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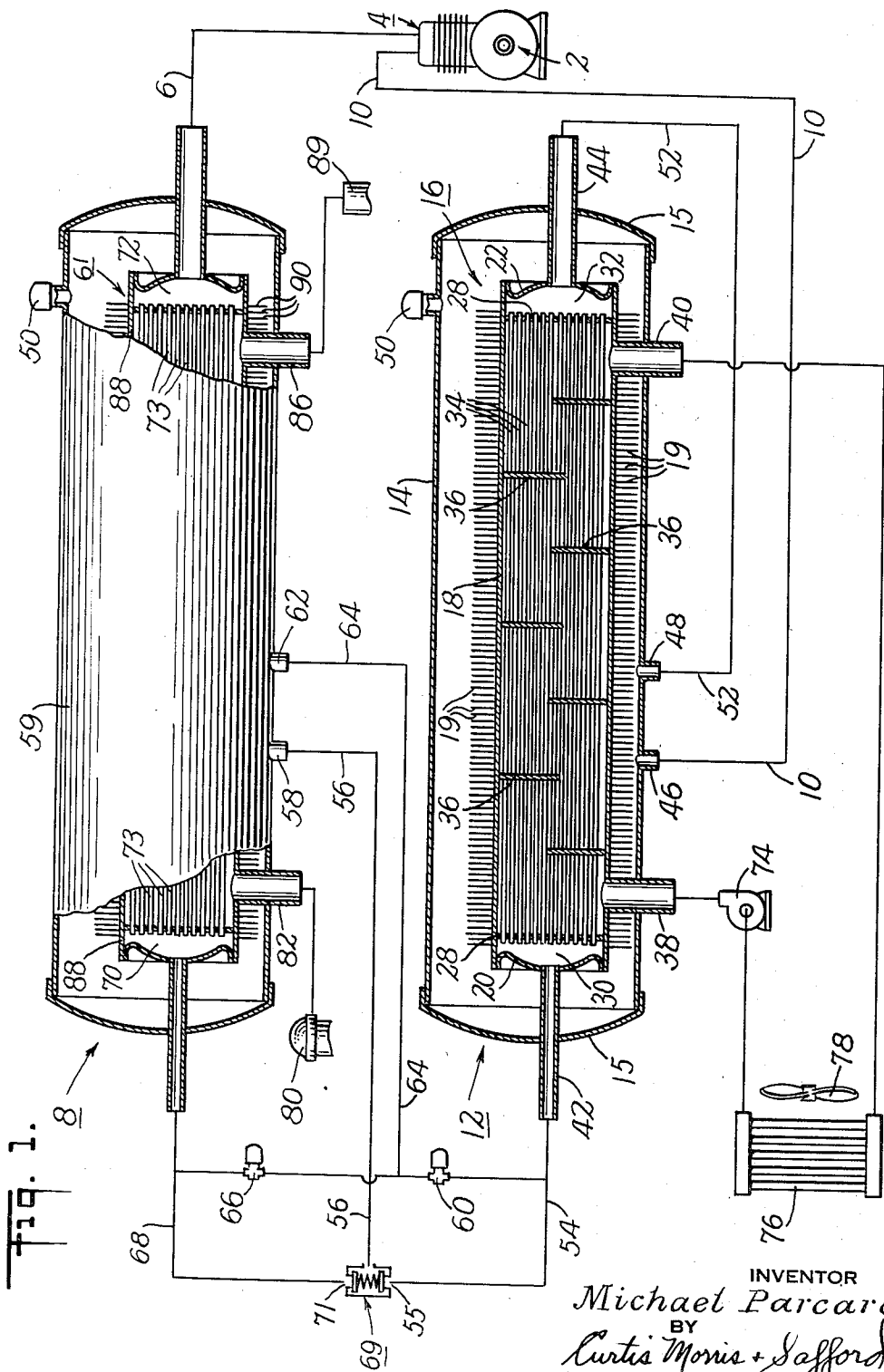
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REFRIGERATION AND AIR CONDITIONING

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Fig. 2.

