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(54) Titre : REFRIGERATEUR A L'HELIUM
(54) Title: HELIUM CHARGED REFRIGERATOR

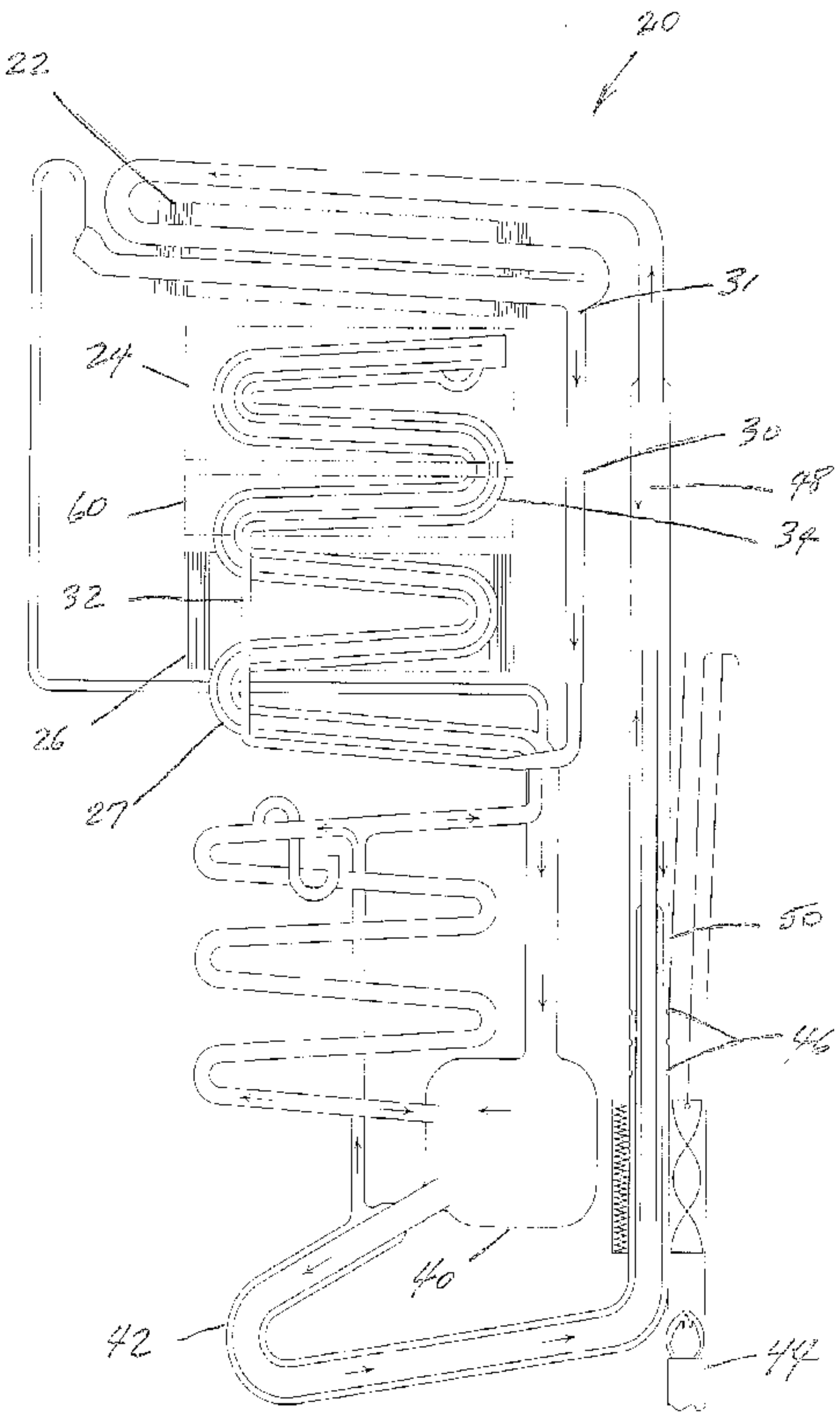

Fig. 3

(57) Abrégé/Abstract:
A refrigerator provides a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas. The refrigeration assembly includes a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger. The liquid ammonia tube includes a first

(57) Abrégé(suite)/Abstract(continued):
vertical section with an inlet and a second vertical section downstream of the first. The second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger. The heat exchanger includes inner and outer tubes. The inner tube has an outer surface, and the outer tube has an inner surface. The outer and inner surfaces each has serrations to produce an increase in surface area of the corresponding surface. The refrigerator has a freezer box defining a first cubic area and a refrigerator box defining a second cubic area. The sum of the first and second cubic areas is equal to or greater than six cubic feet. The assembly is capable of cooling the refrigerator box to a temperature of 6°C (43 °F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43 °C (1 10°F).

