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AIR-CONDITIONING REFRIGERANT****Publication Classification**(76) Inventor: **Hubertus Rudolf Kamsma**, Filderstadt
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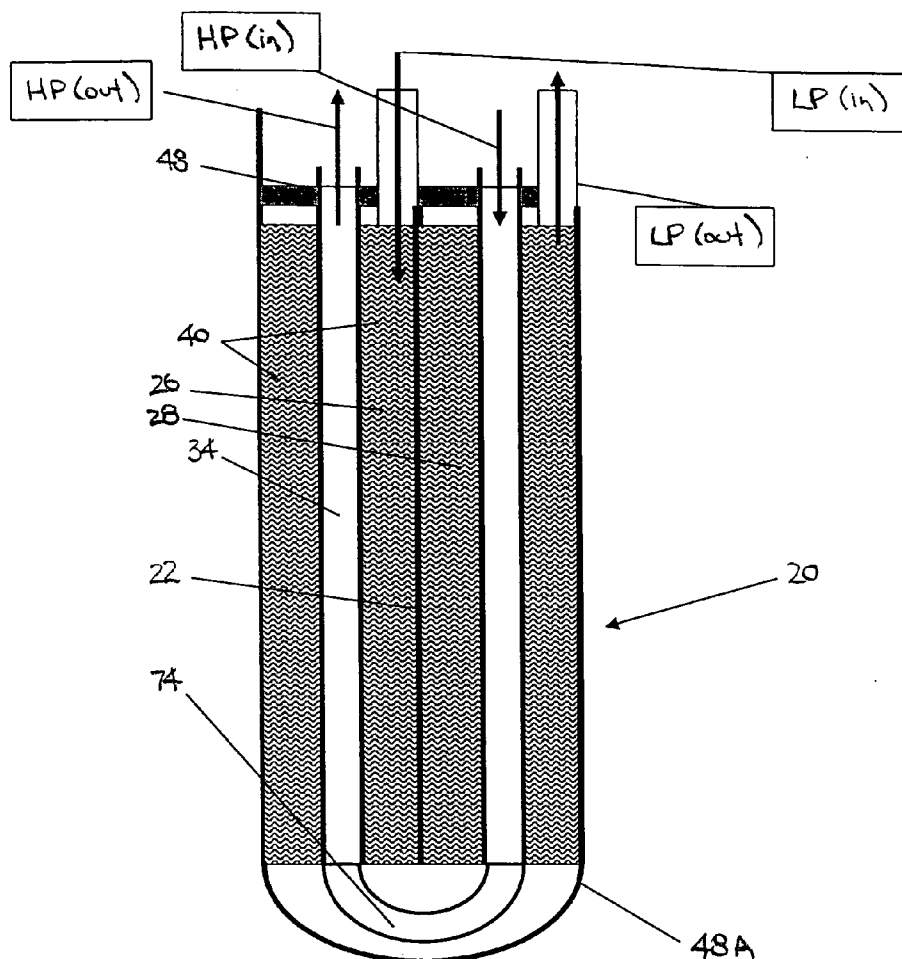
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CHICAGO, IL 60661 (US)**(57) **ABSTRACT**

An intermediate heat exchanger for refrigerant which passes through a high pressure side and a low pressure side in which the refrigerant has a different temperature circulating in an air conditioning loop. The heat exchanger includes a thin pressure-stable vessel defining at least one longitudinal compartment therein, and a flat multi-chamber tube through which refrigerant on one side flows. The tube extends through the at least one compartment and is spaced from at least two opposing walls of the compartment. Heat exchange ribs roughly fill the compartment between the tube and the two opposing walls, wherein refrigerant on the other side flows through the compartment between the tube and the two opposing walls.

(21) Appl. No.: **11/418,611**(22) Filed: **May 5, 2006**(30) **Foreign Application Priority Data**

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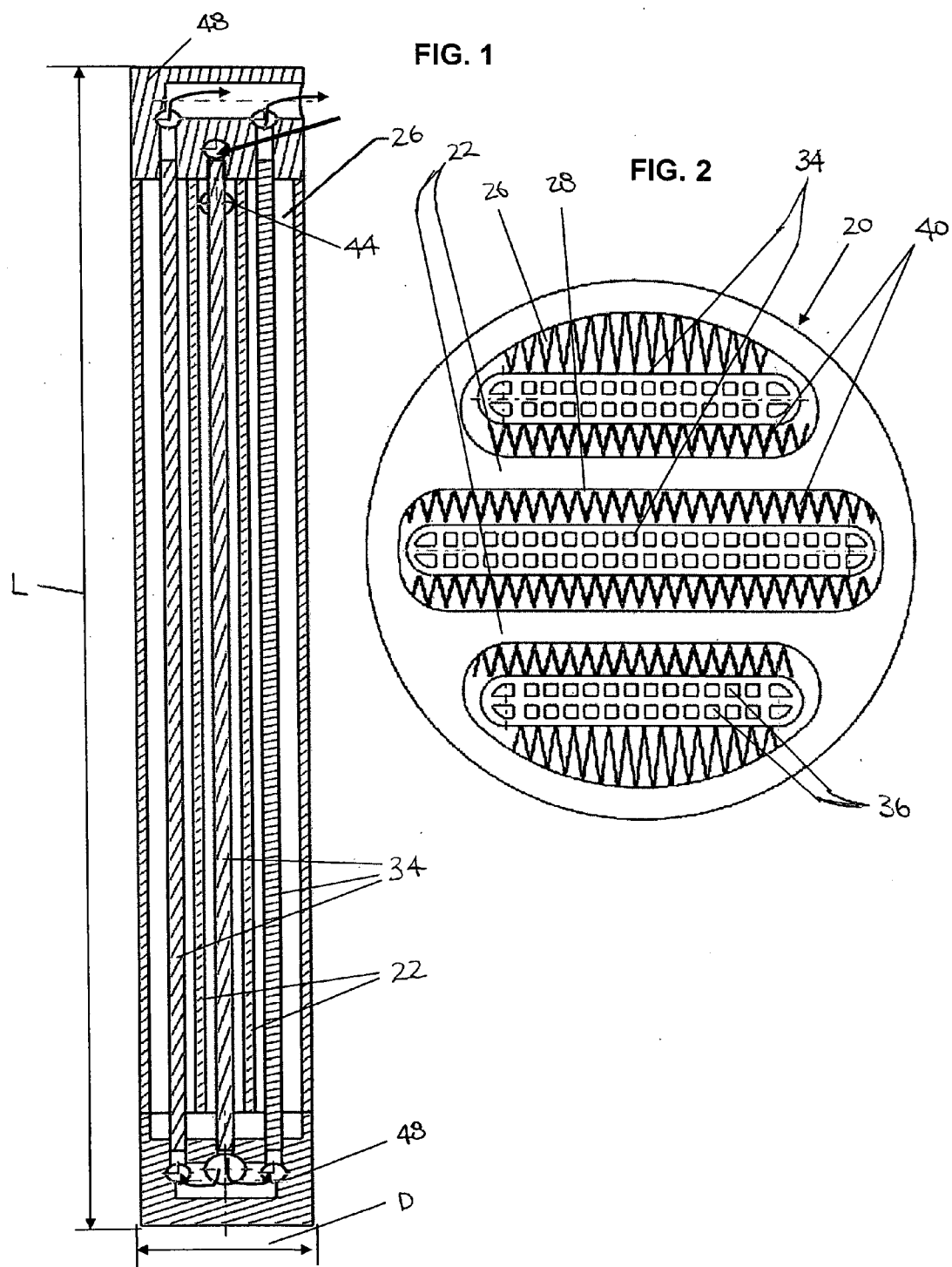


