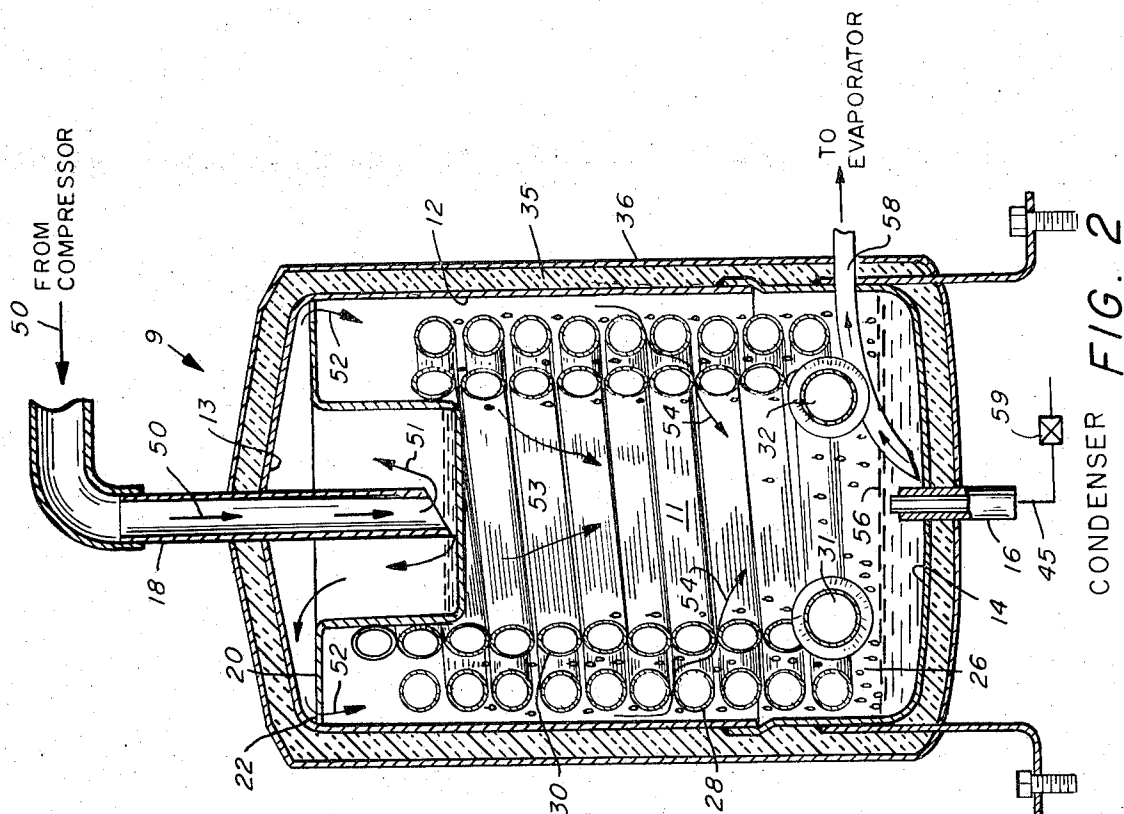
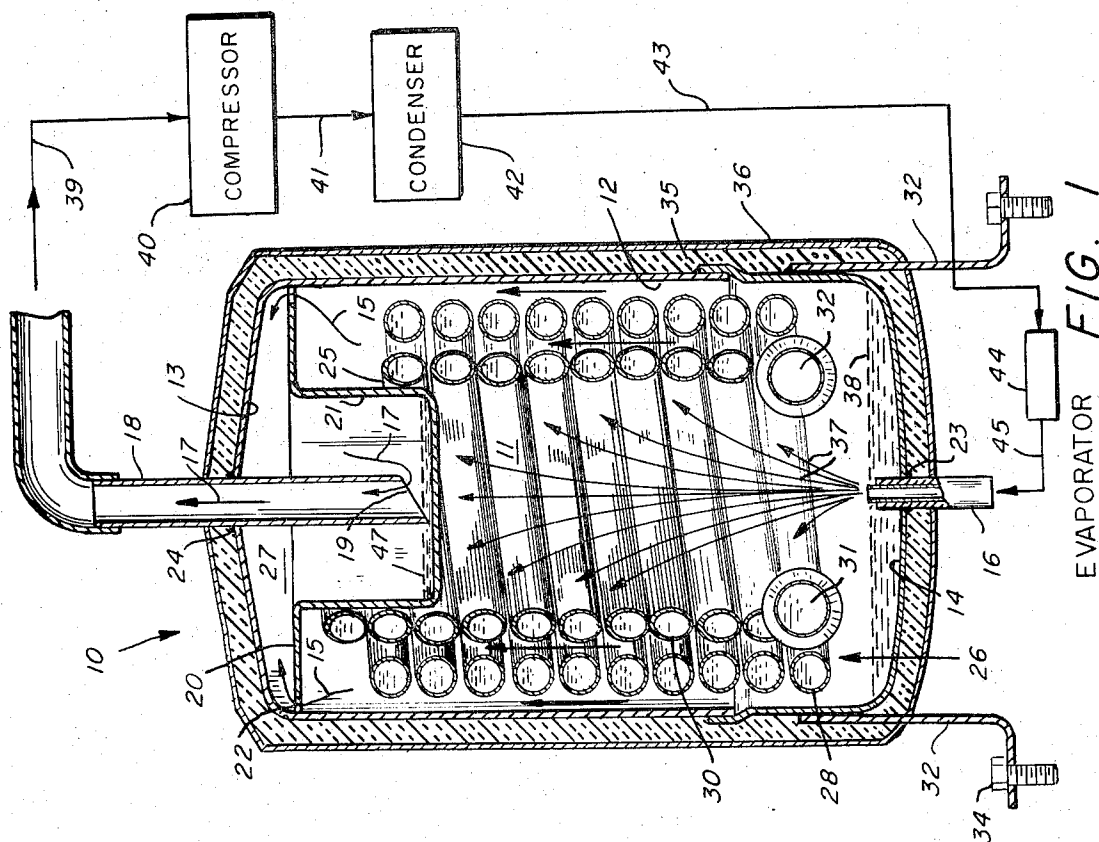
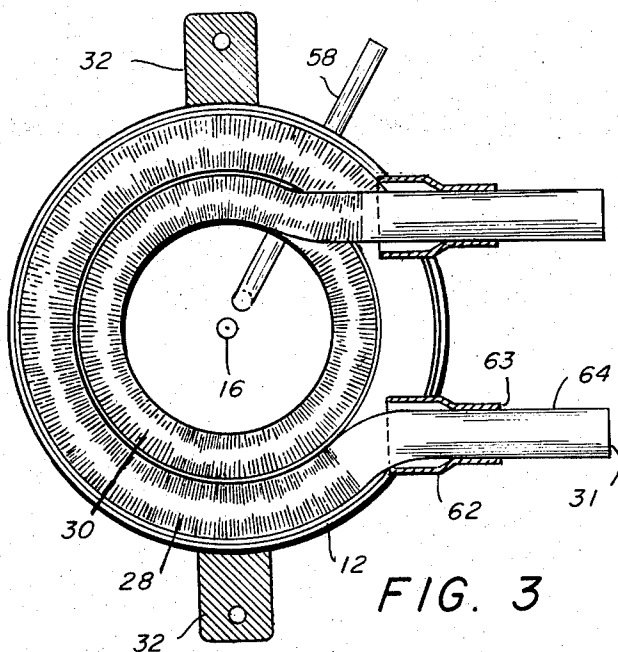