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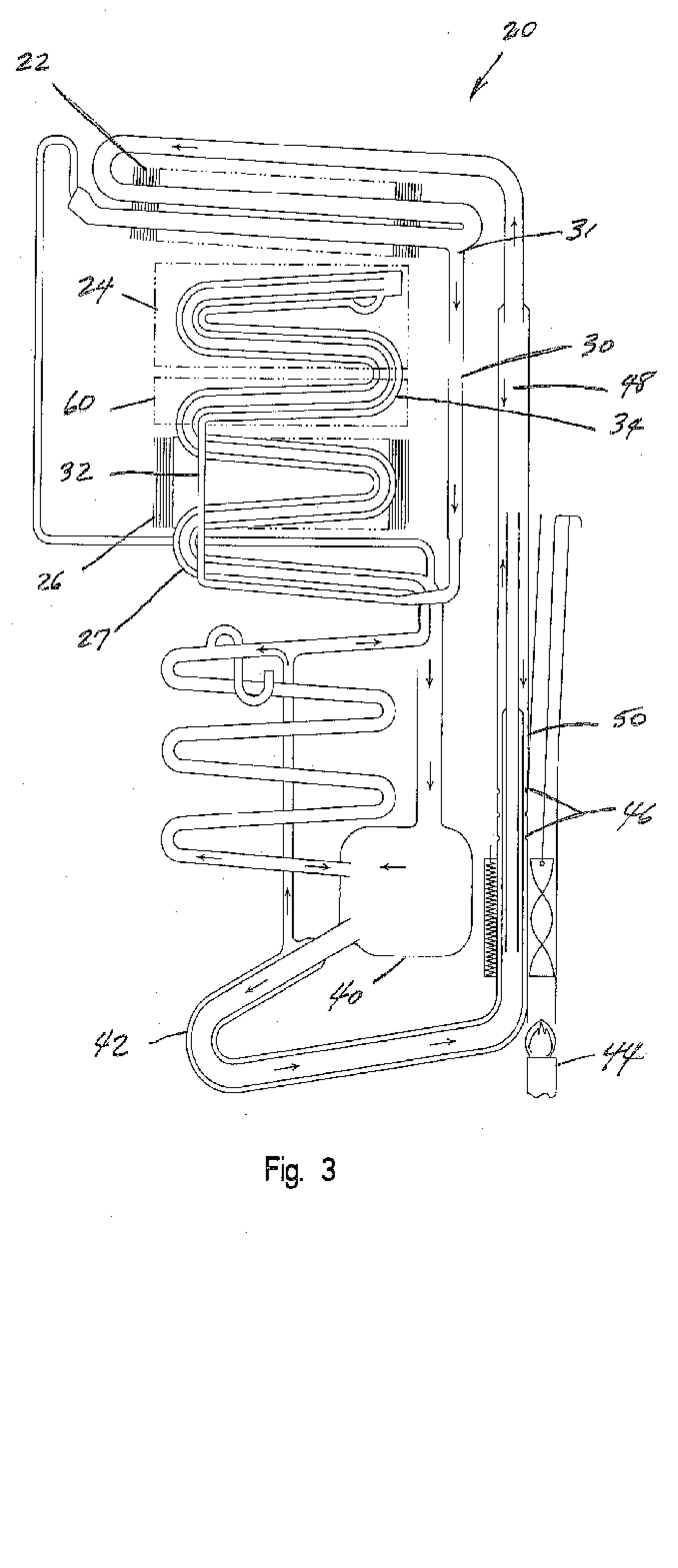

Fig. 3

(57) Abstract: A refrigerator provides a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas. The refrigeration assembly includes a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger. The liquid ammonia tube includes a first vertical section with an inlet and a second vertical section downstream of the first. The second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger. The heat exchanger includes inner and outer tubes. The inner tube has an outer surface, and the outer tube has an inner surface. The outer and inner surfaces each has serrations to produce an increase in surface area of the corresponding surface. The refrigerator has a freezer box defining a first cubic area and a refrigerator box defining a second cubic area. The sum of the first and second cubic areas is equal to or greater than six cubic feet. The assembly is capable of cooling the refrigerator box to a temperature of 6°C (43 °F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43 °C (1 10°F).

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HELIUM CHARGED REFRIGERATOR

REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Patent Application No. 13/415,796, filed March 8, 2012, which claims priority to U.S. Provisional Application No. 61/450,237, filed March 8, 2011, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates generally to gas absorption refrigeration cooling systems and specifically to a helium gas charged refrigerator for a recreational vehicle (RV).

2. Description of the Prior Art

[0003] The cooling cycle of the typical diffusion-absorption refrigeration system starts with liquefied ammonia entering an evaporator at room temperature. The ammonia is mixed in the evaporator with hydrogen. The partial pressure of the hydrogen is used to regulate the total pressure, which in turn regulates the vapor pressure and thus the boiling point of the ammonia. The ammonia boils in the evaporator, providing the cooling required. The fluids are endlessly recirculated by gravity.

[0004] Hydrogen is assumed to be the optimum diffusion gas used in diffusion-absorption cooling systems because it is the lightest element of the periodic table. It has an atomic weight of one, and its molecular weight is about the same. Hydrogen has always been the preferred diffusion agent because its partial pressure, which regulates the overall pressure of the closed system, is small and easily calculable. Hydrogen is predictable as the element moves between phase changes and solution in the system as well.

[0005] Helium, on the other hand, has an atomic weight of two and is considered ineffective as a diffusion gas for such cooling systems. The more weighty helium has a different partial pressure and requires a higher boiling temperature for the ammonia in a helium charged system. Refrigerators that operate outdoors at higher ambient temperatures have difficulty reaching desirable cooling temperatures. Normal-sized diffusion-absorption type refrigerators where the total area chilled is about eight cubic feet, for example, cannot use helium and meet applicable ANSI standards.

[0006] Hydrogen, however, is volatile and extremely dangerous. Fire and explosion have produced a need for an alternative diffusion or charging gas. Prior refrigerators that use helium as a charging gas, e.g., hotel mini bar refrigerators, are for low ambient temperatures (i.e., 32°C (90°F) or lower). Such applications have a nominal ambient temperature rating of 25°C (77°F). The ANSI standard applicable to RV gas absorption refrigeration cooling systems, however, requires the following specifications at an ambient temperature of 43°C (110°F): (i) the refrigerator compartment cooled to a temperature of at least 6°C (43°F) and (ii) the freezer compartment cooled to a temperature of at least -9°C (15°F).

[0007] The invention has overcome the perceived barriers to using helium as a diffusion gas for normal-sized refrigerators and results in a refrigerator that meets the applicable ANSI standards—that is, the inventive helium charged system provides desirable freezer/refrigeration temperatures for larger refrigerators operative where the ambient is *not* temperature controlled.

SUMMARY OF THE INVENTION

[0008] The disadvantages heretofore associated with the prior art are overcome by the inventive RV refrigeration cooling system using helium as the charging gas. The novel system is for a refrigerator of the type that relies upon gravity to move fluid through a closed fluid system for heat exchange between an ammonia solution and a diffusion or charging gas. Such a refrigerator has a freezer evaporator, including a freezer box, a cabinet evaporator, including a refrigerator box, an absorber vessel downstream of the freezer and cabinet evaporators, and a liquid heat exchanger downstream of the absorber vessel.

