Nov. 8, 1960 J. O. EWING 2,959,027

COMBINATION EVAPORATOR-CONDENSER ASSEMBLY WITH CONCENTRIC TUBULAR CONSTRUCTION

Filed Nov. 28, 1958 4 Sheets-Sheet 1

Fig. 1

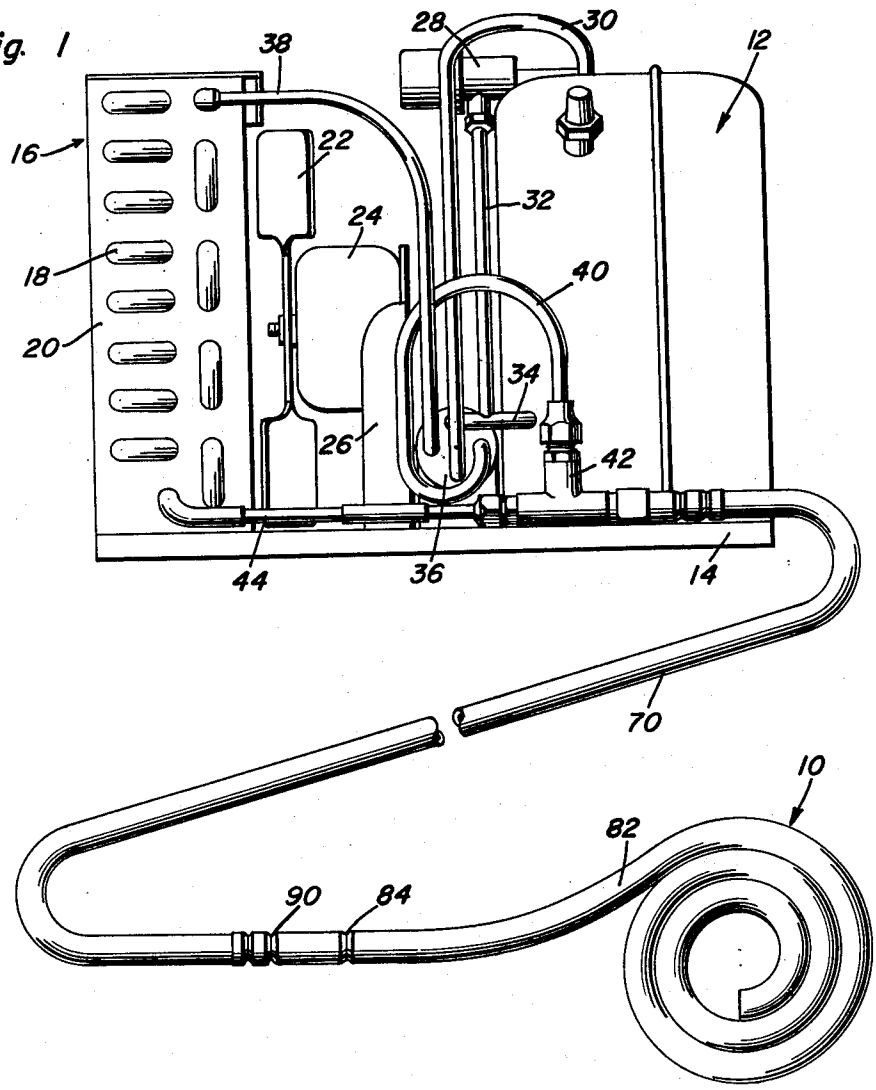
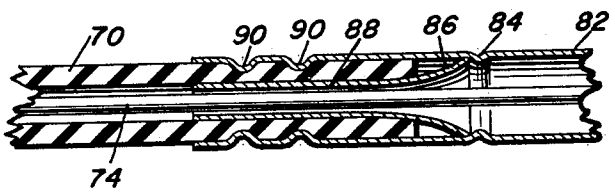