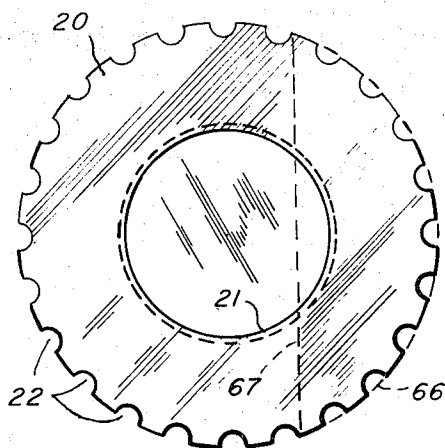
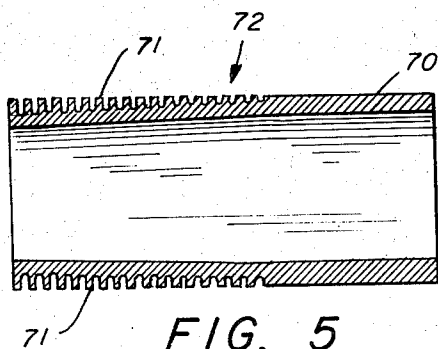
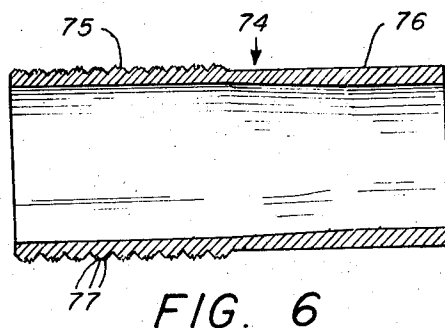