[0009] The new refrigerator includes a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas. The refrigeration assembly includes a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger.

[0010] In one aspect of the invention, the liquid ammonia tube may include a first vertical section with an inlet and a second vertical section downstream of the first. The refrigerator may include a freezer box defining a first cubic area and a refrigerator box defining a second cubic area.

[0011] In another aspect, the sum of the first and second cubic areas may be equal to or greater than six cubic feet such that the assembly is capable of cooling the refrigerator box to a temperature of 6°C (43°F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43°C (110°F).

[0012] In yet another aspect, the heat exchanger includes inner and outer tubes, said inner tube having an outer surface, and said outer tube having an inner surface, said outer and inner surfaces each being shaped to produce an increase in surface area of the corresponding surface.

[0013] One object of the invention is to provide a novel refrigerator having a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas instead of hydrogen and thus is safe if the system is ruptured and gas escapes. It has heretofore not been possible for a helium charged refrigerator to cool eight (8) cubic feet, that is, the size of the refrigerator box to a temperature of 6°C (43°F) and the size of the freezer compartment to a temperature of -9°C

(15°F) when the ambient is at a temperature of 43°C (110°F). In other words, the new refrigerator meets ANSI standards for cooling larger refrigerators where the ambient is *not* temperature controlled. Related objects and advantages of the invention will be apparent from the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The details of the invention, both as to its structure and operation, may be obtained by a review of the accompanying drawings, in which:

[0015] FIG. 1 is an isometric view of a refrigerator of the invention showing the freezer box and the refrigerator box;

[0016] FIG. 2 is a diagrammatic illustration of a typical prior art absorption system;

[0017] FIG. 3 is a diagrammatic drawing of the diffusion-absorption refrigeration assembly of the invention;

[0018] FIG. 4 is a partial cutaway isometric view of an embodiment of the heat exchanger of the invention;

[0019] FIG. 4A is an enlarged view of the outer surface of the inner tube of the heat exchanger of the invention; and

[0020] FIG. 4B is an enlarged view of the inner surface of the outer tube of the heat exchanger of the invention.

DETAILED DESCRIPTION OF INVENTION

[0021] The invention is a refrigerator **10** having a diffusion-absorption refrigeration assembly **20** that uses helium as a diffusion gas instead of hydrogen. As shown in FIG. 3, the refrigeration assembly includes a condenser **22**, an evaporator (freezer **24**, cabinet **26**), a liquid ammonia tube **25**, and a gas heat exchanger **27**. The liquid ammonia tube has a first vertical section **30** with an inlet **31**, a second vertical section **32** downstream of the first, and an intermediate section **34** downstream of the second vertical section.

[0022] The second vertical section **32** does not touch the heat exchanger **27**. No heat is exchanged between flowable fluids flowing in the second vertical section and in the heat exchanger as a result. Additionally, the intermediate section **34** is contiguous with the heat exchanger **27** so that heat is exchanged between flowable fluids flowing in the intermediate section and in the heat exchanger.

[0023] Referring to FIG. 1, the refrigerator **10** has a freezer box **12** defining a first cubic area and a refrigerator box **14** defining a second cubic area. In one embodiment, the sum of the first and second cubic areas is equal to about six (6) cubic feet. In a more preferred embodiment the sum of the first and second cubic areas is equal to about eight (8) cubic feet.

[0024] With reference to FIG. 2, the function of a typical absorption system will now be described. The rich solution leaves the absorber vessel **210** and passes through the liquid heat exchanger **212** to the bottom of the pump tube **214**. The heat source (gas or electric) **216** causes the temperature of the solution to rise. This temperature increase causes ammonia and some water vapor to be driven out of the solution, forming vapor bubbles which push columns of liquid up the pump tube. The liquid falls downward through the rectifier **218** where the temperature is increased causing additional ammonia vapor to be released. The remaining liquid is now a weak ammonia solution and flows through the external shell of the liquid heat exchanger **212** where it transfers its residual heat to the rich solution and enters the top of the absorber coil **220** at a reduced temperature.

[0025] The ammonia/water vapor passes through the water separator **222** whose reduced temperature causes any water vapor to liquefy and join the weak solution in the boiler **224**. The ammonia vapor enters the condenser **226** where it condenses to hot liquid ammonia. The liquid ammonia enters the tubular coil of the freezer and cabinet evaporators **228, 230** and wets the internal surface of the tubes.

[0026] As the weak gas passes over the wetted surface of the evaporator tubing, the liquid ammonia evaporates into the hydrogen, creating an initial refrigeration temperature of about -20°F. The weight of the hydrogen and ammonia mixture is heavier than that of weak gas. Consequently, it falls through the gas heat exchanger into the top of the absorber vessel **210**. From this point it enters the bottom of the absorber coil.

[0027] As this mixture travels up through the absorber it contacts the weak solution entering the top of the absorber from the boiler. As the weak solution drops through the absorber it absorbs the ammonia from the ammonia/hydrogen mixture. The relatively pure hydrogen passes through the hydrogen circuit to the evaporator and now the rich solution falls to the bottom on the absorber vessel where the cycle starts again.

[0028] Referring to FIG. 3, the rich ammonia water solution leaves the absorber vessel **40** and passes through the liquid heat exchanger to the bottom of the pump tube. The heat source (gas or electric) **44** causes the temperature of the solution to rise. This temperature increase causes ammonia and some water vapor to be driven out of the solution, forming vapor bubbles, which push columns of liquid up the pump tube. The liquid falls downward through the rectifier **46** where the temperature is increased causing additional ammonia vapor to be released. The remaining liquid is now a weak ammonia solution and flows through the external shell of the liquid heat exchanger 42 where it transfers its residual heat to the rich solution and enters the top of the absorber coil at a reduced temperature.

[0029] The ammonia/water vapor passes through the water separator **48** whose reduced temperature causes a water vapor to liquefy and join the weak solution in the boiler **50**. The ammonia vapor enters the condenser **22** where it condenses to hot liquid ammonia. The liquid ammonia enters the tubular coil of the freezer and cabinet evaporators **24, 26** and wets the internal surface of the tubes. Referring to FIGS. 4, 4A and 4B, the increased tube volume of

Applicant's device accommodates the increased weight of the helium over hydrogen. Smaller heat exchange tubes suitable for hydrogen provide restriction for the larger helium molecules.