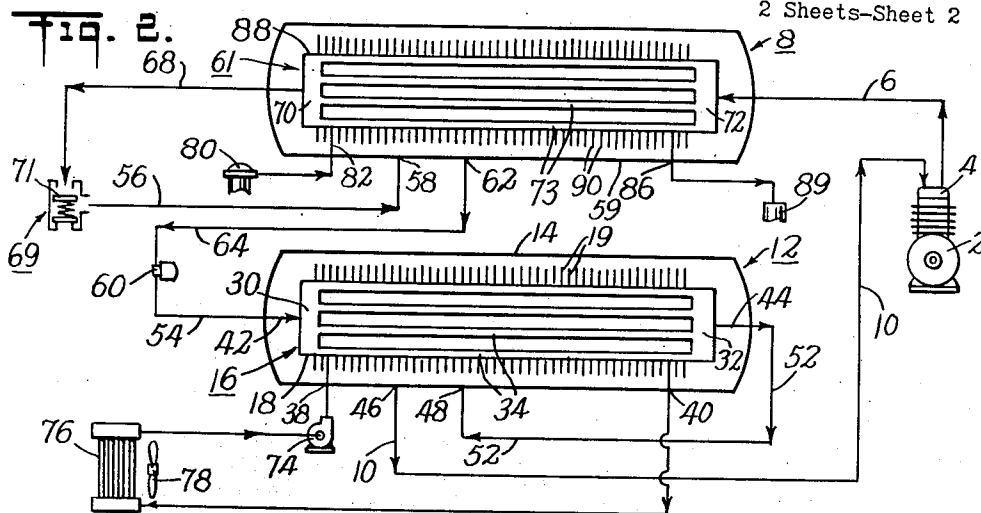


Fig. 3.

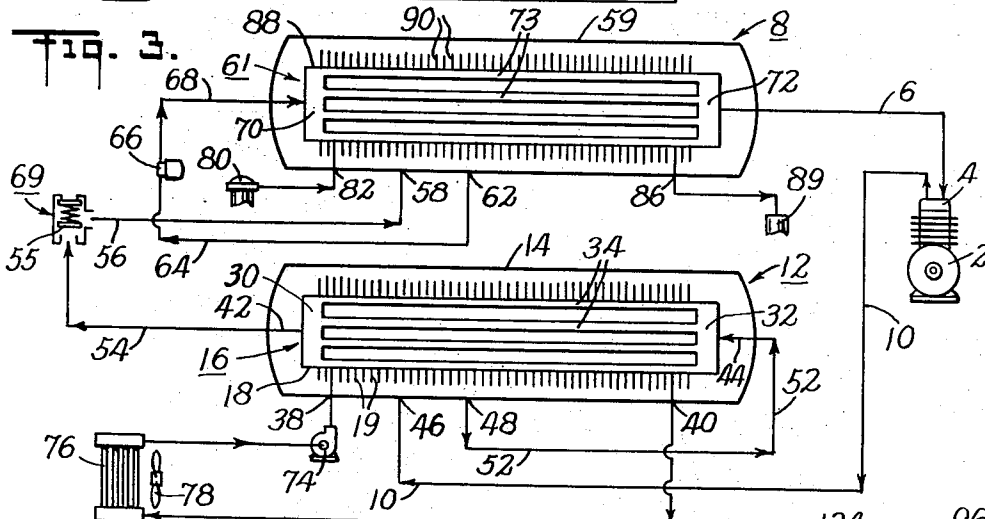
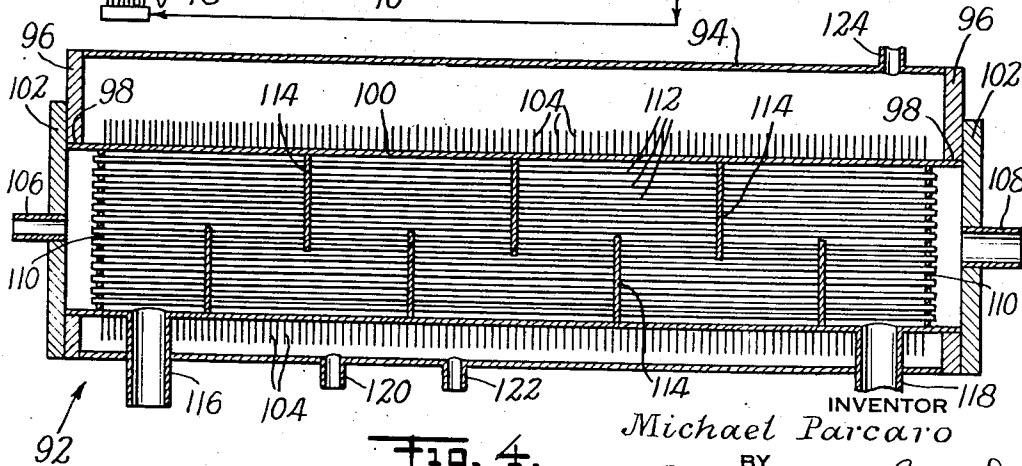


Fig. 4.

