United States Patent

Park

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[54] **HEAT EXCHANGER**

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[73] Assignee: **Oklahoma Manufacturing Company**, Oklahoma City, Okla.

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[52] **U.S. Cl.** **62/333**, 165/156, 62/99, 62/434, 62/435, 62/511

[51] **Int. Cl.**.....**F25d 17/00**

[58] **Field of Search** 62/333; 165/156

[56] **References Cited**

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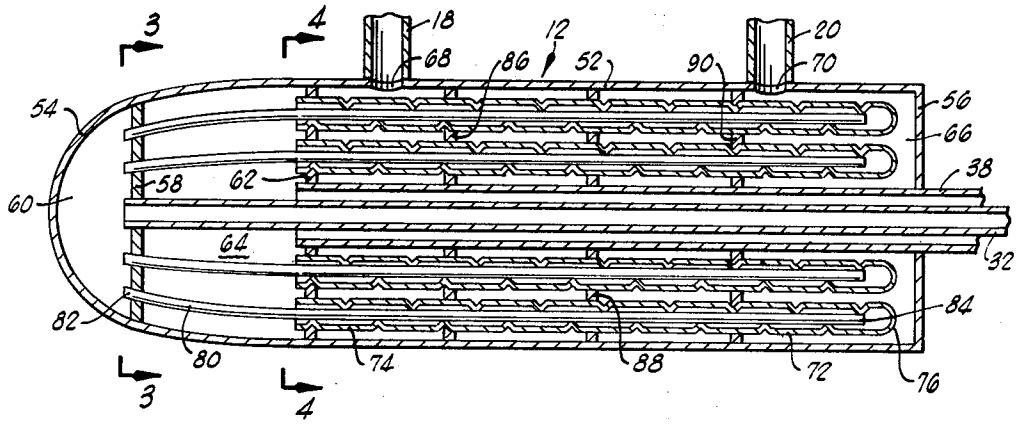
Primary Examiner—William J. Wye

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[57] **ABSTRACT**

A heat exchanger adapted for use in a combination heating and refrigeration system for transferring heat to or from a secondary refrigerant, which includes a plurality of heat exchange tubes closed at one end and opened at the other end with helical corrugations formed in the walls thereof, and a restrictor tube extending into each heat exchange tube and communicating with the closed end of the respective heat exchange tube to receive the primary refrigerant first directed into the respective heat exchange tube, wherein the closed ends of the heat exchange tubes are lower than the open ends thereof and liquid primary refrigerant accumulates in the closed ends of the heat exchange tubes when the exchanger is used in a heating system, such that the rate of flow of primary refrigerant through the heat exchanger is automatically controlled for both refrigeration and heating system operations, and the same amount of primary refrigerant may be used when the system is used for either heating or refrigeration.