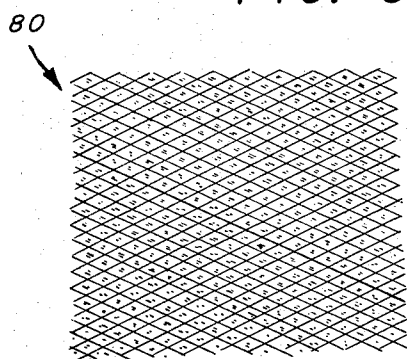
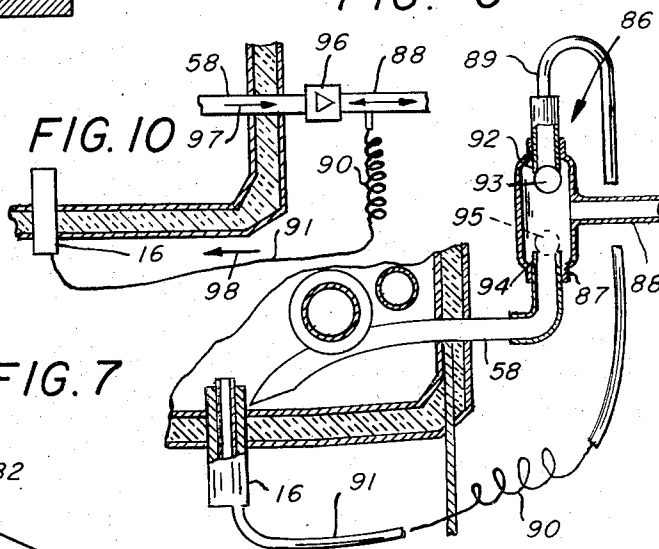
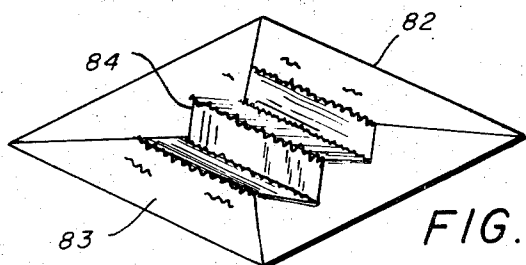