Fig. 6



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Fig. 2

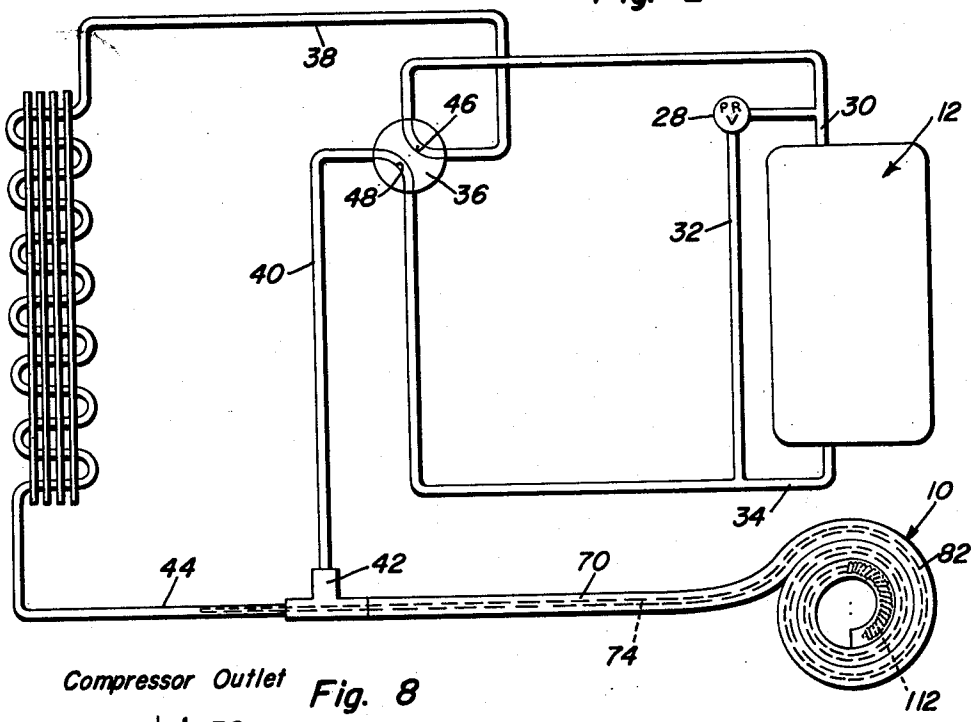


Fig. 8

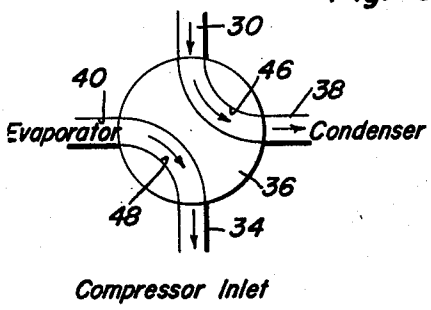
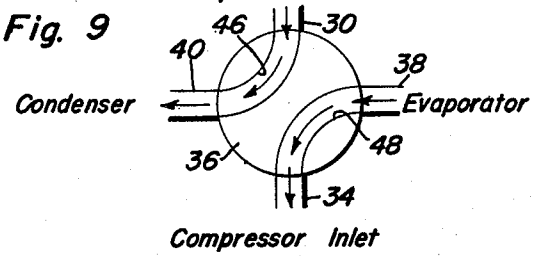


