first end connected to the outlet of the condenser **105** via the dryer and filtering unit **106** and a second end connected to the inlet of the evaporator.

A middle portion **109** of the length the capillary tube **108** is secured to a middle portion **110** of the length of the suction tube **107**, while each of the tubes **107** and **108** have free portions adjacent their ends to allow relevant connections to other components of the heat transfer system.

During the production of the refrigeration unit **101**, the suction tube **107**, has its first end connected to the evaporator. Its second end is then passed through holes in rear walls of the refrigeration unit and then connected to the compressor **103**. This process requires a degree of manual manipulation and bending of the suction tube **107**. Conventionally, the suction tube has been made from copper which allows such manipulation and bending to be manually performed. However, the present suction tube is made from a steel material which has also been found to provide the necessary softness to facilitate these manual operations.

Figure 2

The heat transfer system of the refrigerator **101** is shown schematically in *Figure 2*. In addition to the compressor **103**, condenser **105**, dryer and filter unit **106**, capillary tube **108** and suction tube **107**, *Figure 2* also shows the evaporator **201** located within the refrigeration cavity **202**.

The evaporator **201** comprises a meandering tube which has an inlet connected to the capillary tube **108** and an outlet connected to the suction tube **107**. Typically, the evaporator tube will be mounted on a plate which assists the transfer of heat from the air within the refrigeration cavity **202** to the evaporator tube. Alternatively, the evaporator tube may take the form of deformations in a pair of connected plates, formed in a roll bond process as is known in the art.

The heat transfer system contains a refrigerant fluid that is a gas at ambient pressure and temperature but is capable of being liquefied under pressure. During operation, the compressor **103** pumps the refrigerant around a circuit comprising the condenser **105**, the drying and filtering unit **106**, the capillary tube **108**, the evaporator **201**, and the suction tube **107**, in that order. The capillary tube **108** has an internal diameter, typically of 0.7 millimetres, that is small when compared with the internal diameters of the tubes of the condenser **105** and the evaporator **201**. Consequently, the capillary tube acts as a resistance to flow of refrigerant and during operation of the compressor it allows pressure to build up in the condenser **105**.

During operation, the compressor **103** pumps very warm gaseous refrigerant (typically at 70 degrees centigrade) into the condenser **105**. As the refrigerant travels through the condenser **105** it loses heat to the surrounding air until its temperature becomes so low that it condenses to form a liquid. (Typically at around 35 degrees centigrade.) Thus, by the time the refrigerant reaches the capillary tube it is in the form of a warm liquid.

Consequently, liquid refrigerant is transported into the evaporator, where the pressure is comparatively low, and it evaporates into a gas again. The process of evaporation requires the absorption of the latent heat of evaporation of the refrigerant and thus it has a cooling effect on the evaporator and the refrigeration cavity.

The gaseous refrigerant then passes through the suction tube **107** back to the compressor **103**.

As mentioned above, a portion **109** of the length of the capillary tube **108** is secured to a portion **110** of the length of the suction tube **107**, such that conduction of heat can take place between the two tubes and between the fluid in the two tubes. Consequently, heat is conducted from the liquid refrigerant in the capillary tube to the fluid in the suction tube. This has two beneficial effects. Firstly, the heat from the capillary tube received by the suction tube ensures that any residual liquid leaving the evaporator **201** is evaporated before it reaches the compressor **103**. Secondly, the loss of heat from the liquid refrigerant in the capillary tube means that it reduces in temperature during its passage to the evaporator. Consequently, the low temperature of the liquid entering the evaporator ensures that the evaporation of liquid takes place along much of the length of the evaporator.

Thus, the suction tube **107** in combination with the capillary tube **108** form a heat exchanger which has beneficial effects on the operation of the refrigeration unit **101**.

In alternative embodiments the refrigeration unit **101** is a domestic freezer, or other refrigeration unit which makes use of a heat exchanger for transferring heat from a evaporator inlet tube, such as a capillary tube, to an evaporator outlet (suction) tube.

Figure 3

A heat exchanger **301** comprising the suction tube **107** and capillary tube **108** is shown in *Figure 3*, prior to fitting within the refrigeration unit **101**. The heat exchanger **301** is formed as an item in advance of the assembly of the refrigeration unit **101**. In addition, the heat exchanger is bent by machinery prior to the assembly of the refrigeration unit **101**, so as to minimise the need for manual bending during assembly.

Thus, in the present embodiment, the portion **110** of the suction tube **107** and the portion **109** of the capillary tube **108** are secured together by soldering, and then the tubes are bent to the required shape. In the present example, the heat exchanger **301** is provided with a 180 degree bend **302** and a 90 degree bend **303**.

Figure 4

A section of the soldered portions of the suction tube **107** and capillary tube **108** are shown in *Figure 4*. The capillary tube **108** comprises a copper tube having an internal diameter of typically 0.7 millimetres.