FIG. 3

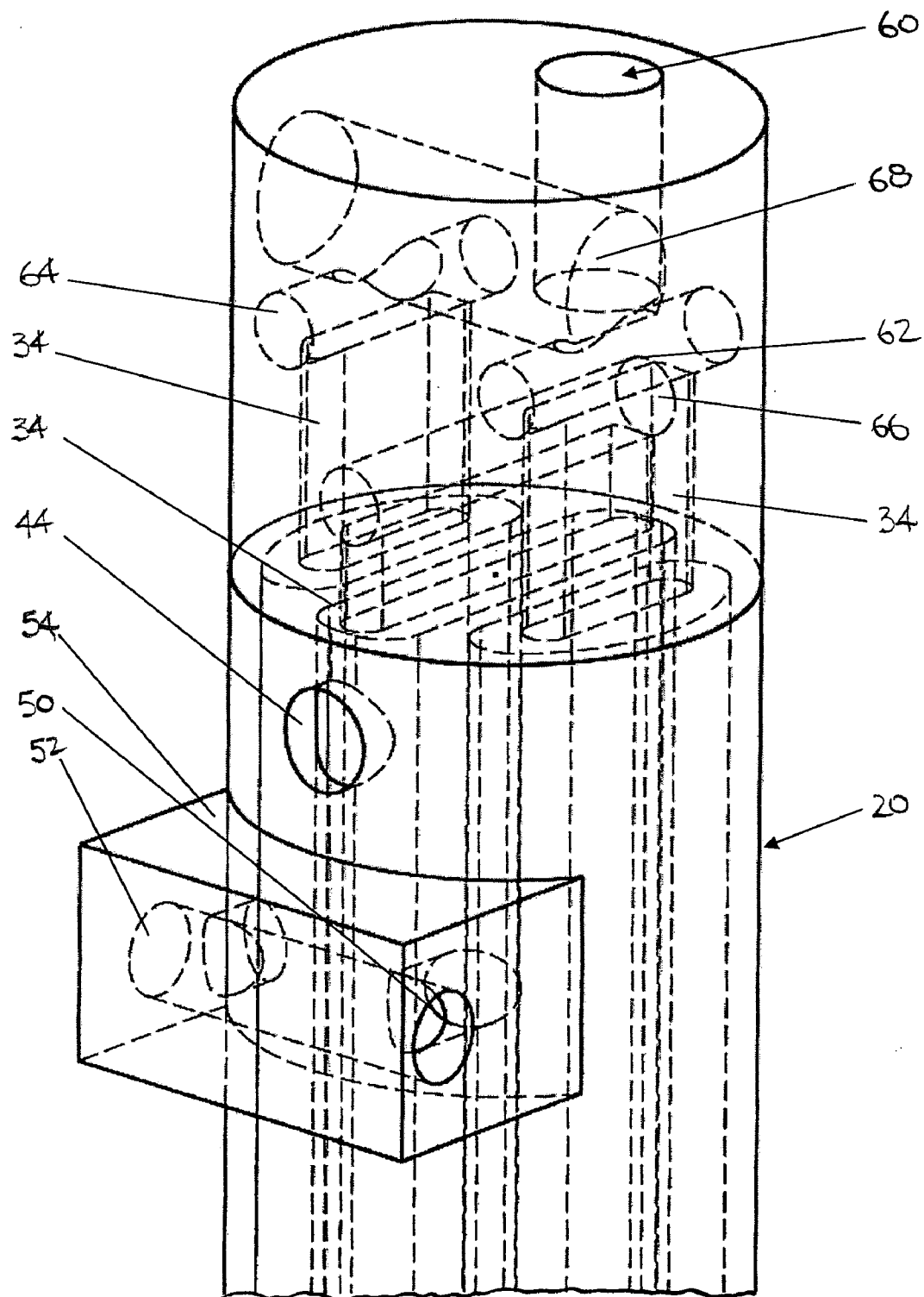
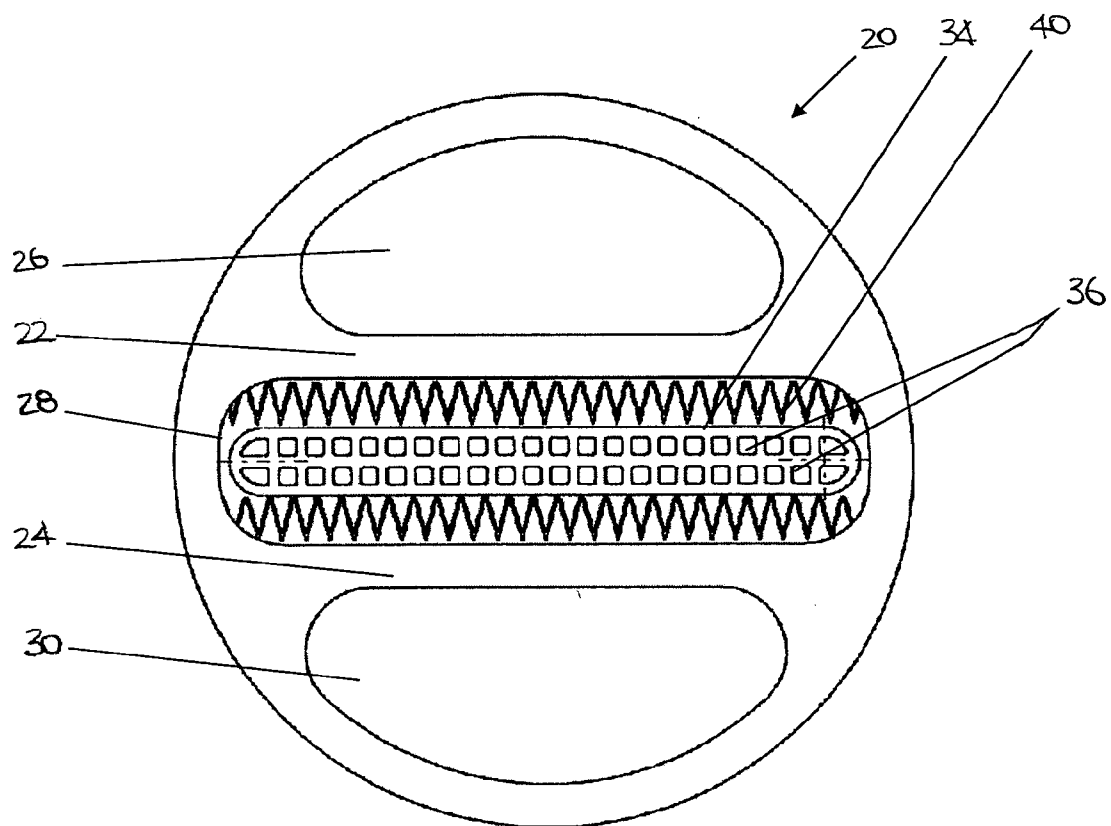