Fig. 7

Fig. 9



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Fig. 3

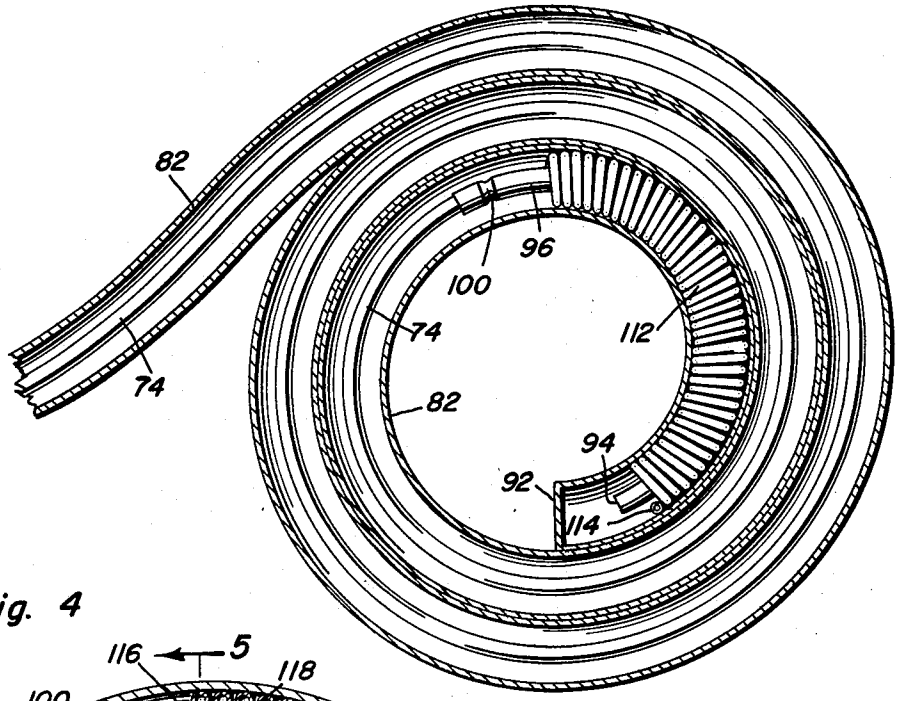


Fig. 4

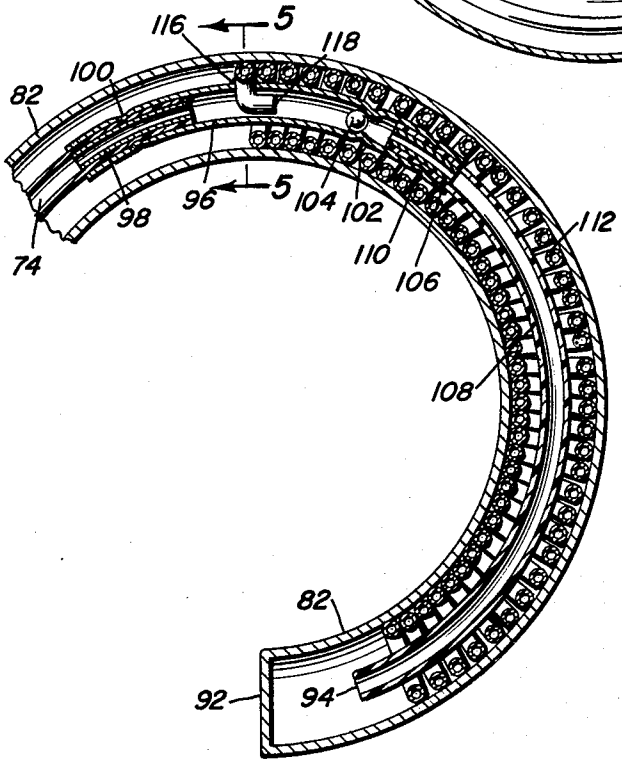
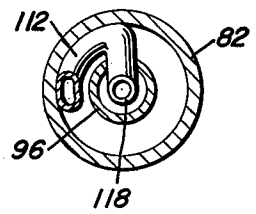