The suction tube has a relatively larger internal diameter of typically 4.6 to 6.6 millimetres and has a wall thickness of 0.7 millimetres. The outer surface of the suction tube is coated with a zinc coating **401** during its production and prior to soldering of the two tubes **107** and **108**.

The zinc coating **401** provides the steel suction tube **107** with protection against corrosion during use. In addition, zinc coating **401** provides the steel suction tube **107** with a surface that allows the solder to wet the tube in a reliable and repeatable manner. Consequently, a well formed fillet of solder is produced between the two tubes.

The solder **402** is a tin and silver alloy solder having 97% tin and 3% silver. However, in an alternative embodiment, the solder is a tin and copper alloy and the use of other similar solders is envisaged.

In an alternative embodiment the capillary tube is brazed to the suction tube rather than being soldered.

Figure 5

An alternative heat exchanger **501** to that of *Figure 3* is shown in *Figure 5*. Heat exchanger **501** is of similar construction to heat exchanger **301** in that it has a steel suction tube **507** having an outer surface coated with zinc, and a copper capillary tube **508**. However, the capillary tube **508** is secured to the suction tube **507** by an outer sleeve **520** which, in this case, is a heat-shrink material. In the present example the heat shrink comprises of a polyolefin material, but in alternative embodiments other known heat shrink materials, such as PVC and PTFE, are used.

Figure 6

A further alternative heat exchanger **601** is shown in *Figure 6*. The heat exchanger **601** has a suction tube **607** formed in three sections **607A**, **607B** and **607C** which are joined together by a solder joint to form a continuous tube. The central section **607B** of the suction tube **607** contains a middle portion of the length of a copper capillary tube **608**. Consequently, during use, heat is able to leave the liquid refrigerant in the capillary tube, pass through the capillary tube wall and increase the heat in the gas/liquid refrigerant in the suction tube.

Figure 7

A portion of the heat exchanger **601** at the solder joint connecting section **607B** and section **607C** of suction tube **607** is shown in cross-section in *Figure 7*. The solder joint connecting sections **607A** and **607B** is similarly configured.

The central section **607B** of the suction tube has mechanically deformed end portions **702** produced by expanding said end portions over a mandrel. The end portions of the suction tube are deformed such that the bore has a keyhole-like shape. Thus the end portions have an enlarged cylindrical part **703** configured to receive an end of the outer sections **607A** and **607B** respectively, and an eccentric part **704** configured to accommodate the capillary tube **608**.

Solder **701** mechanically fixes the sections **607B** and **607C** and capillary tube **608** together and seals around the suction tube and capillary tube to form a leak tight joint. Thus, the solder joints provide a means of allowing the capillary tube to enter and exit the bore of the suction tube.

In an alternative embodiment, the suction tube is formed as a single length and holes are drilled to allow the entry and exit of the capillary tube. The capillary tube is soldered in place where it enters and exits the holes to make the suction tube leak-proof.

Figure 8

A flow chart showing the steps in producing a refrigeration unit containing an above described heat exchanger is shown in *Figure 8*. At step **801** strip metal is formed by a rolling mill into a tubular form and induction welded to close the seam of the tube. The strip used is a low carbon steel strip, with alloyed components as described below.

The tube formed at step **801** has a diameter that is larger than required, and it is drawn down to the required diameter of the suction tube at step **802**. For example, a tube of 11mm diameter may be drawn down to produce an 8mm diameter suction tube.

At step **803** the tube is annealed to reduce its hardness to facilitate bending. The annealing process at step **803** and the process steps **801** are all performed in-line. Thus, immediately after the formed tube emerges from the rollers of the rolling mill of step **801** it is drawn down to size at step **802** and also annealed at step **803**. In a preferred annealing process the tube is heated to a temperature of 480 to 800 degrees centigrade for 5 seconds and maintained at 480 degrees for 15 seconds. However, in practice, an annealing process in which the tube is heated to a temperature of 750 degrees centigrade for 3 seconds, cooled down to 450 degrees centigrade and maintained at 450 degrees for 10 seconds produces a tube which is sufficiently soft to be of practical value. The ease with which this tube may be bent is demonstrated in the bend measurement described below, with reference to *Figure 10*.

At step **804** the tube is coated with a corrosion protection layer which protects the steel from corrosion during the suction tube's operational life. In the present example, the coating is a layer of zinc with a weight of at least 70 grams per square metre applied by a hot dip zinc coating process, in accordance with Italian standard UNI 5741-66.

In an alternative embodiment a zinc coating is applied to the outside of the tube at step **804** by electroplating to a thickness of at least 12 micrometres according to international standard ISO 2081, and then yellow passivated in a chrome base electrolyte according to international standard ISO 4520.