EVAPORATOR AND/OR CONDENSER FOR REFRIGERATION OR HEAT PUMP SYSTEMS

BACKGROUND OF THE INVENTION

This invention is in the field of refrigeration or heat pump systems. More particularly, it is a device which can be used alternately as an evaporator or as a condenser for refrigerants in such system.

In any heat pump system there is always one piece of equipment which is required, and that is a means for transferring heat to or from the refrigerant. In one case heat is required to be abstracted from the hot compressed refrigerant gas in order to permit it to condense to a liquid. In the other case, heat is applied to the liquid refrigerant in order to cause it to evaporate into a gas. There are many types of heat transfer systems for accomplishing this. However, because of the wide range in volume of the refrigerant as between the liquid and gaseous states it is very difficult to design a system where adequate heat transfer can be provided under all conditions. One of the more successful systems in the prior art is one in which there is a pipe inside of a pipe, with refrigerant gas or liquid in the annulus and heat transfer liquid on the inside of the inner pipe. However, because of pressure requirements and various other factors these have proven unsatisfactory due to the collapse of the inner pipe and for other reasons.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a single unitary device which can be used alternately as a condenser and as an evaporator of refrigerant in a heat pump system.

It is a further important object of this invention to provide such a device in which there is no direct path in which liquid refrigerant can pass through the device into the gas outlet pipe, and to the compressor, where it can do great damage.

It is a further object of this invention to provide a highly efficient heat transfer system so that the device can handle large volumes of heat carrying liquid with a minimum volume of apparatus.

These and other objects are realized and the limitations of the prior art are overcome in this invention by providing a pressure vessel into which liquid refrigerant is introduced or removed through a first pipe at one end, and a second pipe means at the other end, through which gaseous refrigerant can flow into or out of the pressure vessel. There is a baffle or diffusion means placed across the cross-section of the vessel with scalloped openings around the periphery of the plate. This device is for the purpose of preventing direct flow of droplets of liquid refrigerant, and at the same time providing an azimuthal distribution of the refrigerant gas so as to provide equal cooling and heating action around the periphery of the pressure vessel. The diffusion means effectively breaks up the internal volume of the vessel into two chambers, a second small chamber primarily for refrigerant gas, and a first large chamber primarily for liquid refrigerant, but also including gaseous refrigerant.

In the first chamber there is a helical coil of pipe near the outer wall. This may be in the form of one or more separate coils, and may have one or more layers of turns. The pressure vessel is, of course, insulated and provided with an outer protective cover.

In operation as an evaporator, the liquid refrigerant is sprayed into the bottom end of the pressure vessel where it impinges upon the coil of pipe through which water is pumped. In the evaporator the water is cooled by the evaporation of the liquid refrigerant, which turns into a gas and flows through the annular openings in the baffle plate and out through the gas flow pipe to the compressor. From the compressor the hot gas goes to a condenser where the heating effect of the apparatus can be utilized. From the condenser the liquid refrigerant passes through a flow regulating device back to the liquid inlet end of the pressure vessel.

In the use of this device as a condenser the hot compressed gases enter at the top end and are diverted through the annular openings down against the cool surface of the coil of pipe where they are condensed and drop to the bottom of the chamber. The liquid is drawn out of the pool at the bottom, to be returned to an evaporator and to the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention and a better understanding of the principles and details of the invention will be evident from the following description taken in conjunction with the appended drawings, in which:

FIGS. 1 and 2 show, in cross-section, the preferred embodiment of this invention for the case of the use of the device is an evaporator in FIG. 1 and as a condenser in FIG. 2.

FIG. 3 illustrates a detail of the water coil inside the pressure vessel.

FIG. 4 is a plan view of the baffle diffusion plate.

FIG. 5 illustrates one form of the tubing used in the helical coil.

FIGS. 6, 7 and 8 illustrate a preferred form of the pipe used in the helical coil.

FIG. 9 illustrates a valving system so that the pressure vessel can be switched rapidly for use as a condenser to its use as an evaporator and vice versa.

FIG. 10 represents a second embodiment of valving means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and in particular to FIG. 1, numeral 10 indicates generally, in cross-section, the use of the device of this invention as an evaporator. The device comprises a pressure vessel 12 with a first axial pipe 16 through which liquid refrigerant flows into the chamber 11 of the pressure vessel. There is a second axial pipe means 18 at the chamber 27 at the top of the vessel through which gas refrigerant flows into or out of the pressure vessel. In the case of the use as an evaporator the flow of gaseous refrigerant is outwardly, as indicated by the arrow 17.