Fig. 5



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COMBINATION EVAPORATOR-CONDENSER ASSEMBLY
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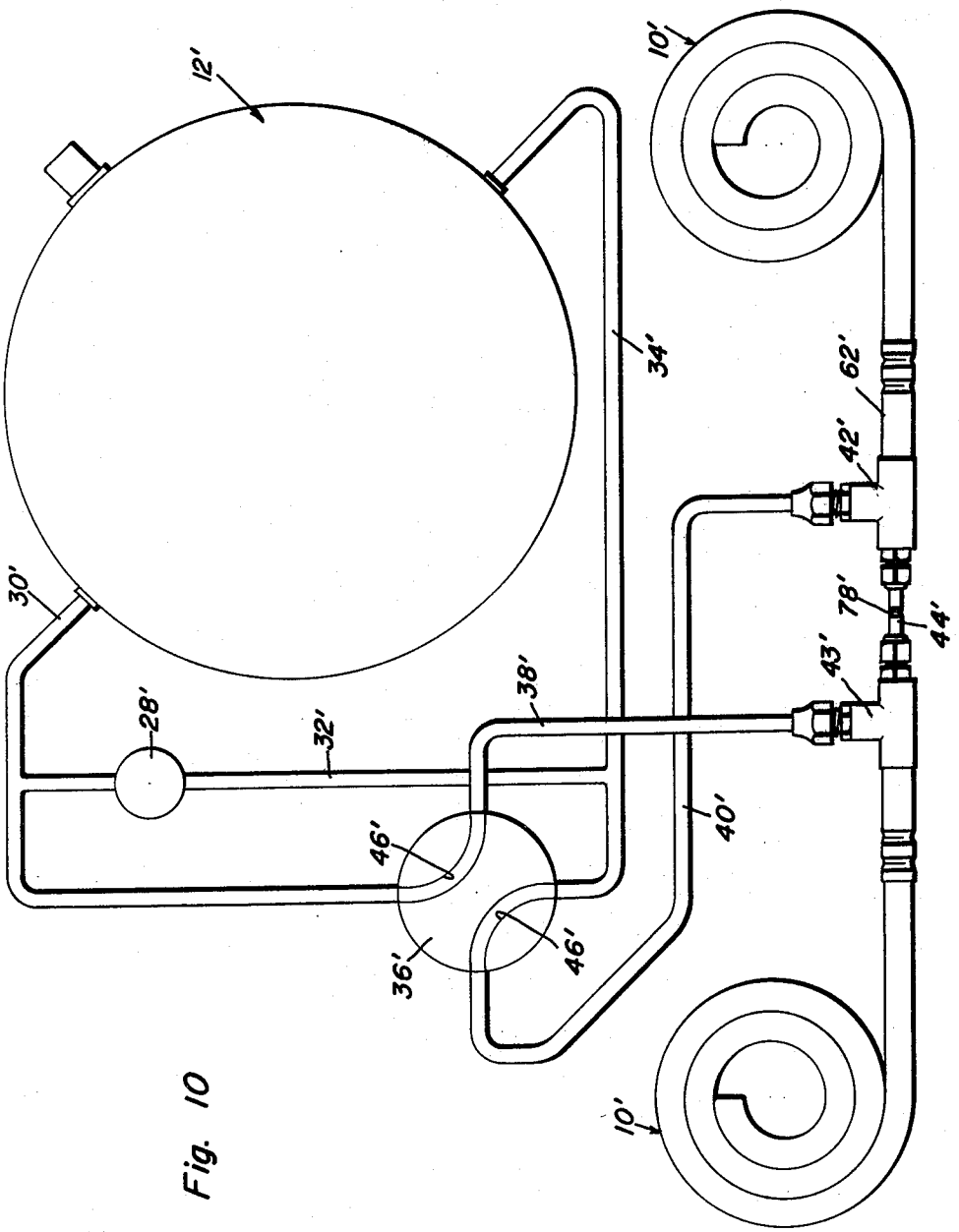


Fig. 10

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2,959,027

COMBINATION EVAPORATOR-CONDENSER ASSEMBLY WITH CONCENTRIC TUBULAR CONSTRUCTION

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8 Claims. (Cl. 62—160)

The present invention generally relates to a combined evaporator and condenser assembly connected with a compressor in which the assembly is reversible in that the two heat exchange mechanisms may be either a condenser or an evaporator depending upon the direction of flow of refrigerant in the system. Specifically, the present invention represents novel and improved structural arrangements having generally the same purposes as that construction shown in my copending application Serial No. 569,527 filed March 5, 1956 now Patent No. 2,910,838 granted November 3, 1959.

While the broad concept of a reversible refrigeration cycle has been disclosed in the copending application mentioned above, the present invention has for its primary object the provision of a combination evaporator-condenser assembly which includes concentric tubes for flow of the refrigerant in either direction in the inner tube and in either direction in the annular space disposed between the inner tube and the outer tube with substantially the entire assembly being disposed in a spiral arrangement with all of the loops lying in the same plane so that the assembly may be immersed in a heat exchange agent and requiring a minimum of space requirement. This feature is extremely desirable in solution tanks employed in various photographic processes in which it is desirable to maintain the temperature of the liquids substantially at a constant level thereby enabling the present invention to take away heat or add heat depending upon the requirements for maintaining the solution substantially at a constant predetermined temperature.

Another feature of the present invention is to provide an assembly in accordance with the preceding object in which a major portion of the concentric tubes are constructed of flexible material so that the orientation of the assembly may be easily changed.

A further important feature of the present invention is to provide a reversible evaporator-condenser assembly in accordance with the preceding object in which there is a novel structural arrangement for providing flow restriction for expansion of refrigerant in one direction which restriction is in the form of a capillary tube disposed in the space between the inner and outer tubes and with the restriction in the other direction of flow being formed by the size of the inner tubular member.