In a further alternative embodiment at step **804** the outside of the tube is coated by electroplating aluminium onto it.

Following step **804** the tube is cut to the required length of the suction tube at step **805** and a length of copper capillary tube is attached to the suction tube to form the heat exchanger. In the present example a portion of the length of the capillary tube is soldered along the outside of the suction tube using a tin/silver solder comprising 97% tin and 3% silver. However, alternative solders such as tin/copper solder, tin/copper/silver, etc. are envisaged.

In the case of the alternative embodiment *Figure 6*, the step **805** of attachment of the capillary tube to the suction tube comprises passing the two tubes through a suitable length of heat shrink sleeve, and then heating the sleeve.

In the case of the alternative embodiment of *Figure 6*, the three sections of suction tube are cut to the required lengths, and the ends of the middle section **607B** are deformed. The capillary tube is then passed through the middle section and the two end sections positioned and brazed with a silver alloy into the ends of the middle section.

The heat exchanger produced at step **805** is then bent to a required shape at step **806**, to produce a formed heat exchanger, such as those shown in Figures 3, 5 and 6.

At step **807** the heat exchanger is located within a heat transfer system of a refrigeration unit. This step requires leak proof connections to be made between the suction tube and the capillary tube and a respective end of the evaporator, and then connections between the capillary tube and the filtering and drying unit and between the suction tube and the compressor. During step **807** further manual bending of the heat exchanger is often required, and therefore it is advantageous for the suction tube to be made from a material which is easily bent.

In each of the above described embodiments, the capillary tube is a copper tube. However, in alternative embodiments the capillary tube is an aluminium tube, or other metal capillary tube.

Figure 9

A table showing alloyed elements of the steel alloy from which the suction tube is made is shown in *Figure 9*. The suction tube is formed from a low carbon steel, having: a carbon content of less than 0.03% by mass; a manganese content of less than 0.35% by mass; a phosphorus content of less than 0.03% by mass; sulphur content of less than 0.03% by mass; and titanium content of between 0.05 and 0.4%.

In preferred embodiments the carbon content is between 0.001% and 0.02% by mass and typically 0.02% by mass; the manganese content is between 0.10% and 0.25% by mass and typically 0.25% by mass; the phosphorus content is between 0.00% and 0.02% by mass and typically 0.02% by mass; the sulphur content is between 0.01% and 0.02% by mass and typically 0.02% by mass; and the titanium content is between 0.06 and 0.3% and typically 0.3%. This type of steel has a yield strength of 180 N/mm^2, a tensile strength of 270-350 N/mm^2 and a minimum elongation of

40%. Consequently, it has been found that a suction tube made from such steel may be manually manipulated and bent in a similar manner to a copper suction tube.

Figure 10

In an experiment to illustrate the suitability of the annealed low carbon suction tube for use in the heat exchanger, a typical length of 6mm diameter copper tube was secured at one end between a pair of jaws and the opposing end was pulled using a scale to measure the force applied. This was repeated for a similar lengths of a conventional steel tube, made from steel strip according to EN10139 ed.1999, and the annealed low carbon steel tube, used in the heat exchanger of *Figure 3*.

The parameters of the tubes and relative bending torque required to cause the tubes to plastically bend are shown in the table of *Figure 10*. As demonstrated, the copper tube was the easiest to bend but the annealed low carbon steel tube was substantially softer than the conventional steel tube.

Previously, the relative rigidity of the conventional steel tube often meant that a copper suction tube must be used. However, the workability of the annealed low carbon steel tube facilitates the bending and positioning of the heat exchanger within refrigeration units, such as unit **101**.

Claims

1. In a heat transfer system using a working fluid that undergoes compression and evaporation, a heat exchanger comprising a first tube for fluid transmission and a second tube for fluid transmission, in which said first tube is placed in thermal contact with said second tube for a proportion of the respective lengths of said first tube and said second tube so as to allow an exchange of heat between the fluid within said tubes, wherein

said first tube is constructed from steel alloy; and

said steel alloy has alloyed components which reduce the hardness of said steel to facilitate tube bending, thereby allowing said first tube to be constructed from said steel within the heat transfer system, in preference to copper.

2. A heat exchanger according to claim **1**, wherein the first tube is a suction tube for transmission of fluid from an evaporator, and the second tube is a capillary tube for transmission of fluid to the evaporator.

3. A heat exchanger according to claim **1** or claim **2**, wherein said first tube comprises steel having a carbon content of less than 0.03% by mass.

4. A heat exchanger according to any of claims **1** to **3**, wherein said first tube comprises steel having a titanium content between 0.05% and 0.4%.

5. A heat exchanger according to claim **4**, wherein said first tube comprises steel having a titanium content between 0.06% and 0.3%.