3 Claims, 5 Drawing Figures



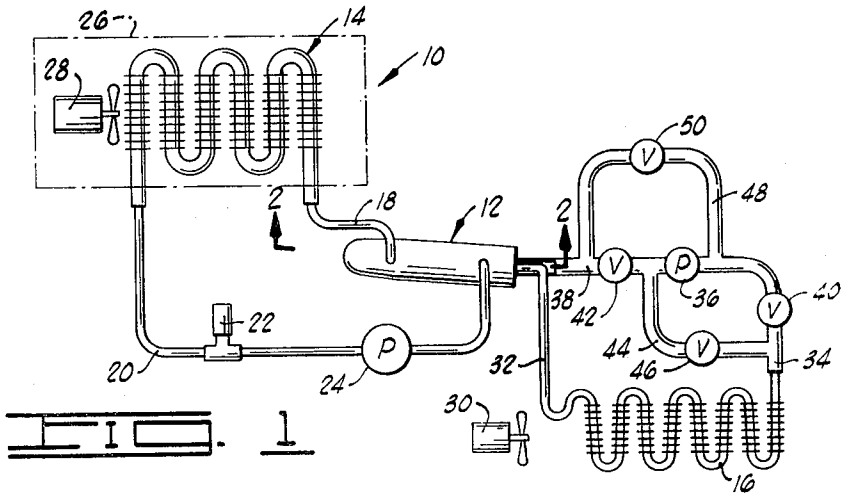


FIG. 1

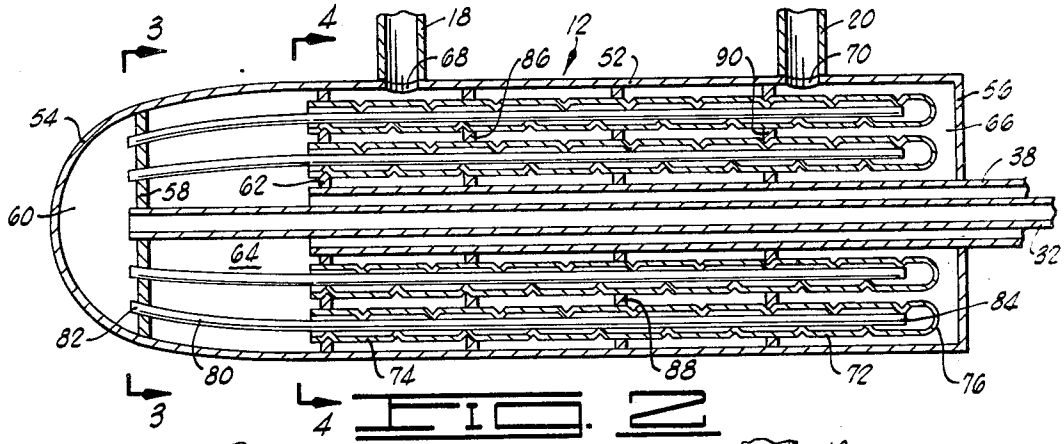


FIG. 2

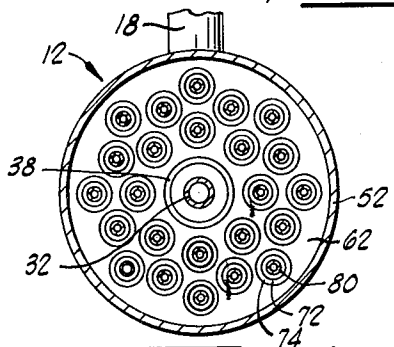


FIG. 4

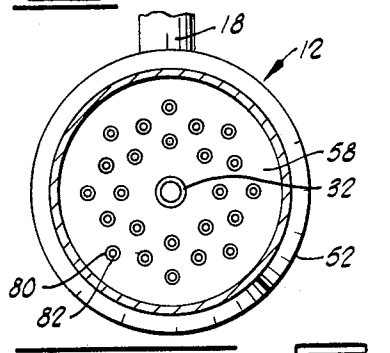


FIG. 3

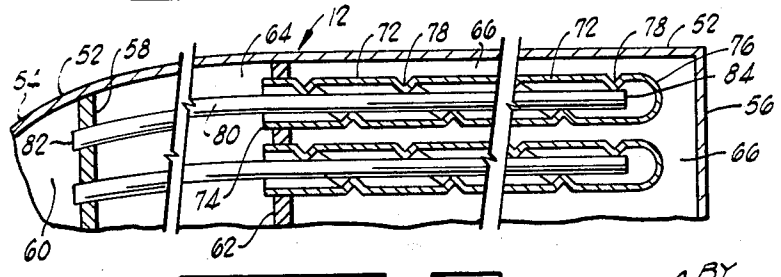


FIG. 5

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HEAT EXCHANGER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to improved heat exchangers. More particularly, but not by way of limitation, this invention relates to an improved heat exchanger for use in air conditioning systems wherein the exchanger is utilized to transfer heat to or from a primary refrigerant to a secondary refrigerant.