FIG. 4



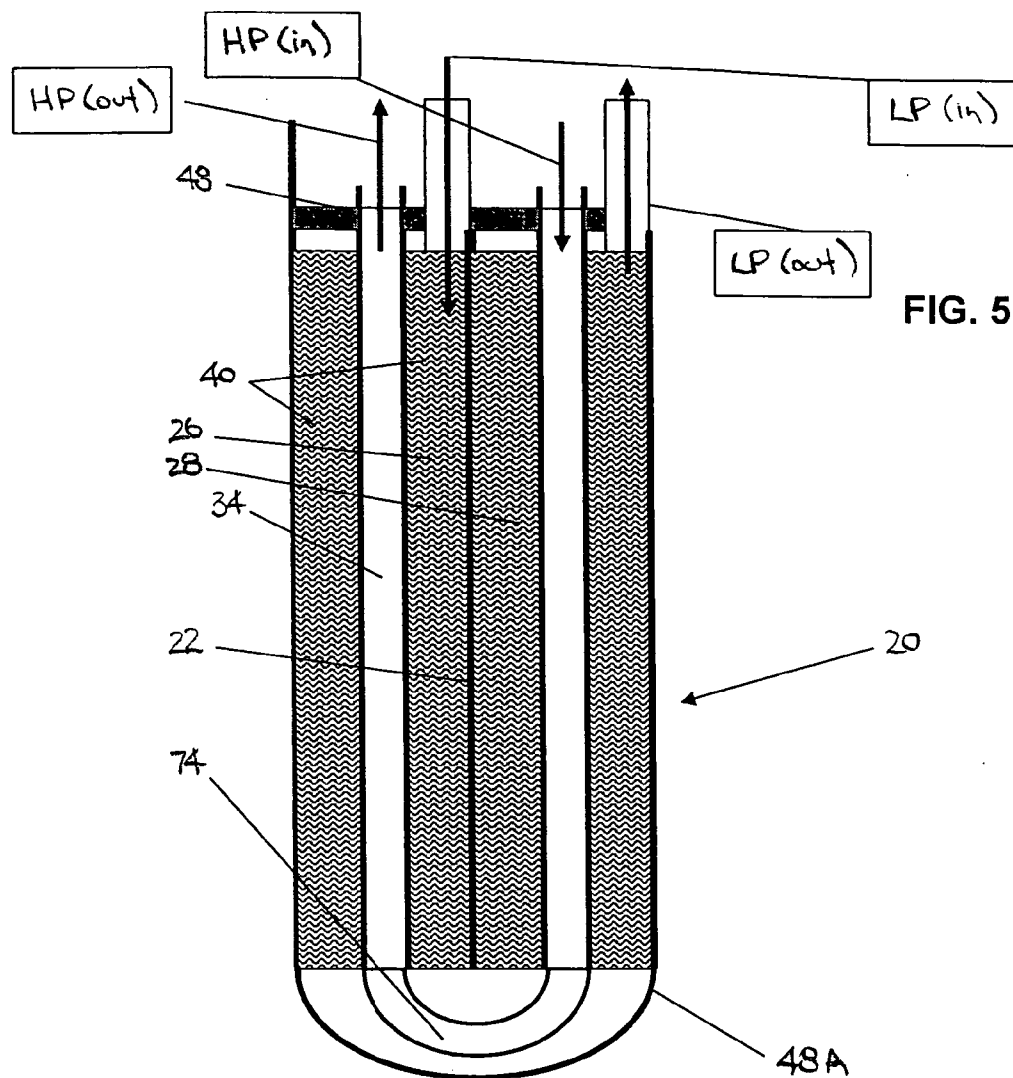


FIG. 6

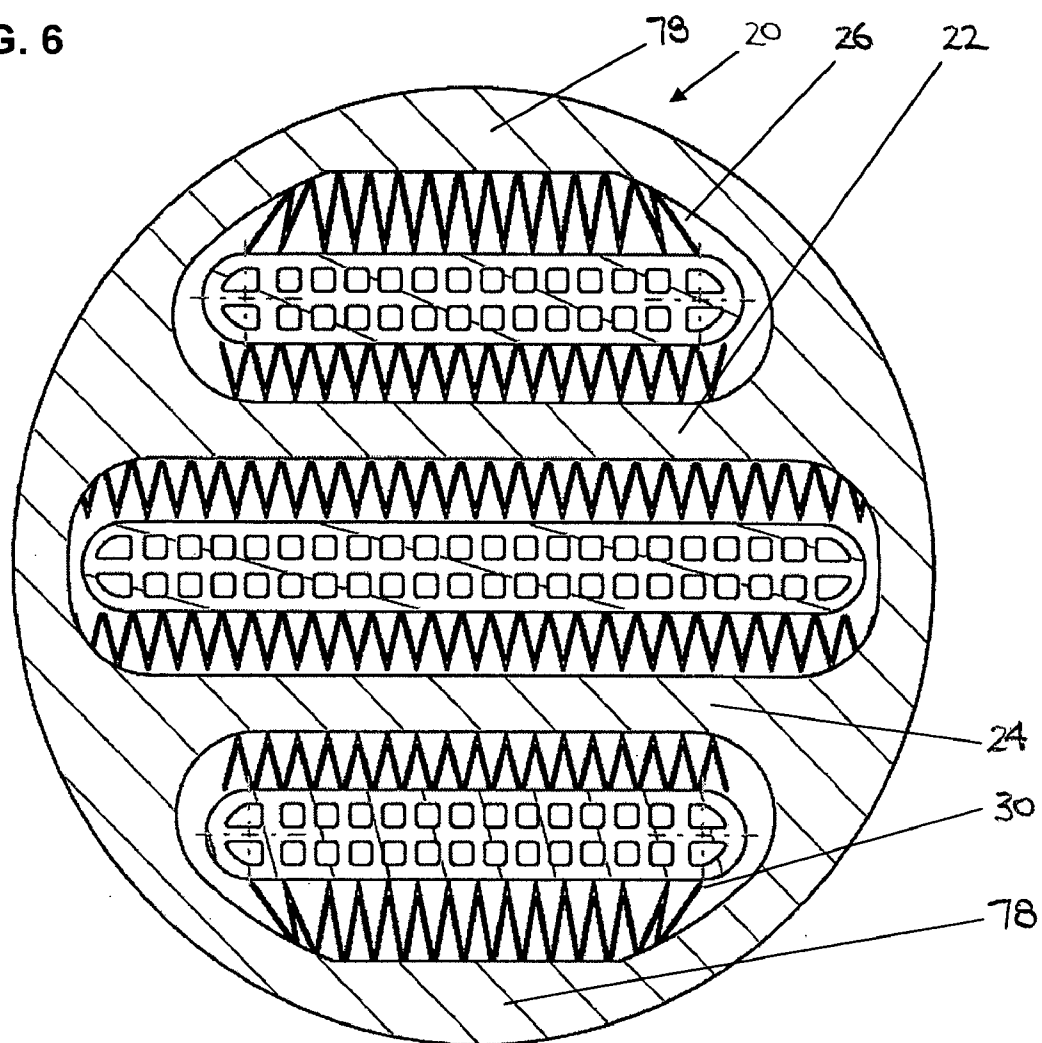