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REFRIGERATION AND AIR CONDITIONING

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4 Claims. (Cl. 62—115)

This invention relates to refrigeration, and more in particular to systems which include two heat interchange units, each of which provides for the efficient transfer of heat between refrigerant and a stream of liquid, such as water.

An object of this invention is to provide improved refrigeration systems. Another object is to provide improved air conditioning and heat pump systems. A further and additional object is to provide improved water chilling and water heating systems. A further object is to provide a heat interchange unit which is adapted for a variety of uses and which provides for improved heat transfer between refrigerant and a flowing stream of liquid, such as water. A further object is to provide for the above with structure which is simple and compact in construction, easy to manufacture, light in weight, and which is adaptable to many conditions of operation and use. These and other objects are in part obvious and in part pointed out below.

In the drawings:

Figure 1 is a partially schematic representation of an air conditioning system constituting one embodiment of the invention, and showing unique units of the system in section;

Figures 2 and 3 are further simplified representations of the system of Figure 1, representing the operation respectively as a cooling system and as a heating system; and

Figure 4 is a sectional view of a heat interchange unit embodiment of the invention.

Referring to Figure 1 of the drawings, a motor compressor 2 has an integral reversing valve 4. A refrigerant gas line 6 extends from valve 4 to the central refrigerant gas circuit of a heat interchange unit 8, and another refrigerant gas line 10 extends to the outer shell of a similar heat interchange unit 12. Units 8 and 12 are identical in construction, and unit 12 only will be described in detail.

Unit 12 has an outer cylindrical shell 14 which has end bells 15, and which encloses an internal shell and tube unit 16. Unit 16 has a cylindrical shell 18 which has external fins 19, and has its ends closed by a pair of end bells 20 and 22. These end bells are positioned within and welded to the respective ends of shell 18. Positioned in the shell and spaced respectively from the end bells are two header plates 28 which form headers 30 and 32 in the ends of shell 18. Mounted between headers 30 and 32 in the header plates is a set of tubes 34 through which refrigerant flows from one header to the other in heat interchange relationship with water on the outside of the tubes. A set of staggered baffles 36 extend alternately from the top and bottom of shell 18 to increase the flow path of the water between a water inlet pipe 38 at the left and a water outlet pipe 40 at the right.

The left-hand header 30 of unit 16 has a connecting tube 42 which extends through the end bell of the outer shell 14, and header 32 has a similar connecting tube

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44 extending through the other end bell of the shell. At the bottom of shell 14 there are two refrigerant connections 46 and 48, and at the top of the shell, there is a safety valve 50.

Line 10 extends to connection 46, thus to provide for the flow of refrigerant between the compressor and shell 14, and connection 48 is connected by a line 52 to tube 44. Tube 42 is connected through a line 54 to a check valve 55 which permits refrigerant flow through it only to the right to a line 56. Line 56 extends to a connection 58 in the outer shell 59 of unit 8. Shell 59 encloses an internal shell and tube unit 61. Line 54 also extends to an expansion valve 60 which is operative only when refrigerant is flowing into unit 12 through pipe 42.

The outer shell of unit 8 is also connected at 62 through a line 64 and an expansion valve 66 to a line 68 which extends to the left-hand header 70 of unit 8. Line 68 is also connected to a check valve 71 which permits flow to the right only from line 68 to line 56. The right-hand header 72 of unit 8 is connected to the line 6 referred to above, and thence to the reversing valve 4 of the compressor. In the illustrative embodiment, check valves 55 and 71 are in the form of a uniting valve assembly 73.

In this embodiment, the system is intended to be operated to cool air with unit 12 acting as an evaporator and unit 8 acting as a condenser; or the system may be operated as a heat pump with unit 12 acting as a condenser and unit 8 acting as an evaporator. The cooling or heating function is performed by either cooling or heating a stream of water flowing through the shell 18, entering at pipe 38 and leaving at pipe 40. This water is circulated by a pump 74 through an air coil 76, and there is a fan 78 which directs air through this coil, thus to cool or heat the air.

Illustratively, a stream of water from a well acts to carry away heat during cooling operations, and also as the source of heat during heating operations. The water is drawn from the well by a pump 80 and is directed through connection 82 into the inner shell 88 of unit 8. The water is discharged from shell 88 at 86 and passes to a diffusion well 89.