Other features of the present invention will reside in the simplicity of construction, ease of control, adaptation for control by automatic control devices, efficiency in operation, compactness, utility in many places, dependability and generally inexpensive to manufacture.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

Figure 1 is a side elevation of the assembly of the present invention illustrating the orientation of the component parts;

Figure 2 is a schematic view of the refrigeration assembly;

Figure 3 is a sectional view of the combination evaporator and condenser assembly illustrating the orientation of the concentric tubular members and the capillary tube;

Figure 4 is a detailed sectional view of the capillary tube portion of the assembly, on an enlarged scale, illustrating the specific structural details of the capillary tube and the structure of the inner tube;

Figure 5 is a transverse, sectional view taken substantially upon a plane passing along section line 5—5 of Figure 4 illustrating the orientation of one end of the capillary tube in relation to the inner tubular member;

Figure 6 is a detailed sectional view of the attachment between the outer tubular member and the outer hose;

Figure 7 is a detailed sectional view of the T-connection employed in the system;

Figure 8 is a schematic view of the reversing valve in one orientation with the valve set in one position;

Figure 9 is a schematic view illustrating the valve set in another position; and

Figure 10 is a generally schematic view of a slightly modified form of the invention in which two of the combined condenser and evaporator assemblies of the present invention are employed in the same refrigeration system.

Referring now specifically to the drawings, the numeral **10** generally designates the combined evaporator and condenser assembly which is incorporated in a reversible refrigeration system. The refrigeration system includes the usual and conventional compressor and motor assembly designated generally by the numeral **12** which may be of any commercially available type and which may have any desired horsepower. The compressor assembly **12** may be hermetically sealed and may be supported on any suitable base **14** which may have any configuration and which may be supported in any area desired and provided with any shock absorbing equipment that may be deemed advisable. The details of the compressor **12** and the base **14** are not important to the invention in their detail but only in their orientation to the rest of the refrigeration system.

A looped tube type of condensor-evaporator assembly is generally designated by the numeral **16** and is mounted on the base **14** and includes the usual looped tubes **18** and heat transfer fins **20** thereon. Disposed between the compressor **12** and the assembly **16** is a fan **22** driven by a motor **24** mounted on a bracket **26**. The compressor **12** is provided with a pressure relief valve **28** in the discharge line **30** which pressure relief valve is manually adjustable and communicated with a bypass line **32** connected to the intake line **34** of the compressor **12**. A reversing valve **36** is provided with the discharge line **30** being connected to one side of the valve and the intake line **34** being connected to the valve at opposite sides in relation to the discharge line **30**. A line **38** extends from the top of the assembly **16** to the valve **36** and a line **40** extends from the valve **36** to a T-coupling **42** which forms a portion of the assembly **10**. A line **44** extends from the bottom of the assembly **16** and enters into the T-coupling **42** in a manner described hereinafter.

Referring particularly to Figures 8 and 9, when the valve **36** is in the usual position for operation of the refrigeration system in the usual manner, the discharge of compressed refrigerant gases will pass through the line **30** and through passageway **46** in the valve **36** and into the line **38** and thus to the condenser assembly **16** which is acting as a condenser. The inlet **34** is then communicated with a passage **48** in the valve **36** which also communicates with the line **40** from the combined con-

denser and evaporator assembly **10** which is acting as an evaporator. The orientation of the valve **36** is the same in Figure 2 as it is in Figure 8. Each of the passageways **46** and **48** are substantially right angular and in Figure 9, the valve **36** has been rotated 90° so that the compressor outlet is now communicated with line **40** and the compressor inlet is communicated with line **38** wherein the assembly **16** then becomes the evaporator and the assembly **10** becomes the condenser.

Reference is made to Figure 7 which illustrates the details of the T-coupling **42**. There is provided an upwardly extending externally threaded integral adapter **50** which receives a coupling nut **52** holding the flared end **54** of the tubular line **40** thereto in sealed relation. The branch of the T-coupling **42** facing the tubular line **44** is provided with an externally threaded adapter **56** similar to the adapter **50** for receiving a cap **58** similar to the nut **52** which holds the flared end **60** of the tubular line **14** to the T-coupling **42** in sealed relation. Extending longitudinally from the other branch of the T-coupling **42** is a cylindrical or tubular member **62** secured thereto as by brazing, silver soldering or the like **54**. Also secured to the same end of the T-coupling **42** is an inner cylindrical member **66** having an outwardly flared inner end **68** secured to the T-coupling **42** in the same manner. The tubular members or cylindrical members **62** and **66** define a cylindrical space therebetween for receiving a hose **70** or outer tube which is crimped and secured therein by two peripheral beads or grooves **72** formed in the outer cylindrical member **62**. The inner cylindrical member **66** prevents collapse of the hose **70** thereby assuring a sealing relationship between the hose **70** and the cylindrical member **62**.