2.Description of the Prior Art

The most common form of heat exchanger previously constructed for use with secondary refrigerant type air conditioning systems includes a hollow body member having a pair of plates or bulkheads disposed transversely relative to the elongation of the body thereby forming a header or chamber in each end of the hollow body. A plurality of open-ended tubular members are disposed in the hollow body having each open end in communication with a respective one of the headers in the heat exchanger and having each end connected with one of the bulkheads. Heat exchangers constructed in this manner were subject to extreme pressures due to expansion of the secondary refrigerant during freezing often resulting in rupture of the heat exchanger.

An improved heat exchanger was disclosed in U.S. Pat. No. 3,360,036, entitled "Heat Exchangers," issued Dec. 26, 1967, to Earl F. Holyfield. The Holyfield heat exchanger includes a plurality of heat exchange tubes closed at one end and opened at the other end, and a restrictor tube extending into each heat exchange tube and communicating with the closed end of the respective heat exchange tube. This heat exchanger provided improved cooling and reliability by providing sub-cooling of the primary refrigerant and eliminating the rupture problem resulting from freezing of the secondary refrigerant.

The Holyfield heat exchanger design, though noteworthy, is not as efficient as desired since the heat exchange tubes provide a limited amount of surface area in contact with the secondary refrigerant for a given tube length limiting its heat transfer capability.

SUMMARY OF THE INVENTION

This invention generally contemplates an improved heat exhanger including: a hollow body having first, second and third chambers formed therein, and having inlet and outlet openings in the body in communication with the third chamber; a plurality of elongated tubes, each having an open end in communication with the second chamber, a closed end located in the third chamber, and a continuous helical corrugation formed in the tube wall through substantially the full length thereof; a plurality of open-ended tubular members, each of the members being disposed in a respective one of the tubes and having one open end in communication with the first chamber; a first conduit connected in fluid communication with the first chamber; and, a second conduit connected in fluid communication with the second chamber.

One object of the invention is to provide an improved heat exchanger.

Another object of the invention is to provide an improved heat exchanger for use in air conditioning systems incorporating secondary refrigerants wherein the heat exchanger will not be damaged should the secondary refrigerant freeze.

One other object of the invention is to provide an improved heat exchanger that can be used for either heating or cooling a secondary refrigerant in an air conditioning system.

Still another object of the invention is to provide an improved heat exchanger providing greater efficiency of operation.

A further object of the invention is to provide an improved heat exchanger requiring no maintenance during its service life.

Still another object of the invention is to provide an improved heat exchanger that can be easily and economically constructed.

The foregoing and additional objects and advantages of the invention will be more apparent as the following detailed description is read in conjunction with the accompanying drawings wherein like reference characters denote like parts in all views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating the installation of a heat exchanger, constructed in accordance with the invention, located in an air conditioning system;

FIG. 2 is an enlarged cross-sectional view of the heat exchanger taken substantially along the lines 2—2 of FIG. 1;

FIG. 3 is a transverse cross-sectional view taken substantially along lines 3—3 of FIG. 2;

FIG. 4 is a transverse cross-sectional view through the heat exchanger of FIG. 2 taken substantially along the line 4—4 of FIG. 2; and,

FIG. 5 is a fragmentary cross-sectional view more clearly illustrating the construction of the heat exchanger.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing and to FIG. 1 in particular, shown therein and generally designated by the reference character **10** is an air conditioning system including a heat exchanger, designated generally by reference character **12**, constructed in accordance with the invention. As shown therein, the air conditioning system **10**, in addition to the heat exchanger **12**, includes an air conditioning coil **14** and a condensing coil **16**.

One end of the air conditioning coil **14** is connected with the heat exchanger **12** by an outlet conduit **18**. The opposite end of the air conditioning coil **14** is connected with the heat exchanger **12** by an inlet conduit **20**.