[0030] Additionally, a second heat exchanger **60** is between the freezer and the cabinet evaporators **24, 26.** In one embodiment, the new heat exchange conduit section **60** includes a first tube **61** having an outer surface **62** and a second tube **63** having an inner surface **64**. The new heat exchange conduit section **60** is connected "stream wise" into the overall absorption system. The first tube **61** has an outer diameter smaller than the inner diameter of the second tube **63** so that the first tube can be positioned inside the second to define a space that has a cross sectional area and a length. Applicant's have discovered that to meet the ANSI RV refrigeration standards (i.e., the refrigerator compartment cooled to at least 6°C (43°F) and the freezer compartment cooled to at least -9°C (15°F) when the ambient is at 43°C (110°F)), the inner diameters of the tubes have to be substantially modified if helium is used as the diffusion gas.

[0031] In one embodiment, therefore, the cross sectional area between the inner surface of the outer tube and the outer surface of the inner tube is about 200 square millimeters. In another embodiment, the outer diameter of the inner tube is increased, thus reducing the cross-sectional area between the inner and outer tubes by twenty percent (20%). In a more preferred embodiment, the outer diameter of the inner tube **61** is between about 14 and 16 millimeters and the outer diameter of the outer tube **63** is between about 25 and 27 millimeters; however, other combinations of inner and outer tube diameters may be derived that would serve to compensate for the larger helium molecules. Thus, the evaporator tubes of the new system are specially sized in proportion to the other tubes so that the larger gaseous helium molecules are effective in replacing hydrogen as the diffusion gas.

[0032] The assembly **20** is thus capable of cooling the refrigerator box **14** to a temperature of 6°C (43°F) and the freezer box **12** to a temperature of -9°C (15°F) when the ambient is at a temperature of 43°C (110°F). The assembly meets applicable ANSI standards.

[0033] The outer and inner surfaces **62, 64** are preferably shaped, respectively, in a manner to increase their area. The example shown in FIGS. 4A and 4B may be construed as a serrated shape. Those skilled in the art will appreciate that any one of a number of shapes may be formed in the surfaces to increase their surface area. Fins may be another example of a shape contemplated.

[0034] The shaped outer surface of the tubes increase the surface area exposed, as shown in FIGS. 4A-4B. As the weak gas passes over the wetted surface of the evaporator tubing, the liquid ammonia evaporates into the helium. As the ammonia continues to evaporate into the helium, the partial pressure of ammonia continues to rise slowly. As the ammonia pressure rises, the evaporation temperature also rises.

[0035] The new heat exchanger conduit section **60** of the new system between the refrigerator and freezer compartments pre-cools the liquid ammonia before it enters the freezer's evaporators section. This prevents hot liquid ammonia from injecting heat into the coldest portion of the evaporator and helps lower the temperature in the evaporator, which improves the overall cooling performance.

[0036] As the ammonia continues to evaporate into the helium, the partial pressure of ammonia continues to rise slowly. As the ammonia pressure rises the evaporation temperature also rises. This increase in ammonia partial pressure raises the evaporation temperature steadily down through the evaporator. The weight of the helium and ammonia mixture is heavier than that of a weak gas. Hence, it falls through the gas heat exchanger into the top of the absorber vessel. From this point it enters the bottom of the absorber coil.

[0037] As this mixture travels up through the absorber it contacts the weak solution entering the top of the absorber from the boiler. As the weak solution drops through the absorber, it absorbs the ammonia from the ammonia/helium mixture. The relatively pure helium passes through the helium circuit to the evaporator and now the rich solution falls to the bottom of the absorber vessel where the cycle starts again.

[0038] A significant advantage of the new helium charged cooling system in RV refrigeration applications is the increased safety of the refrigerator **10**. A hydrogen charged gas absorption system may create a serious fire or explosion if the closed fluid system is compromised.

[0039] For the purposes of promoting an understanding of the principles of the invention, specific embodiments have been described. It should nevertheless be understood that the description is intended to be illustrative and not restrictive in character, and that no limitation of the scope of the invention is intended. Any alterations and further modifications in the described components, elements, processes, or devices, and any further applications of the principles of the invention as described herein , are contemplated as would normally occur to one skilled in the art to which the invention relates.

WHAT IS CLAIMED IS:

1. A refrigerator having a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas, the refrigeration assembly comprising, a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger, wherein the liquid ammonia tube comprising a first vertical section with an inlet, and a second vertical section downstream of the first.

2. A refrigerator according to claim 1, wherein the second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger.

3. A refrigerator according to claim 1, wherein said liquid ammonia tube further comprising an intermediate section downstream of the second vertical section, said intermediate section being contiguous with said heat exchanger, wherein heat is exchanged between flowable fluids flowing in said intermediate section and in said heat exchanger.

4. A refrigerator according to claim 3, wherein said liquid ammonia tube further comprising a freezer section upstream of the intermediate section, said freezer section being contiguous with said heat exchanger, wherein heat is exchanged between flowable fluids flowing in said freezer section and in said heat exchanger.

5. A refrigerator according to claim 4, wherein the second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger.

6. A refrigerator having a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas, the refrigeration assembly comprising, a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger, wherein the liquid ammonia tube comprising a first vertical section with an inlet, and a second vertical section downstream of the first, said refrigerator having a freezer box defining a first cubic area, and a refrigerator box defining a

second cubic area, the sum of said first and second cubic areas being equal to or greater than six cubic feet, wherein said assembly being capable of cooling the refrigerator box to a temperature of 6°C (43°F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43°C (110°F).

7. A refrigerator according to claim 6, wherein the heat exchanger includes inner and outer tubes, said inner tube having an outer surface, and said outer tube having an inner surface, said outer and inner surfaces each being shaped to produce an increase in surface area of the corresponding surface.