FIG. 7

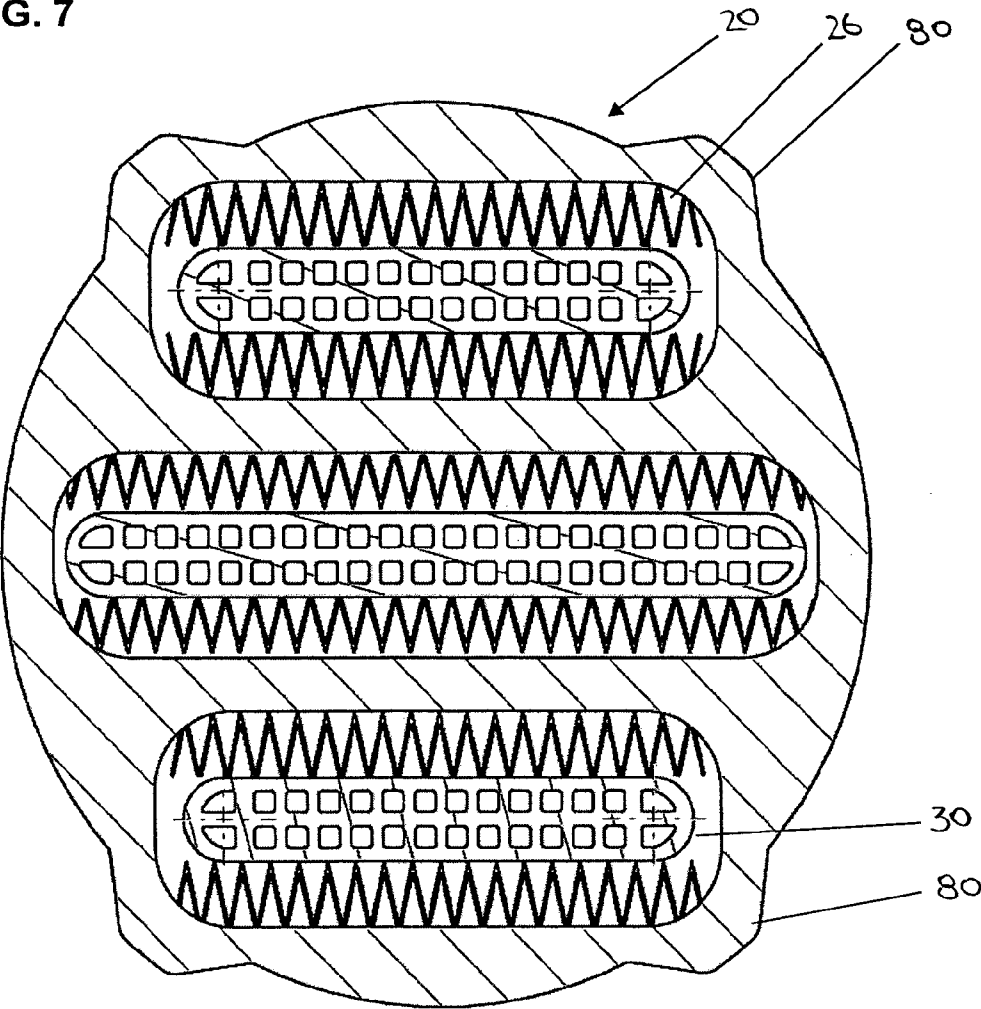


FIG. 8