An air trap and bleed **22** is operably disposed in the inlet conduit **20**. The air trap **22** is of a conventional construction and is commercially available from many manufacturers. The purpose of the air trap **22** is to remove air that might be entrained in the secondary refrigerant (not shown) that fills a portion of the heat exchanger **12** in the air conditioning coil **14**.

A refrigerant pump **24** is operably connected in the inlet conduit **20** between the air trap **22** and the heat exchanger **12**. The purpose of the refrigerant pump **24** is to circulate the secondary refrigerant through the

heat exchanger 12 and through the air conditioning coil 14.

The air conditioning coil 14 is disposed in a casing or duct 26 (illustrated in dashed lines in FIG. 1). Some means such as the motor driven fan 28 is provided to force air through the duct 26 and across the air conditioning coil 14.

The condensing coil 16 is cooled by a motor driven fan 30 and has one end connected by a conduit 32 with the heat exchanger 12 as will be described more fully in connection with FIG. 2. The other end of the condensing coil 16 is connected by a conduit 34 with a compressor or refrigerant pump 36. The refrigerant pump 36 is connected by a conduit 38 with the heat exchanger 12 as will also be described more fully in connection with FIG. 2. The condensing coil 16 and the conduits associated therewith are filled with a primary refrigerant (not shown), such as Freon or ammonia.

A valve 40 is operably disposed in the conduit 34 between the condensing coil 16 and the pump 36. A valve 42 is connected in the conduit 38 between the pump 36 and the heat exchanger 12. A branch conduit 44 has one end connected with the conduit 38 between the valve 42 and the pump 36 and the other end connected with the conduit 34 between the valve 40 and the condensing coil 16. A valve 46 is disposed in the branch conduit 44. The purpose of the branch conduit 44 and the valve 46 will be explained more fully hereinafter.

A branch conduit 48 has one end connected with the conduit 34 between the pump 36 and the valve 40 and the other end connected with the conduit 38 between the valve 42 and the heat exchanger 12. A valve 50 is operably connected in the branch conduit 48 for purposes that will become more apparent hereinafter.

FIGS. 2, 3, 4 and 5 illustrate the structure of the heat exchanger 12 in detail. As shown therein, the heat exchanger 12 includes a hollow body portion 52 having closed ends 54 and 56.

A perforated plate 58 extends transversely across the hollow body 52 (see also FIG. 3). The perforated plate 58 has its peripheral portion connected in a fluid-tight arrangement with the hollow body 52 to form a chamber 60 with the closed end 54 of the heat exchanger 12.

A second perforated plate 62 also extends transversely across the hollow body 52 (see FIG. 4) in generally parallel spaced relation with the plate 58. The plate 62 has its peripheral portion connected in a fluid-tight arrangement with the hollow body 52 forming a chamber 64 with the plate 58 and the walls of the hollow body 52. A chamber 66 is formed within the hollow body 52 between the plate 62 and the closed end 56 of the hollow body 52.

As may be seen clearly in FIG. 2, the outlet conduit 18 is in communication with the chamber 66 through an opening 68 formed in the wall of the hollow body 52. Similarly, the inlet conduit 20 is in communication with the chamber 66 through an opening 70 formed in the hollow body 52.

A plurality of elongated tubes 72 are disposed in the hollow body 52. Each tube 72 has an open end 74 extending through an aperture in the perforated plate 62 and connected therewith in fluid-tight relationship. Each tube 72 has a closed end 76 disposed relatively adjacent the closed end 56 of the hollow body 52. Each tube 72 has a continuous helical corrugation 78 formed in the tube wall. Each helical corrugation 78 extends from a point on the tube 72 adjacent the connection between the tube 72 and the perforated plate 62 to a point on the tube 72 adjacent the closed end 76 and projects radially inwardly from the tube wall. As may be clearly seen in FIG. 2, the elongated tubes 72 have the open ends 74 disposed in fluid communication with the chamber 64. The major portions of the tubes 72 are disposed in the chamber 66 in the hollow body 52 so that they are in contact with the secondary refrigerant filling the chamber 66.