8. A refrigerator having a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas, the refrigeration assembly comprising, a condenser, an evaporator, a liquid ammonia tube, a gas heat exchanger, wherein the liquid ammonia tube comprising a first vertical section with an inlet, and a second vertical section downstream of the first, said refrigerator having a freezer box defining a first cubic area, and a refrigerator box defining a second cubic area, the sum of said first and second cubic areas being equal to or greater than six cubic feet, wherein said assembly being capable of cooling the refrigerator box to a temperature of 6°C (43°F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43°C (110°F), wherein the second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger.

9. A refrigerator according to claim 8, wherein the heat exchanger includes inner and outer tubes, said inner tube having an outer surface, and said outer tube having an inner surface, said outer and inner surfaces each having serrations to produce an increase in surface area of the corresponding surface.

10. A refrigerator according to claim 9, wherein said liquid ammonia tube further comprising an intermediate section downstream of the second vertical section, said intermediate section

being contiguous with said heat exchanger, wherein heat is exchanged between flowable fluids flowing in said intermediate section and in said heat exchanger.

11. A refrigerator according to claim 10, wherein the second vertical section of the liquid ammonia tube being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger.

12. A refrigerator having a diffusion-absorption refrigeration assembly that uses helium as a diffusion gas, the refrigeration assembly comprising, a condenser, an evaporator, a liquid ammonia tube, and a gas heat exchanger, wherein the gas heat exchanger comprising an inner tube having and outer diameter of between about 14 and about 16 millimeters and an outer tube having an outer diameter of between about 25 and 27 millimeters, said refrigerator having a freezer box defining a first cubic area, and a refrigerator box defining a second cubic area, the sum of said first and second cubic areas being equal to or greater than six cubic feet, wherein said assembly being capable of cooling the refrigerator box to a temperature of 6°C (43°F) and the freezer compartment to a temperature of -9°C (15°F) when the ambient is at a temperature of 43°C (110°F).

13. A refrigerator according to claim 12, wherein the liquid ammonia tube comprising a first vertical section with an inlet, and a second vertical section downstream of the first, wherein the second vertical section being noncontiguous with said heat exchanger, wherein no heat is exchanged between flowable fluids flowing in said second vertical section and in said heat exchanger.

14. A refrigerator according to claim 13, wherein said liquid ammonia tube further comprising an intermediate section downstream of the second vertical section, said intermediate section being contiguous with said heat exchanger, wherein heat is exchanged between flowable fluids flowing in said intermediate section and in said heat exchanger.

15. A refrigerator according to claim 14, wherein said liquid ammonia tube further comprising a freezer section upstream of the intermediate section, said freezer section being contiguous with said heat exchanger, wherein heat is exchanged between flowable fluids flowing in said freezer section and in said heat exchanger..

16. A refrigerator according to claim 15, wherein said inner tube of the heat exchanger includes an outer surface, and said outer tube includes an inner surface, said outer and inner surfaces each having serrations to produce an increase in surface area of the corresponding surface.