There is a baffle or diffusion plate 20 fastened across the cross section of the pressure vessel near the second end where is positioned the second pipe. This diffusion plate comprises a flat circular plate with a cup portion 21 in the middle. The plate 20 divides the internal volume of the pressure vessel into two chambers, a first chamber 11 below the plate wherein primarily the liquid refrigerant is confined, forming gaseous refrigerant which passes into the chamber 27 where only gaseous refrigerant is confined. The outer edges of the plate 20 have a plurality of scalloped openings 22 which provide

passage between the scallops and the internal surface of the pressure vessel for the passage of refrigerant gas between chambers 11 and 27.

In the chamber 11 there is a helical coil of pipe indicated generally by numeral 26. This may comprise a single layer of turns 28 or a plurality of layers such as 28, 30, etc. These are placed close to the outer wall of the chamber and are formed so that the turns are substantially in contiguous position. There is very little space between the turns in each of the layers for the passage of liquid droplets. Furthermore, the cup portion of the diffusion plate 21 fits closely to the inside surfaces of the inner layer of turns, again closing off any direct passage between the liquid inlet pipe 16 and the openings 22 in the diffusion plate. As liquid refrigerant enters through the pipe 16 it is sprayed out through a small opening in the form indicated by the arrows 37, where it falls on the surface of the coiled pipes 26. With water running through the pipe 26 and liquid refrigerant contacting the surface of the pipe is heated and evaporates. The gaseous refrigerant formed passes by way of arrows 15 through the outer apertures in the plate 20 and out through the pipe 18 in accordance with arrows 17. Any liquid that does not evaporate immediately on contact with the coil drops down to the bottom of the chamber and forms a shallow pool 38. When this pool becomes deep enough, it will be agitated by the jet of incoming liquid, and will recirculate by being sprayed upward against the coils of the pipe and eventually will be evaporated.

Indicated in FIG. 1 is the flow of gaseous refrigerant through pipe 18 and thence through pipe 39 to compressor 40 where the compressed, hot gas passes by pipe 41 to a condenser 42, then as a liquid refrigerant through pipe 43 to a flow control means 44, and then as a controlled slow flow through a small diameter pipe or capillary 45, and thence into the chamber 11. The flow control device 44 can be a capillary tube or an expansion valve or similar device. Where the condenser 42 is close to the evaporator the pipe 45 and flow limiting device 44 can conveniently comprise together a short length of capillary tube, which provides the connection between the condenser and the evaporator, and also controls the rate of flow of liquid refrigerant.

When this device is used in a heat pump system the water passing through the coil 26 goes to a sump, or large tank, which acts as a heat sink. The condenser 42 would represent a heating means whereby air blowing over the condenser would be warmed in the operation of cooling and condensing the compressed refrigerant. The output of the heated air from condenser 42 is the useful output of this system. In the meantime the liquid in the coil 26 would be cooled in the operation of heating and evaporating a liquid refrigerant.

Now let us consider FIG. 2 where the operation of this device as a condenser is illustrated. The hot compressed gas from the compressor enters pipe 18 in accordance with arrows 50, then into chamber 27, then passes through the openings 22 in the diffusion plate 20, down into the chamber 11 of the pressure vessel. Here the hot gas is passed over the cool water in the coil 26 of pipe, and the condensed liquid then drops down to the bottom of the chamber as a shallow pool 56. It is forced out of the chamber through the pipe 58 which is emerged in the pool 56. The pipe 58 leads them to an evaporator and to the compressor and back to the inlet pipe 18.

In this operation the line 58 carrying liquid refrigerant goes to an evaporator over which air is blown and is cooled by the evaporation of the liquid refrigerant. In this use as a condenser the liquid passing through the coil 26 is heated whereas in the evaporator operation the liquid is cooled. Thus, a large heat capacity sink is required to store sufficient thermal energy to be able to provide the heat transfer either to supply heat, or to remove heat, as required by the use of this device as an evaporator or condenser. Some temperature control of the sink may be desirable in certain circumstances.

In many large heat pump systems there are parts of the system which at the same time require cooling, and some which require heating. Thus the heat sink supplying water to the coils in some cases will supply warm water and be cooled, and in other cases will supply cool water and will be heated.