A plurality of elongated restrictor tubes 80 are also disposed in the hollow body 52. The restrictor tubes 80 each have an open end 82 extending through the perforations in the plate 58 and connected with the plate 58 in fluid-tight relationship. An open end 84 of each restrictor tube 80 is disposed in a respective tube 72 relatively near the closed end 76 thereof. The restrictor tubes 80 are in intimate relation with helical corrugations 78 of the respective tubes 72 in which they are disposed. The restrictor tubes 80 extend through the chamber 64 and have the open end 82 thereof in fluid communication with the chamber 60.

The clearance between the outside diameter of the restrictor tubes 80 and the inside diameter of the helical corrugations 78 of tubes 72 should be as small as possible, consistent with ease of assembly. This results in the primary refrigerant being caused to follow a spiral path as it is forced between a restrictor tube 80 and a respective elongated tube 72. A typical example of the relative sizes of these elements would be a clearance of 0.019 inch between a restrictor tube 80 having an outside diameter of 0.081 inch and a helical corrugation 78 having an inside diameter of 0.100 inch. Although a small portion of the primary refrigerant will pass through the clearance space between the restrictor tube 80 and the helical corrugation 78, most of the primary refrigerant will follow the spiral path.

While the various figures of the drawing illustrate the installation of a relatively small number of tubes 72 and restrictor tubes 80 in the heat exchanger 12, it should be understood that many times the number shown may be installed in the actual construction of the heat exchanger 12. Also, it can be perceived from viewing FIG. 2 that the open ends 82 of the restrictor tubes 80 are in communication with the conduit 32 through the chamber 60 and that the tubes 72 are in communication with the conduit 38 through the chamber 64.

Baffle plates 86, 88 and 90 extend generally transversely across the hollow body 52 in spaced parallel relation with the closed end 56 thereof and between the conduits 18 and 20. The baffle plates are provided with a plurality of ports for receiving the conduit 38 and the tubes 72. It should be pointed out that the baffle plates 86, 88 and 90 are not connected to the tubes 72 and do not extend entirely across the hollow body 52. The purpose of the baffle plates 86, 88 and 90 is to force the secondary refrigerant entering the heat exchanger 12 through the conduit 20 and the opening 70 to follow a circuitous path through the hollow body 52 to the opening 68 and outlet conduit 18. Thus, the secondary refrigerant is forced into contact with the surface area of the greatest number of tubes 72 as it flows through the heat exchanger 12.

OPERATION OF THE PREFERRED EMBODIMENTS

To utilize the air conditioning system **10** for the purpose of cooling, the valves **46** and **50** are closed and the valves **40** and **42** are opened. With the pump **36** running, the primary refrigerant is circulated through the conduit **34** into the condenser coils **16**, through the conduit **32** and into the chamber **60** of the heat exchanger **12**. The primary refrigerant, as it enters the chamber **60**, is in a liquid state. The primary refrigerant flows from the chamber **60** into the open ends **82** of the restrictor tubes **80**.

As the primary refrigerant flows through the restrictor tubes **80**, it is metered to provide the maximum efficiency of expansion of the liquid refrigerant as it passes from the open ends **84** of the restrictor tubes **80**. Upon entering the tubes **72**, the primary refrigerant changes into a gaseous state and, due to its expansion, becomes extremely cool. The cooling of the primary refrigerant in the tubes absorbs heat from the secondary refrigerant in the chamber **66**, thereby cooling the secondary refrigerant.

As the primary refrigerant flows through the tubes **72**, it passes through the open ends **74** of the tubes **72** into the chamber **64**. From the chamber **64**, the gaseous primary refrigerant passes through the conduit **38** returning to the pump **36**.