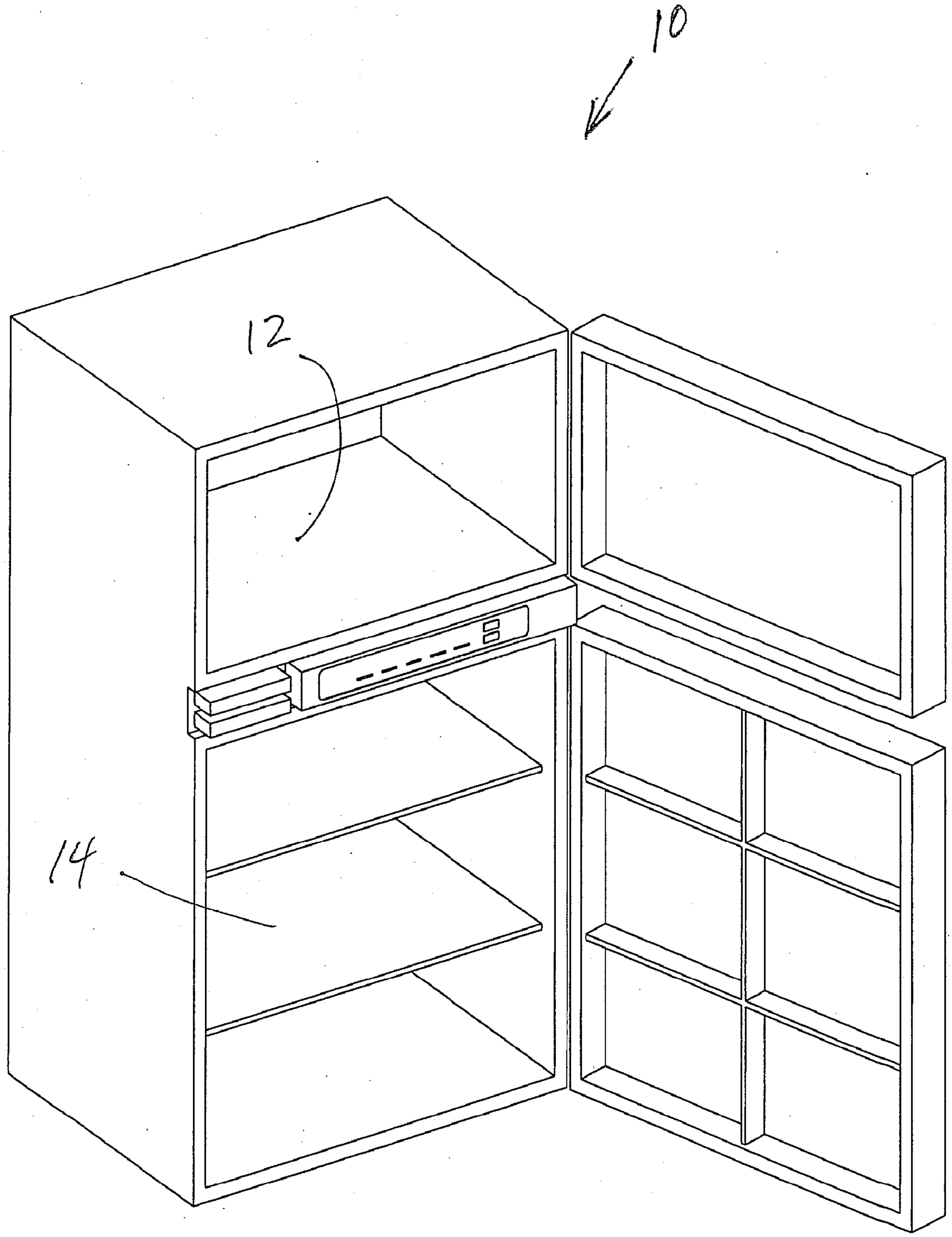

Fig. 1

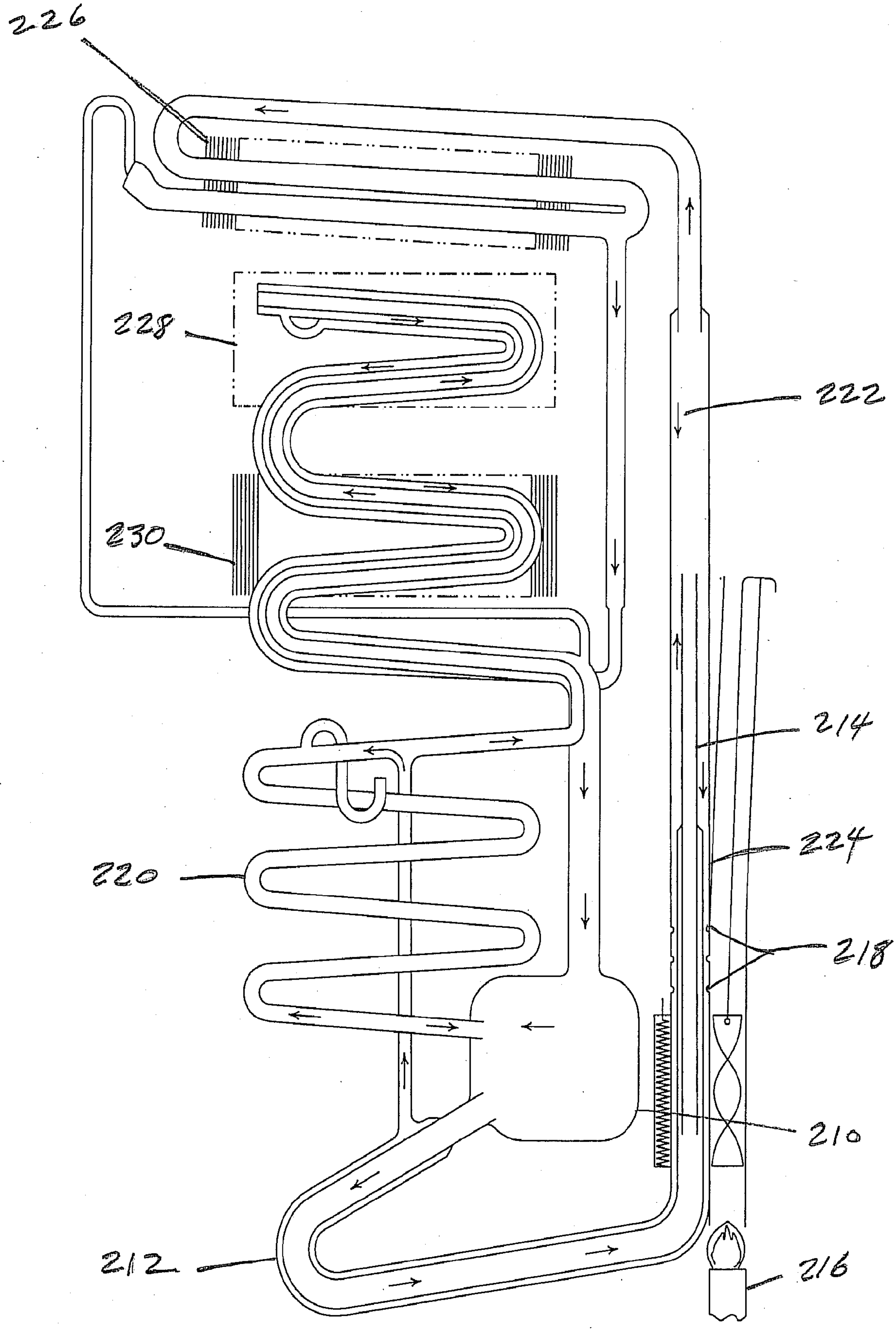

Fig. 2
(Prior Art)