Extending longitudinally and concentrically through the hose **70**, the inner tubular member **66**, the T-coupling **42** and the tubular line **44** is an elongated flexible tube **74** constructed of plastic material such as nylon or the like. One end of the flexible tube **74** is connected to the line **44** by virtue of there being a short cylindrical sleeve **76** disposed into the end of the tube **74**. The sleeve **76** is of rigid material and is locked into position and seals the flexible tube **76** to the rigid line **44** by virtue of a peripheral groove or indentation **78** being formed in the line **44** for sealing the sleeve **76**, the flexible tube **74** and the rigid tube **44**. The sleeve **76** also forms a flow restriction for refrigerant since the internal diameter thereof is less than the internal diameter of the flexible tube **74**. A protective and reinforcing sleeve **80** is disposed on the exterior surface of the line **44** to prevent bending of the line **44** at the point of weakening of the line **44** caused by the peripheral crimp or groove **78**. With this construction, it will be seen that the lines **40** and **44** are sealed in relation to the flexible tube **74** and the hose **70** respectively with there being a space between the hose **70** and the flexible tube **74** both of which are circular in cross-section and which extend longitudinally in concentric relation to each other.

The hose may be as long as is desired but at the outer end thereof, the hose **70** is connected to a rigid tubular member **82** which will be hereafter called the outer tubular member or tube. The tube **74** extends longitudinally into the outer tubular member **82** and will hereafter be called the inner tubular member or tube. The outer tubular member **82** is provided with a peripherally extending indentation **84** forming an internal shoulder for receiving the outwardly flared end **86** of a cylindrical member **88** disposed concentrically within the free end of the outer tubular member **82** for receiving the hose **70** therebetween. The outer end of the outer tubular member **82** is provided with a pair of longitudinally spaced peripheral indentations **90** for rigidly securing and sealing the hose **70** to the outer tubular member **82** without collapse of the hose **70**. This assembly is somewhat similar to the manner in which the hose **70** is attached to the T-coupling **42**. The shoulder defined by the peripheral inwardly extending rib **84** limits the insertion of the flared end **86** of the cylindrical member **88** so that the same may be dropped therein and then brazed or silver soldered into position. The cylindrical member **88** has a diameter greater than the external diameter of the inner tubular member **74** thus providing an annular space between the cylindrical member **86** and the inner tubular member **74** for permitting passage of refrigerant between the outer tubular member **82** and the inner tubular member **74** as well as within the inner tubular member **74**.

As shown clearly in Figure 3 of the drawings, the outer tubular member **82** is formed into a plurality of spiral convolutions with the convolutions lying in the same plane and with the terminal end of the outer tubular member **82** being closed as indicated by the numeral **92**. The inner tubular member **74** is concentric with the outer tubular member **82** but terminates in spaced relation to the closed end **92** with the end of the inner tubular member **74** being open as indicated by the numeral **94** and as illustrated in Figure 4.

In substantially the last half of the innermost convolution of the outer tubular member **82**, the inner tubular member **74** is connected to an arcuately curved rigid inner tubular section **96** by virtue of a rigid sleeve **98** disposed in the end of the inner tubular member **74** together with an inwardly extending peripheral projection **100** in the portion of the rigid inner tubular section **96** which telescopes over the inner tubular member **74** thereby sealing the flexible inner tubular member **74** to the rigid inner tubular section **96** which forms a continuation thereof. The sleeve **98** also forms a flow restriction in the inner tubular member **74**.

Adjacent to but spaced inwardly from the outer end of the rigid inner tubular section **96** is a peripherally extending inwardly extending shoulder **102** which forms a valve seat for a freely movable ball valve **104**. In the free end of the rigid inner tubular section **96**, there is provided a cylindrical sleeve **106** disposed within the inner end of the outermost section **108** of the flexible inner tubular member **74** with the portion of the rigid tubular section **96** telescoping over the outermost section **108** being peripherally and inwardly crimped as indicated by the numeral **110** for sealing the outermost section **108** of the inner tubular member **74** to the rigid inner tubular section **96**.