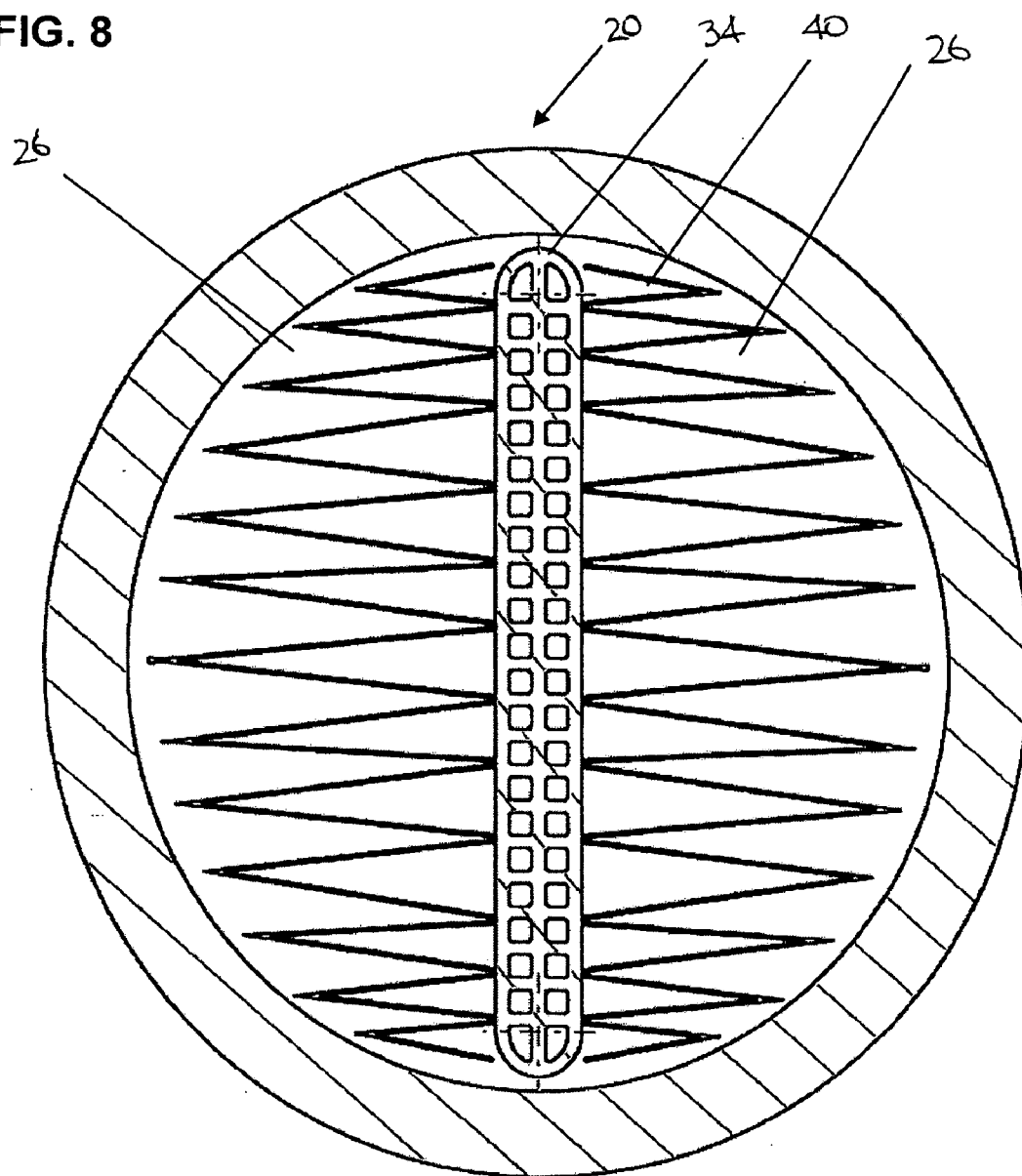
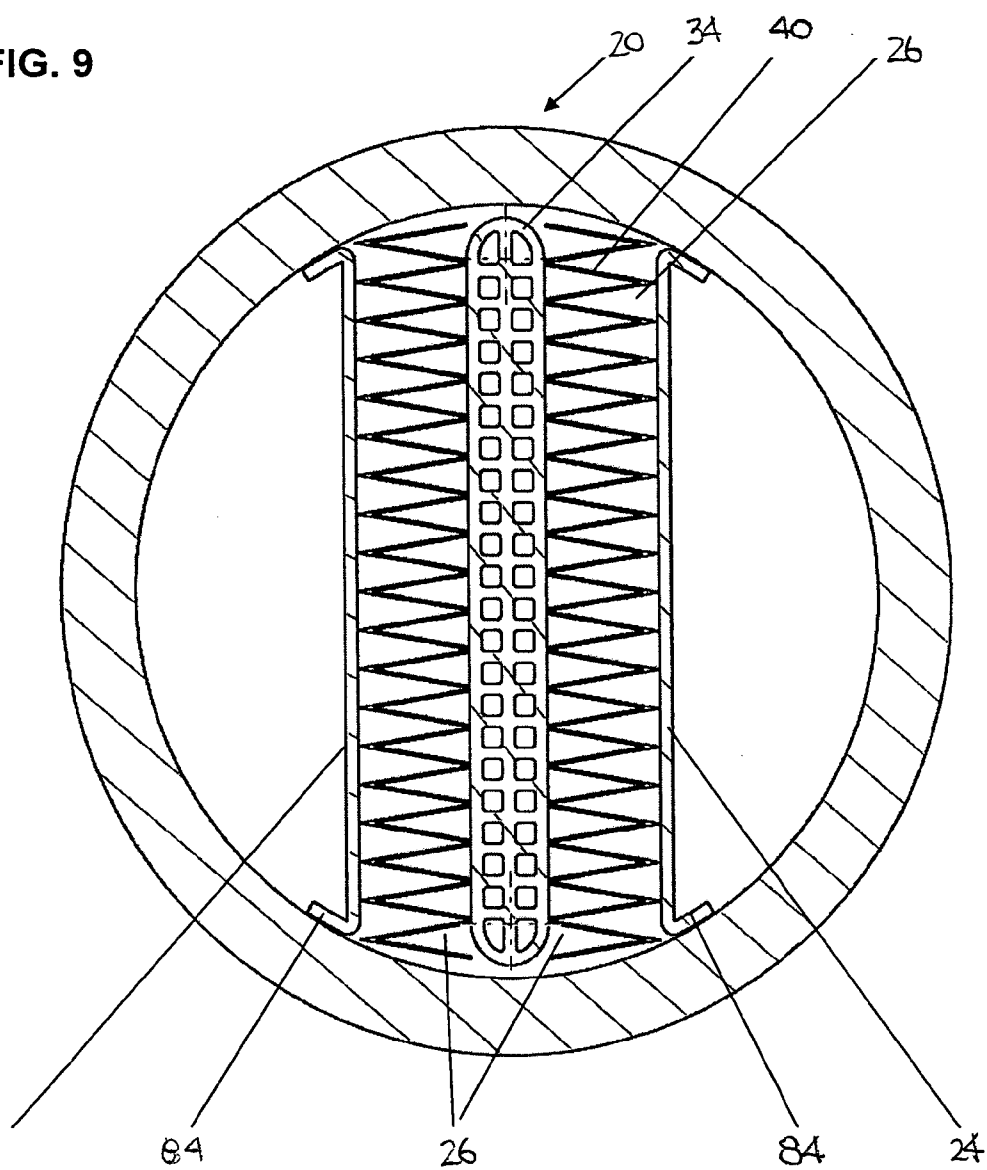