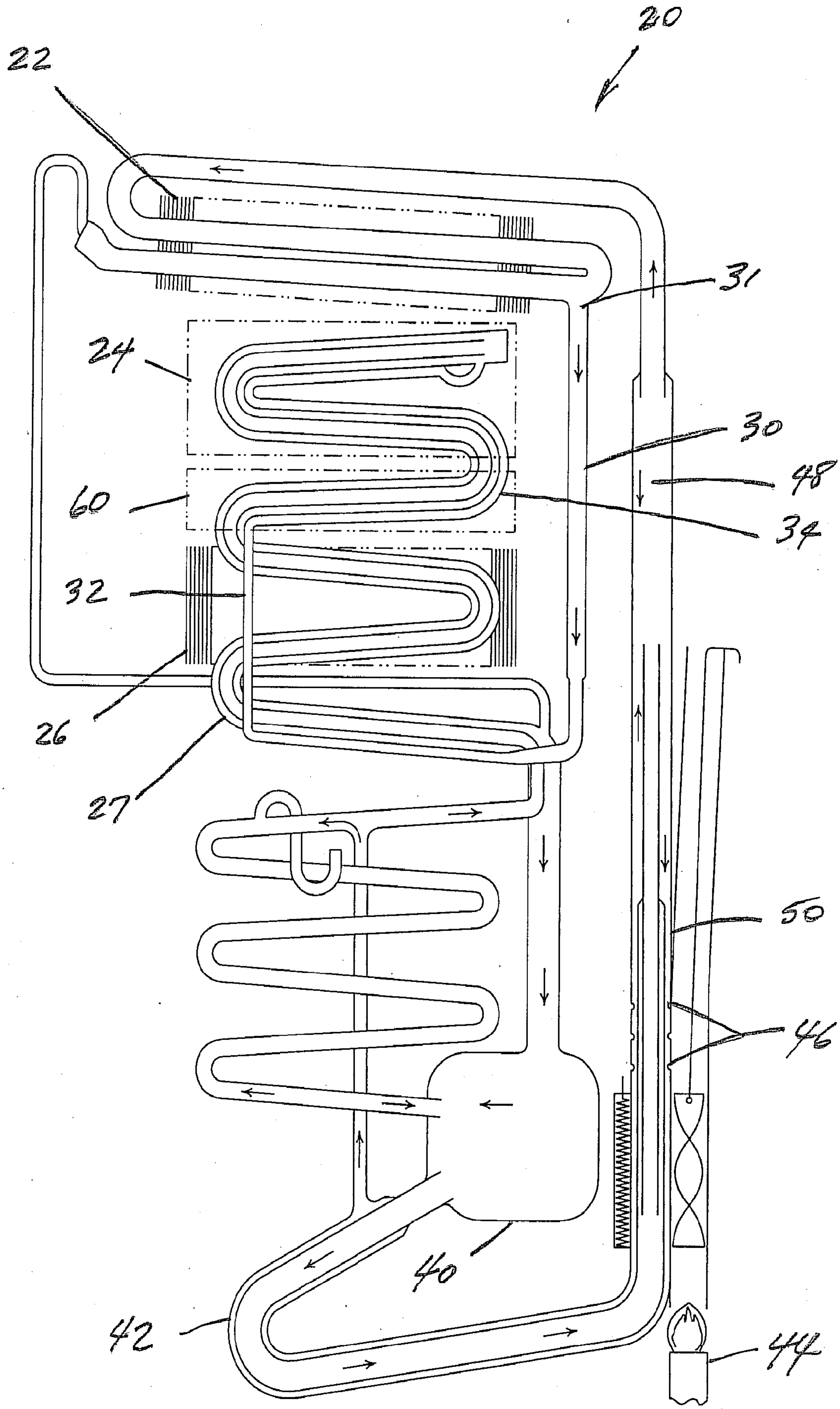

Fig. 3

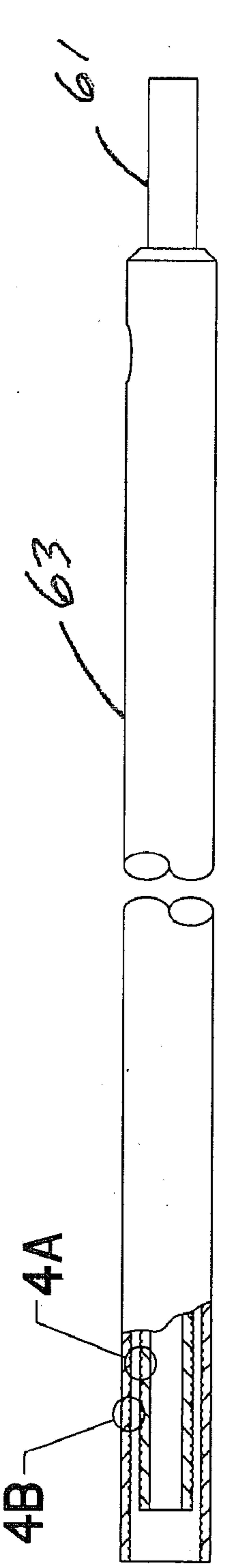

Fig. 4

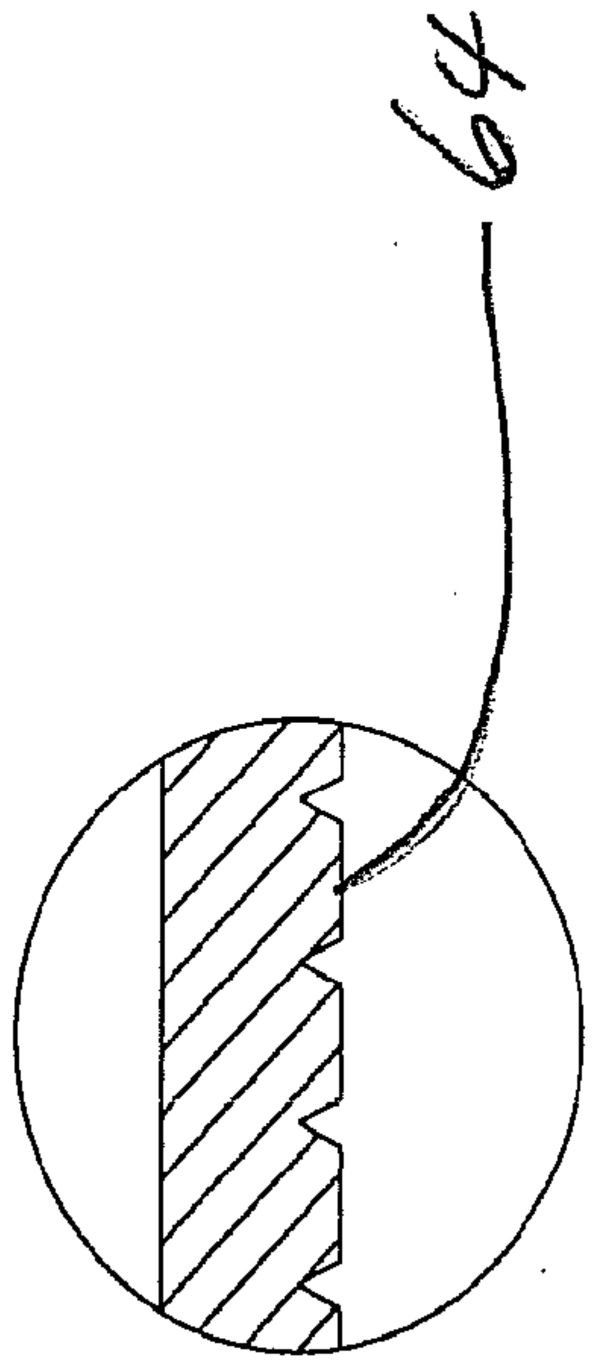