Simultaneously with the operation of the pump **36**, the pump **24** is placed in operation moving the secondary refrigerant through the inlet conduit **20**, the opening **70** in the hollow body **52** through the chamber **66** as previously described. As the secondary refrigerant flows through the chamber **66**, it loses its heat to the cooled tubes **72**. Therefore, the secondary refrigerant flowing from the chamber **66** through the opening **68** and the outlet conduit **18** to the cooling coil **14** is in a chilled condition. Air, driven by the fan **28** over the air conditioning coil **14**, is cooled to promote the cooling of the area desired.

As can be perceived in FIG. **2**, the heat exchanger **12** has an increased cooling efficiency due to the disposition of the restrictor tubes **80** in the tubes **72**. It can be appreciated therein that as the liquid primary refrigerant moves through the restrictor tubes **80** it is "precooled" or "sub-cooled" due to the expansion of the primary refrigerant as it flows in a counter-flow direction through the tubes **72** toward the open ends **74** thereof. The helical corrugations **78** of the tubes **72** provide a circuitous path for the primary refrigerant to follow as it flows in a counter-flow direction through the tubes **72** toward the open ends **74**. This circuitous counter-flow provides more efficient heat transfer between the tubes **72** and the secondary refrigerant circulating through the chamber **66**.

When the air conditioning system **10** is to be used as a heat pump, that is, when it is to be used to heat an area adjacent the air conditioning coil **14**, the valves **40** and **42** are closed and the valves **46** and **50** are opened. With this arrangement of valves, the pump **36** moves the primary refrigerant through the branch conduit **48**, the valve **50** and into the conduit **38**. The primary refrigerant flows through the conduit **38** into the chamber **64** and then through the open ends **74** of the tubes **72**. As the primary refrigerant flows through the tubes **72**, it is condensed due to the relatively cool secondary refrigerant in the chamber **66**. The condensed primary refrigerant then passes through the open ends **84** of the restrictor tubes **80**, flowing therethrough into chamber **60**. From the chamber **60**, the primary refrigerant flows outwardly through the conduit **32** into the condenser coil **16**. From the condenser coil **16**, the refrigerant flows through the conduit **34**, branch conduit **44** and open valve **46** to the inlet side of the pump **36**.

When using the heat exchanger **12** in a heat pump system, the closed end **56** thereof should be lowered slightly as shown in FIG. **1**. The lowering of the closed end **56** assures that the open ends **84** of the restrictor tubes **80** will be immersed in the condensed primary refrigerant in the tubes **72** adjacent the closed ends **76** thereof. Thus, the primary refrigerant when moved through the restrictor tubes **80** will be in a liquid state.

As the primary refrigerant flows through the tubes **72**, the secondary refrigerant in the chamber **66** absorbs heat from the primary refrigerant so that the secondary refrigerant flowing through the outlet conduit **18** to the air conditioning coil **14** is at an elevated temperature as compared to the temperature of the secondary refrigerant flowing through the inlet conduit **20** into the exchanger **12**.

Frequently, heat exchangers utilized in air conditioning systems are subjected to freezing, particularly when used as a "chiller." If the secondary refrigerant within the chamber **66** freezes, forces are exerted on the structure of the heat exchanger **12** due to the expansion of the freezing refrigerant. To alleviate the problem of damage to the exchanger **12** when and if such freezing occurs, the tubes **72** are suspended only at the open end **74** thereof. Also, the restrictor tubes **80** are suspended only at the open ends **82** thereof. Thus, the tubes **72** and the restrictor tubes **80** are free to move under the forces imposed if the secondary refrigerant in the chamber **66** should freeze.

Also, the thermal expansion of the tubes **72** and **80** under the influence of changing temperatures in the heat exchanger **12** will not damage the heat exchanger **12** due to the single end suspension of the tubes **72** and the restrictor tubes **80**. In the usual form of constructing heat exchangers, each end of each tube is rigidly supported whereby extreme thermal stresses are imposed thereon.