FIG. 9



INTERMEDIATE COOLER FOR AIR-CONDITIONING REFRIGERANT

CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

[0003] Not applicable.

TECHNICAL FIELD

[0004] The present invention relates to heat exchangers, and more particularly toward intermediate cooling of refrigerant circulating in an air-conditioning loop.

BACKGROUND OF THE INVENTION

AND

TECHNICAL PROBLEMS POSED BY THE PRIOR ART

[0005] Air-conditioning loops commonly include a refrigerant flowing through a compressor, gas cooler, evaporator (heat exchanger) and expansion valve, where the refrigerant passes through a high pressure side and a low pressure side in which the refrigerant has a different temperature.

[0006] One heat exchanger for exchanging heat between the high and low pressure sides, often referred to as an internal heat exchanger in transcritical air conditioning loops, is known from DE 196 35 454 A1 which provides improved heat exchange rates. However, manufacture of this device (arranged flat in the incorporation space in the vehicle) appears to be fairly demanding, among other things because the flat multi-chamber tubes are deformed as coils and insertion of the heat-conducting ribs between the windings of the coils is also complicated.

[0007] An intermediate heat exchanger is also disclosed in DE 103 22 028 B4, which is integrated as a coaxial tube in the collecting tube of the evaporator. This is a compact configuration which provides some ease of manufacture.

[0008] Another device for the same area of application is disclosed in U.S. Pat. No. 6,681,597 B1, in which the high pressure side and low pressure side flow through extruded, flat multi-chamber tubes which extend into a collection reservoir with their broad flat sides in conductive heat exchange relationship.

[0009] The present invention is directed toward improving upon the prior art to provide an easy to manufacture, compact heat exchanger for high and low pressure sides of an air-conditioning loop which provides efficient heat exchange.

SUMMARY OF THE INVENTION

[0010] In one aspect of the present invention, an intermediate heat exchanger is provided for refrigerant which passes through a high pressure side and a low pressure side in

which the refrigerant has a different temperature circulating in an air conditioning loop. The heat exchanger includes a thin pressure-stable vessel defining at least one longitudinal compartment therein, and a flat multi-chamber tube through which refrigerant on one side flows. The tube extends through the at least one compartment and is spaced from at least two opposing walls of the compartment. Heat exchange ribs roughly fill the compartment between the tube and the two opposing walls, wherein refrigerant on the other side flows through the compartment between the tube and the two opposing walls.

[0011] In one form of this aspect of the present invention, at least one of the opposing walls is curved, and the ribs fill the compartment between the curved wall and the flat multi-chamber tube.

[0012] In another form of this aspect of the present invention, at least one longitudinal wall divides the vessel into at least two compartments, wherein the multi-chamber tube extends in the longitudinal direction of the compartments and is substantially straight through at least one compartment. In a further form, the flat multi-chamber tube has a U-bend between two parallel straight portions, wherein the straight portions separately extend through two parallel compartments separated by the at least one longitudinal wall.

[0013] In still another form of this aspect of the present invention, the heat exchange ribs are arranged so as to be exposed to essentially no pressure loads.

[0014] In yet another form of this aspect of the present invention, the vessel is substantially cylindrical with closing covers at each end of the cylinder.

[0015] In another form of this aspect of the present invention, a plurality of longitudinal walls divide the vessel into a plurality of parallel longitudinal compartments. In a further form, a flat multi-chamber tube extends through each vessel compartment, with the tubes being arranged in series with one tube configured to input or output the refrigerant, and at least one other tube configured to output or input, respectively, the refrigerant. In a still further form, the one tube has a greater cross-section than the other tubes. In yet a further form, the vessel is substantially cylindrical, and the one tube extends substantially along the center plane of the cylindrical vessel.

[0016] In still another form of this aspect of the present invention, the vessel is substantially cylindrical, and the cross-sectional shape of the compartments is generally rectangular.