Fig. 4B

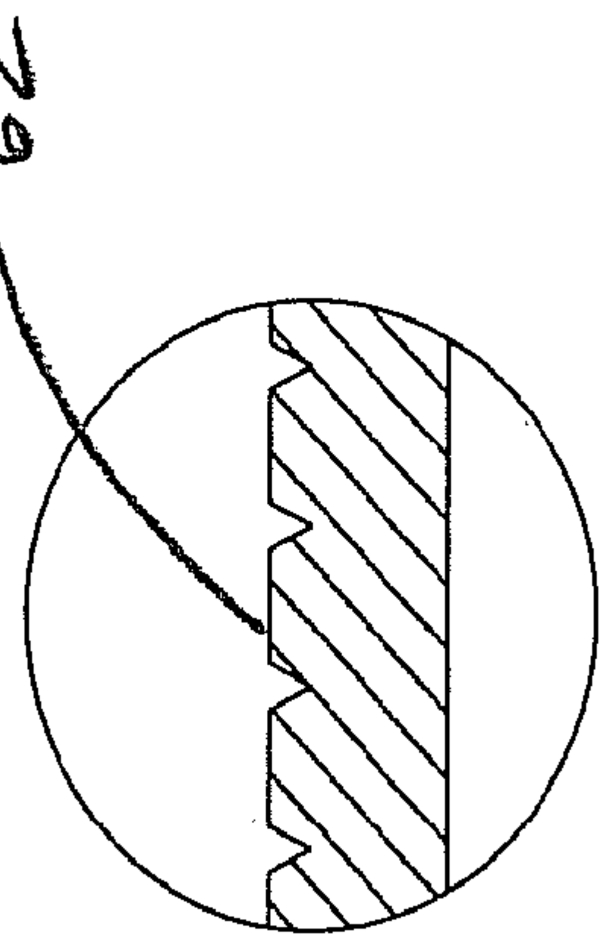

Fig. 4A

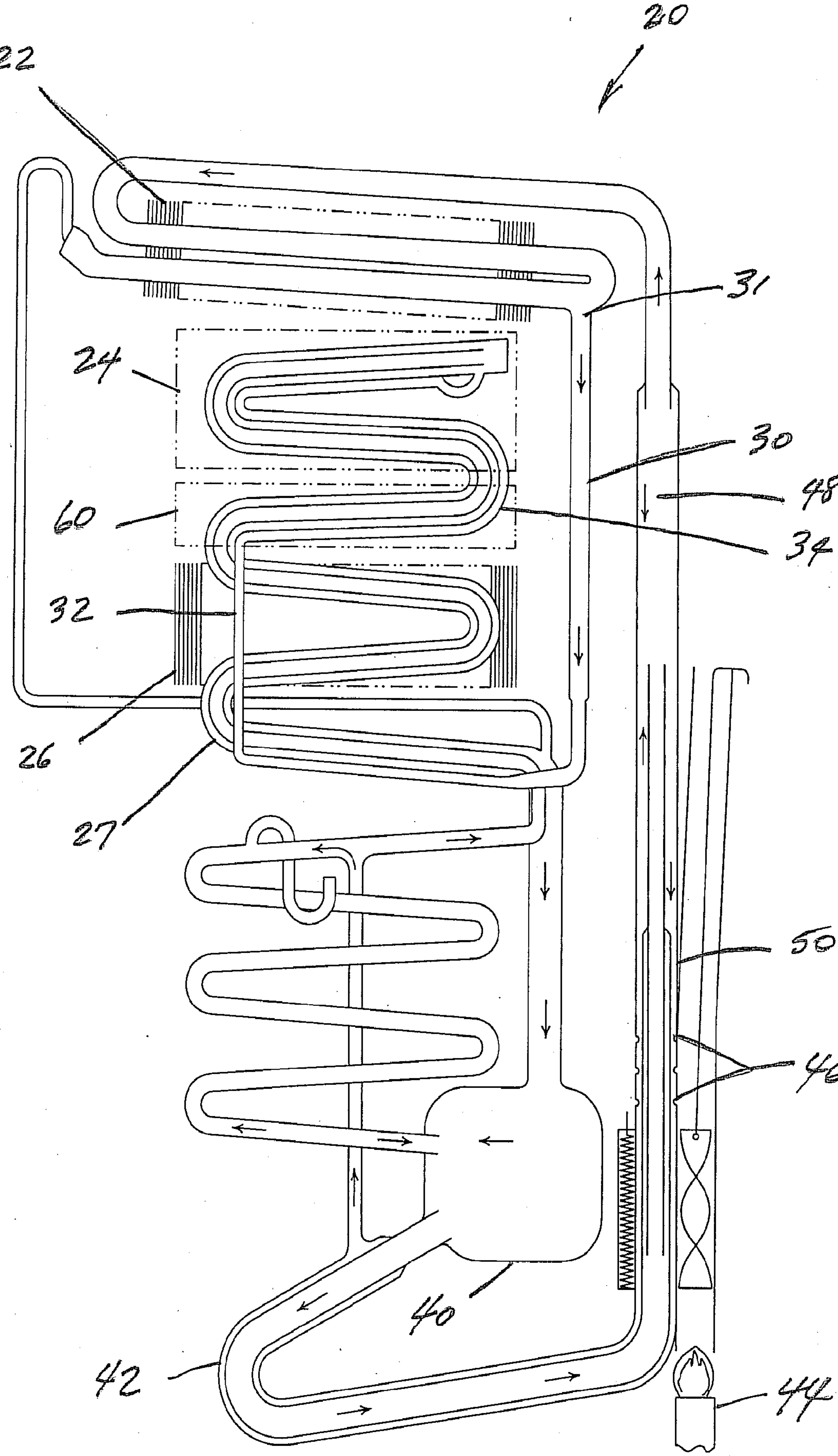

Fig. 3