As described in the foregoing detailed description, the heat exchanger **12** is arranged so that it can be used without alteration either in an air conditioning system as a heat pump or as a refrigerating device. Also, and as previously mentioned, the heat exchanger **12** avoids the possibility of damage due to thermal stresses resulting from changes in temperature in the exchanger or from damage due to the freezing of the secondary refrigerant.

The embodiment described in detail hereinbefore is presented by way of example only and it should be understood that many changes and modifications can be made thereto without departing from the spirit of the invention or from the scope of the annexed claims.

What is claimed is:

1. A heat exchanger comprising:

an elongated, hollow body having first and second closed ends and having inlet and outlet openings therein;

a perforated first plate member disposed in said body adjacent the first closed end thereof having a periphery connected in fluid-tight relationship with said body to form a first chamber in said body;

a perforated second plate member disposed in said body between said first plate member and said second closed end and having a periphery connected in fluid-tight relationship with said body to form a second chamber with said first plate member and a third chamber with the second closed end of said body, said third chamber being in communication with said inlet and outlet openings;

a first conduit having an open end connected in one of the perforations in said first plate member with said open end in communication with said first chamber and extending through the second closed end of said body to transfer fluid to and from said first chamber;

a second conduit encircling a portion of said first conduit and having an open end in communication with said second chamber and connected in one of the perforations in said second plate member, said second conduit also extending through the second closed end of said body to transfer fluid to and from said second chamber;

a plurality of tubes disposed in said body, each of said tubes having an open end connected in a respective perforation in said second plate member, having a closed end thereon disposed in said third chamber adjacent the second closed end of said body, and having a continuous helical corrugation formed in the tube wall that extends for substantially the full length thereof and projects radially inwardly therefrom;

a plurality of open-ended restrictor tubes disposed in said body, each of said restrictor tubes having one open end connected in a respective perforation in said first plate member in communication with said first chamber and having the other open end located in and adjacent the closed end of a respective one of said tubes and in intimate relation to the helical corrugation formed therein; and

a plurality of baffle members located in the third chamber of said body between the inlet and outlet openings whereby fluid flowing therebetween follows a circuitous path through said third chamber.

2. A heat exchanger for use in a combination heating and cooling system which includes a compressor circulating a primary refrigerant, and an air conditioning coil through which is circulated a secondary refrigerant comprising:

a hollow, elongated body supported with one end slightly lower than the other end thereof having a first chamber in the higher end thereof, a third chamber in the lower end thereof, and a second chamber between the first and third chambers, said body further having inlet and outlet connections communicating with the third chamber and adapted for connection with the air conditioning coil;

a first conduit having one end in communication with said second chamber and having the other end adapted to be connected to the refrigerant compressor;

a second conduit having one end in communication with said first chamber and having the other end adapted to be connected with the refrigerant compressor;

a plurality of first tubes supported in said body, each of said tubes having an open end in communication with said second chamber, having a lower closed end located in said third chamber, and having a continuous helical corrugation formed in the tube wall that extends for substantially the full length thereof and projects radially inwardly therefrom;

a plurality of open-ended restrictor tubes supported in said body, each of said restrictor tubes having one open end in communication with said first chamber and having the other open end disposed in a respective one of said first tubes adjacent the closed end thereof and each of said restrictor tubes being in intimate relation to the helical corrugation formed in a respective one of said first tubes, whereby primary refrigerant from the compressor either cools or heats the secondary refrigerant flowing through said third chamber to the air conditioning coil depending on whether the primary refrigerant is flowing from said compressor into said first conduit or into said second conduit.

3. A heat exchanger as defined in claim 2 wherein:

said first conduit extends through the lower end of the body and the third chamber into communication with the second chamber, and

said second conduit extends concentrically through the first conduit in the second chamber into communication with the first chamber.

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