[0017] In yet another form of this aspect of the present invention, the chambers in the flat multi-chamber tube have a diameter of about 1.20 mm or less.

[0018] In another form of this aspect of the present invention, the length to diameter ratio (L/D) of the vessel is at least 3:1.

[0019] In still another form of this aspect of the present invention, both the vessel and the multi-chamber tube are extruded.

[0020] In yet another form of this aspect of the present invention, the ribs have walls extending longitudinally through the compartment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] **FIG. 1** is a longitudinal cross-section through a first embodiment of an intermediate heat exchanger incorporating the present invention;

[0022] **FIG. 2** is an axial cross-section through heat exchanger of **FIG. 1**;

[0023] **FIG. 3** is a perspective view of one end of the heat exchanger of **FIG. 1** showing inlets and outlets for the refrigerant;

[0024] **FIG. 4** is an axial cross-section through a second embodiment of a heat exchanger incorporating the present invention;

[0025] **FIG. 5** is a longitudinal schematic view of a third embodiment of a heat exchanger incorporating the present invention;

[0026] **FIG. 6** is an axial cross-section through a fourth embodiment of a heat exchanger incorporating the present invention;

[0027] **FIG. 7** is an axial cross-section through a fifth embodiment of a heat exchanger incorporating the present invention;

[0028] **FIG. 8** is an axial cross-section through a sixth embodiment of a heat exchanger incorporating the present invention; and

[0029] **FIG. 9** is an axial cross-section through a seventh embodiment of a heat exchanger incorporating the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0030] As illustrated in **FIGS. 1 and 2**, in accordance with one embodiment of the invention, a vessel **20** is formed as a round tube produced by extrusion. The tube has two longitudinal walls **22** and **24**, which divide the tube into three compartments **26**, **28**, **30**, each of which include a flat extruded multi-chamber tube **34** extending roughly the entire length of the compartments (the multi-chamber tube **34** could also be a soldered or welded tube with an internal insert forming the chambers).

[0031] In the illustrated embodiment, each multi-chamber tube **34** has two rows of passages **36** having a diameter of about 1.20 mm or less.

[0032] Further, each multi-chamber tube **34** is provided with one or more heat-conducting ribs **40** that fills up the cross-section of the corresponding compartment, preferably as fully as possible, so that the refrigerant flowing there does not flow through large, free cross-sectional spaces and therefore heat exchange with the tubes **34** is enhanced.

[0033] In the **FIGS. 1-2** embodiment, the refrigerant on the high pressure side (arrows in **FIG. 1**) flows on the top through the middle connection opening into the flat and larger multi-chamber tube **34** (in the center of the vessel **20**). The refrigerant then flows downward through that tube, and at the vessel bottom is distributed to the two other smaller multi-chamber tubes **34**, through which the refrigerant flows back up. From the two smaller tubes **34**, the refrigerant flows via two outflow openings to an expansion device (not shown), and then, for example, through an evaporator.

[0034] In the **FIGS. 1-2** embodiment, the refrigerant on the low pressure side flows into a corresponding inflow opening **44** either into the middle compartment **28** (in which case it flows downward through the heat exchange ribs **40** in the middle compartment **28** and then is distributed to the two other compartments to flow up through them), or the refrigerant on the low pressure side is distributed from the inflow opening **44** to all three compartments **26**, **28**, **30** (in which case it flows downward through all three compartments **26**, **28**, **30** and then to the compressor [not shown] in the loop).

[0035] The tube on the top and bottom has appropriate covers **48**, which complete the vessel **20**. As is apparent, flow channels for the refrigerant on the high pressure side are formed in cover **48**.

[0036] The above described components may advantageously be made of aluminum, which parts may be assembled and joined by soldering.

[0037] **FIG. 3** shows inflow and outflow of the refrigerant on the high pressure side and low pressure side one embodiment such as described in connection with **FIGS. 1-2** above. Reference numbers **44**, **50**, **52** show flow passages of the refrigerant on the low pressure side, with this low pressure refrigerant flowing at **44** into the middle compartment **28** (or flowing out of this compartment there). A connection block **54** includes channels and may be soldered with the other mentioned components, and includes two additional inflow (or outflow) openings or channels **50**, **52** that communicate with the other two compartments **28**, **30**. Openings or channels **60**, **62**, **64**, **66**, **68** are also provided for the refrigerant on the high pressure side, such openings being formed in the upper cover **48** and communicate with the multi-chamber tubes **34**.

[0038] **FIG. 4** illustrates another practical example in which only the middle compartment **28** is occupied by the multi-chamber tube **34** and heat exchange ribs **40**. Refrigerant on the low pressure side flows through the ribs **40** in the middle compartment **28**, and may (or may not) also flow in the two other compartments **26**, **30**. (It should be recognized that the longitudinal walls **70** can be made significantly thinner than is illustrated by **FIG. 4**, since roughly the same pressure is present in the compartments **26**, **28**, **30**).

[0039] **FIG. 5** schematically shows another embodiment incorporating the present invention, wherein the vessel **20** may have with a somewhat smaller degree of thinness. The multi-chamber tube **34** in this embodiment has a U-shaped bend **74**, whereby inflow and outflow of the refrigerant may both occur on the upper cover **48** (where the reference HP stands for the high pressure side and LP for the low pressure side). The lower cover **48A** is arched and the longitudinal wall **22** ends so that the refrigerant on the low pressure side can flow from compartment **26** back to the other compartment **28**, with the remaining cross-section of both compartments **26**, **28** being filled by heat exchange ribs **40** such as previously described.

[0040] **FIGS. 6 and 7** show embodiments which facilitate insertion of the heat exchange ribs **40** with the multi-chamber tube **34** into the corresponding compartments, where the cross-section of compartments **26** and **30** in vessel **20** is configured with an appropriate shape. In the **FIG. 6** embodiment, the wall thickness of the vessel **20** is partially increased somewhat at reference number **78**, whereas, in

FIG. 7, recesses **80** are included in the wall of vessel **20**. Such embodiments are easy to produce by extrusion. Further, ordinary corrugated ribs can be used as heat exchange ribs **40**, which are wound coil-like around the corresponding multi-chamber tube **34** and then inserted together with the tube into the appropriate compartment **26**, **28**, **30X**.