Assuming that the system just described is being used as a cooling system, that is, to cool a conditioned space, the operation is represented schematically in Figure 2. The air passing through the space is blown through coil 76 and is cooled by cold water flowing through the coil. This water is circulated by pump 74 through the coil and thence through a water path of the heat interchange unit 12 where it is cooled. That is, the water passes in at 38 and through the shell 18 past the tubes 34, and the cold water passes from the shell at 40 and flows back to the cooling coil 76.

At this time, unit 12 is acting as an evaporator, receiving liquid refrigerant from shell 59 of unit 8 through line 64, expansion valve 60, and line 54. The liquid refrigerant enters unit 12 through pipe 42 and it flows through header 30 and through the bank of tubes 34 to header 32. The refrigerant then flows through tube 44 and line 52 to shell 14, and it is withdrawn from shell 14 at 46 through line 10 and passes back to the compressor. The major portion of the refrigerant is evaporated in tubes 34 and therefore the refrigerant is mainly in gaseous form at the time that it passes into shell 14. However, the refrigerant which has not evaporated in the tubes is evaporated in the shell, and no liquid refrigerant passes back to the compressor. The fins 19 on the exterior of shell 18 provide heat transfer between the refrigerant in shell 14 and the water being cooled in shell 18.

During the cooling operation, the compressed refrigerant is discharged through line 6 to header 72 of unit 8,

and it passes from header 72 through tubes 73 to header 70. Unit 8 is at this time acting as a condenser with the well water flowing therethrough as described above from the well pump 80 through the shell 88 and from the shell at 86 to the diffusion well 89.

The refrigerant in completely or partially condensed condition flows from tubes 73 to header 70, and thence through line 68 and check valve 71 to line 56. From line 56 the refrigerant flows through connection 58 into shell 59 of unit 8 around shell 84 and its fins 90. Here the refrigerant is further cooled so as to condense any remaining refrigerant gas, and also to sub-cool the liquid refrigerant. Shell 59 also acts as a receiver from which the refrigerant flows as described above through connection 62, line 64 and expansion valve 60 to unit 12. It is thus seen that the system acts efficiently with assurance that the refrigerant is condensed and thoroughly pre-cooled prior to passage through the expansion valve, and with the assurance that liquid refrigerant will not return to the compressor.

When it is desirable to operate this system as a heat pump, valve 4 is merely reversed so as to deliver the compressed gas to line 10 and so as to draw refrigerant from line 6. The flow then is as represented in Figure 3, and is generally in the reverse direction to that described above, with unit 12 acting as a condenser, and with unit 8 acting as an evaporator. During such heat pump operation the air is blown through coil 76 by fan 78 to the conditioned space as explained above for the cooling operation, but the water is heated at unit 12 and is circulated through the coil.

The hot refrigerant gas flows through line 10 and connection 46 into shell 14 where it is partially condensed by the action of the water being circulated through shell 18. The refrigerant then flows through connection 48 and line 52 to tube 44 through which it enters header 32 and it flows to the left through tubes 34 to header 30. The refrigerant at this time is completely condensed, and it flows through tube 42 and line 54 to check valve 55, and through this check valve to line 56. The refrigerant then flows through line 56 to shell 59 of unit 8, and shell 59 acts as a receiver for the liquid refrigerant. The liquid refrigerant then flows from shell 59 through connection 62 and line 64 to expansion valve 66, and it flows through the expansion valve and line 68 to header 70. The refrigerant evaporates as it flows to the right through tubes 73 to header 72, and it is drawn back to the compressor through line 6. During this time, the well water is pumped through unit 8 as described above, and it provides the heat as the refrigerant evaporates. Thus, the well water acts as the source of heat.

The change-over from cooling to heating, or from heating to cooling, involves only the reversing of valve 4. The remainder of the refrigerant valves are unchanged, and the water and air circuits are unchanged. However, the setting of the controls for cooling may be different from those for heating.

With this system, it should be noted that the two units 8 and 12 are identical and yet each unit is used efficiently at all times. With the system operating for heating, the entire unit 12 acts as the condenser with shell 59 of unit 8 being the receiver, and the internal unit 61 only acts as the evaporator, whereas, for cooling the entire unit 12 acts as the evaporator and the entire unit 8 acts as the condenser and the receiver. This insures proper performance for a wide range of load conditions. That is, the well water temperature is fairly constant and its unit 8 is designed to handle the heat transfer to and from the well water for the design load conditions. But the heating and cooling loads vary over wide ranges, and this system insures the handling of the heat transfer to and from the air with maximum efficiency and without danger of liquid returning to the compressor during cooling.