6. A heat exchanger according to any of claims **1** to **5**, wherein said first tube comprises steel having a carbon content of less than 0.03% by mass, a manganese content of less than 0.35% by mass, a phosphorus content of less than 0.03% by mass and a sulphur content of less than 0.03% by mass.

7. A heat exchanger according to claim **6**, wherein said first tube comprises steel having a carbon content of up to 0.02% by mass, a manganese content of up to 0.25% by mass, a phosphorus content of up to 0.02% by mass and a sulphur content of up to 0.02% by mass.

8. A heat exchanger according to any of claims **1** to **7**, wherein said first tube is formed by rolling a sheet into a tubular form and seam welding.

9. A heat exchanger according to any of claims **1** to **8**, wherein said first tube is coated with a protective metallic coating which resists corrosion of the steel.

10. A heat exchanger according to claim **9**, wherein said first tube is plated with aluminium.

11. A heat exchanger according to claim **9**, wherein said first tube is coated with a zinc coating.

12. A heat exchanger according to any of claims **9** to **11**, wherein said portion of the length of the second tube is soldered or brazed to the protective coating of the first tube.

13. A heat exchanger according to any of claims **1** to **10**, wherein the second tube is attached to the first tube using solder or braze.

14. A heat exchanger according to claim **13**, wherein the second tube is soldered to the first tube using a solder comprising of tin alloy.

15. A heat exchanger according to any of claims **1** to **11**, wherein the second tube is attached to the first tube using a heat shrinkable tube.

16. A heat exchanger according to any of claims **1** to **11**, wherein said portion of the length of the second tube is located within the bore of the first tube.

17. A heat exchanger according to any of claims **1** to **16**, wherein said steel alloy is annealed in order to further reduce its hardness.

18. A method of manufacturing a heat exchanger comprising a capillary tube for transporting a liquid to an evaporator of a heat transfer system, and a suction tube for transporting fluid from the evaporator to a compressor of the heat transfer system, said method comprising the sequential steps of:

obtaining a suction tube comprising steel having alloyed components which reduce the hardness of said steel to facilitate bending of the suction tube;

securing a portion of the length of a capillary tube to a portion of the length of a suction tube to allow thermal conduction from fluid in the capillary tube to the fluid in the suction tube; and

bending the suction and capillary tube to a required shape.

19. A heat exchanger comprising a capillary tube for transporting a liquid to an evaporator of a heat transfer system, and a suction tube for transporting fluid from the evaporator,

wherein a portion of the length of the capillary tube is secured to a portion of the length of the suction tube such that thermal conduction is provided from the liquid in the capillary tube to the fluid in the suction tube, and

wherein the suction tube comprises a iron alloy tube, and at least said portion of the iron alloy tube is coated with a protective coating providing a surface onto which the capillary tube is soldered or brazed.

20. A heat exchanger according to claim **19**, wherein the protective coating comprises of zinc.

21. A heat exchanger according to claim **19**, wherein said suction tube has a protective coating produced by hot dip zinc coating.

22. A heat exchanger according to any of claims **19** to **21**, wherein said capillary tube is a copper tube.

Application No:	GB0421274.2
Claims searched:	1-18
Examiner:	Mick Monk
Date of search:	21 December 2004

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
X	1-5,18 at least	GB 1226241 A CARRIER CORPORATION See especially the table on p.3.
X	1-5,18 at least	US 6212891 A EXXONMOBIL UPSTREAM RESEARCH See especially the Tables in columns 7 & 10; paragraph 4 column 19.
X	1,18 at least	GB 2133524 A ECHANGEURS DE CHALEUR SAG SA See for example l.63 p.2
X	1,18 at least	US 5533362 A COLUMBIA GAS OF OHIO INC See eg paragraph 2 p.12.
X	1,18 at least	GB 2046890 A NIPPON KOKAN KABUSHIKI KAISHA Consider whole document
X	1,18 at least	GB 1291748 A NIPPON KOKAN KABUSHIKI KAISHA Consider whole document; see l.56 p.5.
X	1,18 at least	GB 1130038 A R & G SCHMOLE METALLWERKE KG Consider whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[W] :

PATENTS • DESIGNS • The Patent Office • COPYRIGHT • TRADE MARKS

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F4H; F4S

Worldwide search of patent documents classified in the following areas of the IPC[07]

F25B; F28F

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

ONLINE DATABASES : WPI EPODOC JAPIO

19

Application No:	GB0421274.2
Claims searched:	19-22
Examiner:	Mick Monk
Date of search:	18 February 2005

Patents Act 1977
Further 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	19-22	GB 1226241 A CARRIER Heat exchange coil made of iron alloy.
A	19-22	GB 728131 A FOSTER WHEELER Outer tube of cast iron
X	19,22	FR 2528157 A INDESIT See especially Fig.2; return tube is made of galvanised iron; capillary of copper. It appears obvious to use a protective coating.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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