FIG. 3 indicates the general layout of the two layers of coils 28 and 30 inside the outer circumferential wall 12 of the pressure chamber. The two ends of the pipe are brought out through openings in the outer wall, and short sleeves 62 are then inserted over the pipe and into the openings in the wall 12, where they are welded, braised, or soldered as required. Similarly, the junctions between the edges 63 of the short bushings and the pipes 64 are also sealed. Although two layers of coils are shown it is possible to provide one of any number of layers depending on the area of pipe surface required to get the desired volume of heat transfer.

FIG. 4 illustrates in plan view the diffusion plate 20 with the central cup portion 21 and the peripheral scallops or openings 22.

The length of pipe 64 required in the helical coil depends upon the surface area required for the heat transfer. The more efficient the heat transfer can be made, of course, the shorter the length of pipe, which provides for less cost and lower pressure drop and other savings.

FIG. 5 illustrates in cross section one of the commercial types of pipe which could be used for this purpose. It involves a helical fin 71 which is rolled into the surface of the pipe. This provides a large surface area for contact between the gas on the outside and liquid on the inside of the pipe. The pipes which can be used can be of any desired metal such as copper, nickel, admiralty brass, stainless steel. Other materials can, of course, be used. The high thermal conductivity of the copper is of course a very useful property.

FIGS. 6, 7 and 8 indicate details of an improved type of pipe for use as a heat exchange tube in the pressure chamber. This involves a pipe with a knurled type of surface, indicated in FIG. 7, in the form of small diamond pyramids. These may be of the order of 1/16 inch wide and 1/8 inch long. These are formed with four fairly smooth surfaces 83 coming to a peak. However, the peak is not a single sharp edge or point, but is a series of irregular ridges and granular type of surface, such as would be obtained by a tearing or expanding type of operation. These sharp points and corners on the granules of metal provide ideal points or centers, for the evaporation and condensation of a liquid. Such points 77 are shown in the cross section of FIG. 6. The tube 74 is to be preferred, although the tube 72 of FIG. 5 is also satisfactory. In both cases it is desired to provide a smooth end portion 70 and 76 for example.

No matter what type of pipe is used, the end portions illustrated in FIGS. 5 and 7 as 70 and 76 respectively,

are generally smooth so that connections can be easily soldered or welded to the pipe.

In FIG. 2 is shown the single pipe 18 at the upper end of the pressure chamber and a capillary pipe 16 entered on the axis of the chamber 11 at the bottom, with a large pipe 58 coming through the side wall of the chamber at the lower end. For use as an evaporator, the liquid refrigerant enters the chamber through the bottom capillary through pipe 59. However, when used as a condenser the liquid is drawn off from the pool 56 in the chamber 11 through pipe 58, which is of considerably greater size than the capillary 16. The capillary 45 must be closed by valve 59. Therefore in some systems which alternately use this device as an evaporator and as a condenser some sort of valving system is necessary such as that indicated in FIG. 9.

Illustrated in FIG. 9 is a commercial valve which is essentially a tee-section. One part of the tee has an inlet 87 on one end and an outlet 89 at the other end. The stem is a pipe 88 which goes to the evaporator. The pipe 58 goes to the end 87 of the tee and the capillary 16 is connected to the portion 89 of the tee. There are two seats 94 at one end and 92 at the other end, and there is a ball 93 placed inside of the tee which alternately seats on the lower or the upper seat. When the device is being used as an evaporator the ball seats in the position indicated by the dashed line 95, and liquid refrigerant coming in from the right through the pipe 88 passes out through the seat 92 through capillary 89 through the flow limiting device 90, which is indicated here as a capillary tube, then by small tube 91 to the capillary 16 where it is sprayed into the inner chamber.

When used as a condenser the liquid refrigerant passes out through pipe 58 and the ball 93 then seats on the upper seat 92, and the liquid refrigerant then passes out to the right through the pipe 88. Since this type of valve is a commercial device which is available on the market, no further description is required. It is indicated here simply for the purpose of showing that, with a valve of this or other similar type, a simple switching of the output of the compressor from the pipe 18 to the condenser shown in FIG. 1 or to the pipe 18 as shown in FIG. 2 will permit sequential operation as an evaporator or a condenser.