Under some circumstances, the two check valves 55 and

71 in the system of Figure 1 are not used, but a three-way valve is used with suitable lines and this valve is operated when valve 4 is reversed. In domestic air conditioning systems utilizing the invention, the hot refrigerant gas may pass through a coil in a water tank to provide hot water for household use.

Figure 4 is a cross-sectional view of a second heat interchange unit 92 embodying features of the invention. This unit can be substituted for either or both of units 8 and 12 but has certain structural differences therefrom. It consists of an outer shell 94 closed at each end by plates 96 and 102. An inner shell 100 is supported at each end in an opening 98 in plate 96. This shell has fins 104 spaced along its outside. Header plates 110 support tubes 112 within shell 100 and baffles 114 lengthen the path of water flow between inlet pipe 116 and outlet pipe 118. Tubes 106 and 108 through plates 102 permit refrigerant to flow through pipes 112. Connections 120, 122 and 124 permit fluid flow between shell 94 and shell 100.

Units such as 8, 12 and 92 are adapted for various uses other than those discussed above; for example, in water-to-water heat pumps or in water chillers. These may be of the so-called "package type" with which one stream of water is used as the heat source or the heat "sink," and another stream of water is directed through a cooling circuit to a point of utilization.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a refrigeration system, a pair of substantially similar heat interchange units each of which has an internal shell and tube unit enclosed within an outer shell with there being space around the shell and tube unit and with the shell and tube unit having parallel refrigerant tubes extending between a pair of headers at the ends of the unit and with there being a water flow path for water externally of the tubes and in contact therewith, a compressor, refrigerant lines connecting the high pressure refrigerant gas from said compressor to the header of one of said heat interchange units and from the other header to the outer shell of that heat interchange unit, means constituting water supply directing a stream of water through the flow circuit of that heat interchange unit whereby the refrigerant is condensed, refrigerant line and restrictor means connected to permit the flow of liquid refrigerant from the outer shell of the last-named heat interchange unit to one header of the other heat exchange unit whereby refrigerant is delivered to said header at a reduced pressure during operation, a refrigerant line connecting the other header of the last-named heat exchange unit to the outer shell thereof, a refrigerant line connecting the outer shell of the last-named heat interchange unit to the refrigerant suction inlet of said compressor, and means to circulate water through the flow circuit of the last-named heat interchange unit for the cooling of the water.

2. Apparatus as described in claim 1, wherein each of said interchange units has fins upon the outer surface of said tube and shell unit.

3. A system as described in claim 1 which includes, means to reverse the refrigerant lines connected to said compressor whereby the compressed refrigerant gas is delivered to the second-mentioned heat interchanger and refrigerant is withdrawn from the first-named heat interchanger, and valve means connecting the outer shell and the header and tube circuit of the second-mentioned heat interchange unit in series to act as a condenser and to the outer shell of the first-mentioned heat interchange unit to act as a receiver, said system also including an expan-

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sion valve through which refrigerant flows from the outer shell to the header and tube circuit of the first-mentioned heat interchange unit.

4. In a refrigeration system, a first heat interchange unit having an internal shell and tube unit enclosed within an outer shell with there being space around the shell and tube unit and with the shell and tube unit having parallel refrigerant tubes extending between a pair of headers at the ends of the unit and with there being a water flow path for water externally of the tubes and in contact therewith, a second heat interchange unit having a pair of headers and an outer shell for refrigerant and a water flow circuit, a compressor, refrigerant lines connecting the high pressure refrigerant gas from said compressor to the header of said first heat interchange unit and from the other header to the outer shell of that heat interchange unit, means constituting water supply directing a stream of water through the flow circuit of said first heat interchange unit whereby the refrigerant is con-

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densed, refrigerant line and restrictor means connected to permit the flow of liquid refrigerant from the outer shell of the said first heat interchange unit to one header of said second heat exchange unit whereby refrigerant is delivered to said header at a reduced pressure during operation, a refrigerant line connecting the other header of said second heat exchange unit to the outer shell thereof, a refrigerant line connecting the other header of said second heat exchange unit to the outer shell thereof, a refrigerant line connecting the outer shell of said second heat interchange unit to the refrigerant suction inlet of said compressor, and means to circulate water through the water flow circuit of said second heat interchange unit for the cooling of the water.

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