Disposed in coiled relation about substantially all of the outermost section **108** as well as a portion of the rigid section **96** is a coiled capillary tube **112** having a free and open end **114** adjacent to but spaced from the open end **94** of the inner tubular member **74**. The other end of the spiral tube **112** is disposed adjacent the center of the rigid section **96** and extends radially inwardly and through the wall of the rigid section **96** with the same being secured thereto as by soldering or brazing as indicated by the numeral **116**. The inner end of the capillary tube **112** extends into the interior of the rigid section **96** and then turns at right angles in concentric relation to the rigid inner tubular member **96** and is disposed with an open end **118** in facing relation to the ball valve **104** whereby the ball valve **104** may roll against the open end **118** so that the open end **118** forms a stop for the ball **104** whereby the ball **104** can only move between the open end **118** and the valve seat defined by the peripheral shoulder **102**.

The orientation in Figure 10 is generally equivalent to that shown in Figures 1–9 with the exception that two concentric tubular assemblies generally designated by the numeral **10'** are employed with one of them being hooked to line **38'** by a T-coupling **43'** similar to T-coupling **42'** with the inner tubular members being interconnected by a pipe **44'** having the sealing ring **78'** therein.

In operation, assuming that the refrigeration system operates in the usual manner and the valve **36** is set in the manner as shown in Figure 8, the compressor **12**

will operate upon demand such as by use of a thermostat or other heat responsive device whereupon refrigerant gas will proceed through the condenser assembly **16** for cooling and liquefaction in the usual manner and then pass through line **44** into flexible tube **74** until such time as it reaches rigid inner tubular section **96**. The engagement with the ball valve **104** will cause the ball valve **104** to move against the seat **102** thus precluding further passage of the refrigerant in this direction. The refrigerant will then enter the open end **118** of the capillary tube **112** and will proceed through the capillary tube **112** and be discharged from the free end **114** thereof at which time the refrigerant expands into the larger area between the outer tubular member **82** and the inner tubular member **74** thus causing the rigid outer tubular member **82** to become cold and absorb heat. The expanding or boiling refrigerant caused by the absorption of the heat will then proceed back through the T-coupling **42** and out through the line **40**, the valve **36** and into the intake **34** of the compressor **12** thus completing the cycle. The capillary tube **112** forms the flow restricter and expansion valve such that the refrigerant may expand in the usual manner in the outer tubular member **82**.

When the reversing valve **36** is shifted to the other position and assembly **10** acts as a condenser and assembly **16** as an evaporator, the refrigerant goes from the compressor **12** into the compressor outlet line **30** and through the valve **36** into the line **40**. From the line **40** it proceeds between the outer tubular member **82** and the inner tubular member **74** and will proceed completely to the end of the outer tubular member **82** where it is cooled and then will proceed into the open end **94** of the inner tubular member **74**. The pressure and movement of the partially condensed refrigerant will move the ball valve **104** away from the seat **102** in a pulsating manner thus permitting passage of the refrigerant through the restrictions which maintain a pressure differential including the sleeve **106** and the sleeve **98** and thence into the inner tubular member **74**. As the refrigerant passes through the inner tubular member **74**, it will pass back through the T-coupling **42** and through the flow restricter sleeve **76** wherein the refrigerant which has been cooled during its passage through the assembly **10**, now acting as a condenser, will expand into the assembly **16** thus cooling the assembly **16** and absorbing heat from the fins **20** and the tubes **18**. The boiling and evaporated refrigerant will then proceed back through the valve **38** to the compressor inlet line **34** for repeat of the cycle. In this cycle of the operation, the valve **104** will normally rest against the seat **118** when the refrigerant is in a purely gaseous state. However, when some of the refrigerant is in a liquid state, the liquid refrigerant or combined liquid and gaseous refrigerant will actually cause somewhat of a bubbling action or pulsing action as slugs of liquid refrigerant and gaseous refrigerant pass through inner tubular member **74**.

In the device of Figure 10, the device works in the same manner except that another of the assemblies **10'** replaces the assembly **16** and the inner tubular members of the two assemblies are intercommunicated and the device operates in the same manner.