In certain applications all that will be required will be the pipe 58. In other applications, for use both as a condenser and as an evaporator it will be satisfactory to use only the capillary feed 90, 91.

In FIG. 10 is shown a somewhat simplified valving that accomplishes the same purpose as that of FIG. 9. A check valve 96 is connected between pipes 58 and 88 permitting liquid refrigerant to flow in accordance with arrow 97. The pipe 16 is connected through pipe 91, through capillary 90 and into pipe 88. When used as a condenser, the pressure drop through pipe 58 will be so small compared to that through pipe 91, that essentially all the flow will be through the check valve 96. When used as an evaporator the check valve 96 closes and all the flow goes through the capillary tube and pipe 16 as in FIG. 1.

While I have shown the pressure vessel with its axis vertical, with the liquid pipe at the bottom and the gas pipe at the top, it can be operated on its side just as well.

Consider FIG. 1 turned 90° clockwise so that the cylinder 12 is on its side, axis horizontal, pipe 16 at the left and pipe 18 on the right. Consider also that the diffu-

sion plate 20 is modified as in FIG. 4 so that some of the openings 22 on the bottom are not cut, and the contour of the periphery is a segment of a circle 66. Then, so long as the liquid level 38 is lower than the dashed line 67, the pool of liquid will remain in the chamber 11, and will surround a portion of the coil 26. It is possible also that even with the openings on the diffusion plate around the complete periphery, the vessel can be turned on its side. In this case the pool of liquid will extend into the chamber 27, but this should not cause any difficulty.

Thus, it will be clear that the pressure vessel can operate in any desired position, with axis either vertical, horizontal, or some intermediate angle.

While the invention has been described with a certain degree of particularity it is manifest that many changes may be made in the details of construction and the arrangement of components. It is understood that the invention is not to be limited to the specific embodiments set forth herein by way of exemplifying the invention, but the invention is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element or step thereof is entitled.

While I have indicated that the liquid most used as cooling or warming medium inside of the coiled pipe is water, it is possible to use other liquids, such as oils or other chemical compounds in the liquid state, or brine, for example.

In FIGS. 1 and 2 there is shown in the bottom of the cup portion 21 of the diffusion plate a shallow pool of oil. It is considered that some oil vapor will be carried from the compressor with the compressed refrigerant, and will collect in this cup. However, in the evaporator cycle, with gas flowing up the pipe 18, oil vapor from this pool 47 will be entrained with the gas and carried back to the compressor.

What is claimed:

1. In a heat pump system using a condensible refrigerant, an improved evaporator-condenser device comprising:

- a. a pressure vessel;
- b. diffusion means placed across the cross section of said chamber intermediate the ends thereof to block direct flow of liquid refrigerant to the compressor and also to circumferentially distribute the flow of gaseous refrigerant, said diffusion means forming two chambers, a first liquid chamber, and a second gas chamber;
- c. at least one helical coil of pipe comprising at least one layer of turns adjacent the outer wall of said vessel in said first chamber for passage of heat transfer liquid, and means to flow said liquid through said pipe;
- d. first pipe means for the passage of liquid refrigerant inserted into said first chamber of said vessel near a first end thereof; and
- e. second pipe means for passage of gaseous refrigerant inserted into said second chamber of said vessel near the second end thereof.

2. The evaporator-condenser as in claim 1 in which said first and second pipes are larger than capillary pipes.

3. The evaporator-condenser as in claim 1 in which said first pipe is a capillary and said second pipe is larger than capillary size.

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4. The evaporator-condenser as in claim 1 in which the axis of said vessel is vertical and said diffusion means has apertures completely around its periphery.

5. The evaporator-condenser as in claim 1 in which the axis of said vessel is horizontal.

6. The evaporator-condenser as in claim 5 in which said diffusion means has apertures extending only

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around part of its periphery.

7. The evaporator-condenser as in claim 1 in which
said helical coil of pipe is constructed with the surface
of said pipe knurled to form a plurality of small pyrami-
dal surfaces, including at the apices of said pyramids a
plurality of sharp points.

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