[0041] Perhaps the simplest form of the present invention is shown in **FIG. 8**, wherein the multi-chamber tube **34** extends linearly through the vessel **20** along its center longitudinal plane. The semicircular cross-sections of the compartments **26** of vessel **20** created by the multi-chamber tube **34** are filled up with heat-conducting ribs **40** which have a rib height adapted to the round shape of vessel **20**.

[0042] **FIG. 9** illustrates yet another embodiment of an intermediate heat exchanger incorporating the present invention, which embodiment is particularly suitable for manufacture. In this embodiment, two longitudinal walls **22A**, **24A** include bent longitudinal edges **84**, preferably having some elasticity, which lie against the inside of the vessel wall. The multi-chamber tube **34**, the heat-conducting ribs **40** and the two longitudinal walls **22A**, **24A** may be advantageously combined into a stack and pushed together into the vessel **20** so that the longitudinal edges **84** abut the vessel wall, whereby perfect solder connections are made possible or supported. Moreover, the compartment **28** is filled up by heat-conducting ribs **40** that have a uniform rib height and are therefore favorable to manufacture.

[0043] Overall, the suitability for manufacture of intermediate heat exchangers incorporating the present invention can be understood from the description and the drawings. Further, it should be appreciated that the efficiency of heat exchange, and the ability to fit into limited space requirements, are further of heat exchangers according to the present invention because of a very thin configuration of the vessel **20**. The thinness of the vessel **20**, expressed by the length L /diameter D ratio (see **FIG. 1**), may be advantageously at least 3:1, although an L/D ratio of 6:1 or even thinner is preferred.

[0044] Since the vessel **20** over its entire length is designed as a heat exchanger, good results in terms of heat exchange efficiency can be achieved. The vessel **20** and the intermediate heat exchanger have a noticeably slim appearance and are therefore particularly suitable for applications in which narrow spaces are present (according to the present invention, vessels with a length/diameter ratio of at least 3:1 or larger are considered slim vessels). Further, since the multi-chamber tubes **34** extend essentially straight through the compartments **26**, **28**, **30** (i.e., it need not be deformed), they may be readily assembled in the compartments together with the heat exchange ribs **40** almost completely filling up the remaining compartment cross-section, thereby providing both easy assembly and good heat exchange efficiency.

[0045] It should also be appreciated that the round shape of the longitudinal wall of the vessel **20** is able to withstand enormously high pressures, and therefore the heat exchange ribs **40** can be made from a very thin sheet material since it is not exposed to significant pressure stresses.

[0046] In addition, it should also be appreciated that the extrusion process for production of the vessel **20** makes it possible to design cross-section of the internal compartments **26**, **28**, **30** in the otherwise preferably round pressure

vessel **20** to be rectangular, and as a result the heat exchange ribs **40** can be very favorably inserted there without significant squeezing and in so doing almost completely fill up the compartment as mentioned. Roughly rectangular or square compartment cross-sections can be advantageously achieved either by partially increasing the wall thickness of the vessel **20** or by including gradations of the otherwise round vessel in the longitudinal direction of the vessel **20**, both of which can be efficiently manufactured by the deformation method of extrusion.

[0047] Still other aspects, objects, and advantages of the present invention can be obtained from a study of the specification, the drawings, and the appended claims. It should be understood, however, that the present invention could be used in alternate forms where less than all of the objects and advantages of the present invention and preferred embodiment as described above would be obtained.

1. An intermediate heat exchanger for refrigerant which passes **2** through a high pressure side and a low pressure side in which the refrigerant has a different temperature circulating in an air conditioning loop, comprising:

a thin pressure-stable vessel defining at least one longitudinal compartment therein;

a flat multi-chamber tube through which refrigerant on one side flows, said tube extending through said at least one compartment and spaced from at least two opposing walls of said compartment;

heat exchange ribs roughly filling the compartment between the tube and said two opposing walls, wherein refrigerant on the other side flows through the compartment between the tube and the two opposing walls.

2. The heat exchanger of claim 1, wherein at least one of the opposing walls is curved, and said ribs fill the compartment between said curved wall and said flat multi-chamber tube.

3. The heat exchanger of claim 1, further comprising at least one longitudinal wall dividing the vessel into at least two compartments, wherein the multi-chamber tube extends in the longitudinal direction of said compartments and is substantially straight through at least one compartment.

4. The heat exchanger of claim 3, wherein said flat multi-chamber tube has a U-bend between two parallel straight portions, wherein said straight portions separately extend through two parallel compartments separated by said at least one longitudinal wall.

5. The heat exchanger of claim 1, wherein said heat exchange ribs are arranged so as to be exposed to essentially no pressure loads.

6. The heat exchanger of claim 1, wherein said vessel is substantially cylindrical with closing covers at each end of the cylinder.

7. The heat exchanger of claim 1, further comprising a plurality of longitudinal walls dividing said vessel into a plurality of parallel longitudinal compartments.

8. The heat exchanger of claim 7, wherein a flat multi-chamber tube extends through each vessel compartment, with said tubes being arranged in series with one tube configured to input or output the refrigerant, and at least one other tube configured to output or input, respectively, the refrigerant.

9. The heat exchanger of claim 8, wherein said one tube has a greater cross-section than the other tubes.

10. The heat exchanger of claim 9, wherein said vessel is substantially cylindrical, and said one tube extends substantially along the center plane of the cylindrical vessel.

11. The heat exchanger of claim 1, wherein said vessel is substantially cylindrical, and the cross-sectional shape of the compartments is generally rectangular.

12. The heat exchanger of claim 1, wherein the chambers in the flat multi-chamber tube have a diameter of about 1.20 mm or less.

13. The heat exchanger of claim 1, wherein the length to diameter ratio (L/D) of the vessel is at least 3:1.

14. The heat exchanger of claim 1, wherein both the vessel and the multi-chamber tube are extruded.

15. The heat exchanger of claim 1, wherein said ribs have walls extending longitudinally through said compartment.

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