The reversing valve may have a position wherein the pressures in the device may be equalizd for the purpose of assisting in the reversing of the refrigeration system. It takes very little time for the outer tubular member **82** to become extremely cold when it is normally hot such as when it is acting as a condenser since the release of the liquid refrigerant will immediately permit the refrigerant to expand for absorbing heat thus immediately turning the outer tubular member **82** from a hot condenser member to a cool evaporator member. When reversing the cycle in the other manner, it take some operation of the compressor to unload the boiling and residual expanding refrigerant from the assembly **10** inasmuch as the assembly actually acts as a combined receiver and evaporator and it is necessary to remove all of the liquid refrigerant from the assembly **10** before the assembly **10** can be heated by the incoming hot gaseous refrigerant from the discharge side of the compressor.

The pressure relief valve **28** may be adjusted so as to control the vapor pressure or boiling point of the refrigerant in the assembly **10** when it is acting as an evaporator and to control the amount of heating in assembly **10** when it is operating as a condenser by remotely controlling the boiling point of the refrigerant in assembly **16**. This also will prolong the useful life of the compressor and motor therefor since the compressor is not continuously cycling. Any suitable control means may be provided for the compressor and motor assembly and also for the reversing valve as well as for the pressure relief valve so that the device may be adapted for use in many orientations and for many purposes.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. In a reversible refrigeration system, a heat exchange assembly comprising an outer tubular member and an inner tubular member arranged concentric therewith, said outer tubular member having a closed end, said inner tubular member having an open end spaced from the closed end of the outer tubular member thereby communicating the outer and inner tubular members for flow of refrigerant, a one-way check valve in said inner tubular member for preventing flow of refrigerant from the inner tubular member into the outer tubular member from the outer end of the inner tubular member, capillary tube expansion means having an open end communicating with the interior of the outer tubular member and having another end communicating with the interior of the inner tubular member inwardly of the check valve whereby refrigerant may flow through the capillary tube and be discharged into the outer tubular member for expansion and absorption of heat.

2. The device as defined in claim 1 wherein said check valve is in the form of a gravity operated ball valve resting against a valve seat, said ball valve serving to restrict flow of gaseous refrigerant in the other direction in the inner tubular member, said ball valve adapted to be moved away from the seat by liquid refrigerant thereby providing for flow of liquid refrigerant into the inner tubular member from the outer tubular member when the heat exchange assembly is employed as a condenser.

3. The structure as defined in claim 1 wherein said capillary tube is spirally wound around said inner tubular member in concentric spaced relation thereto.

4. A reversible refrigeration system comprising a compressor, a first heat exchange assembly, a second heat exchange assembly, each assembly including an outer tubular member and an inner tubular member concentric therewith, the inner tubular member of said assemblies being interconnected, and a reversing valve interconnecting the compressor intake and outlet with the respective tubular members for reversing flow of refrigerant, one of said assemblies including a capillary tube means intercommunicating the outer end of the inner tubular member and the outer tubular member and restricting the flow of refrigerant so that the same may expand for absorbing heat, the outer end of the outer tubular member being closed for flow and expansion of the refrigerant from the inner tubular member to the outer tubular member.

5. The combination of claim 4 wherein said outer

tubular member and inner tubular member are wound into a flat spiral coil.

6. The structure as defined in claim 4 wherein said means for restricting flow includes a coiled capillary tube disposed between the inner and outer tubular members and communicating the interior of the inner tubular member and the interior of the outer tubular member for expansion of the refrigerant into the outer tubular member for cooling the same.

7. The structure as defined in claim 6 wherein the outer end of said inner tubular member is provided with a check valve for preventing flow of liquid refrigerant towards the end of the inner tubular member when the assembly is acting as an evaporator, said inner tubular member having an open end for permitting flow of condensed refrigerant inwardly into the inner tubular member and past the check valve when the assembly is acting as a condenser, said capillary tube extending into the inner tubular member inwardly of the check valve

for flow of liquid refrigerant therethrough for expansion thereof.

8. The structure as defined in claim 7 wherein said check valve is a gravity-operated ball check valve freely rollable in said inner tubular member and normally engaged with a valve seat in the inner tubular member, the inner end of said capillary tube having a terminal end disposed in the path of movement of the ball check valve in opposition to the seat for limiting the movement thereof, the weight of the check valve causing build-up of liquid refrigerant in the outer end of the inner tubular member when the assembly is used as a condenser.

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