July 2, 1957 W. J. DONOVAN 2,797,554

HEAT EXCHANGER IN REFRIGERATION SYSTEM

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Fig. 1.

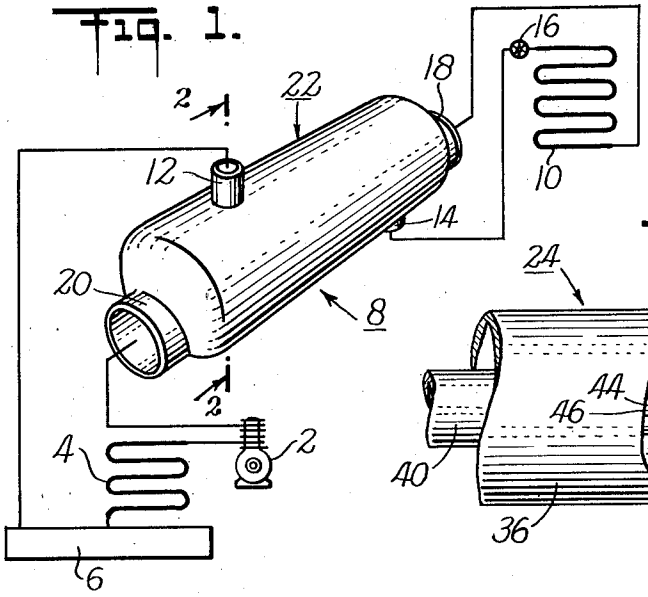


Fig. 3.

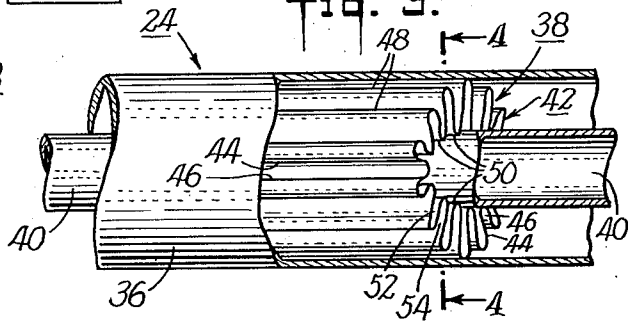


Fig. 2.

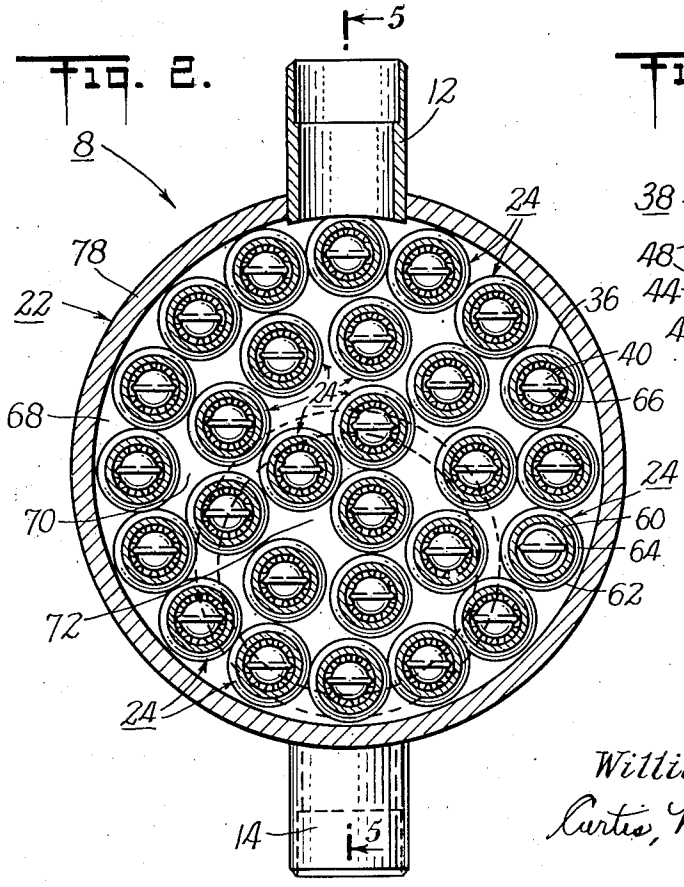
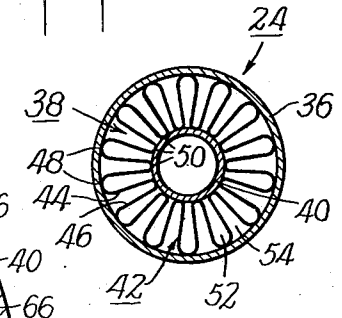


Fig. 4.



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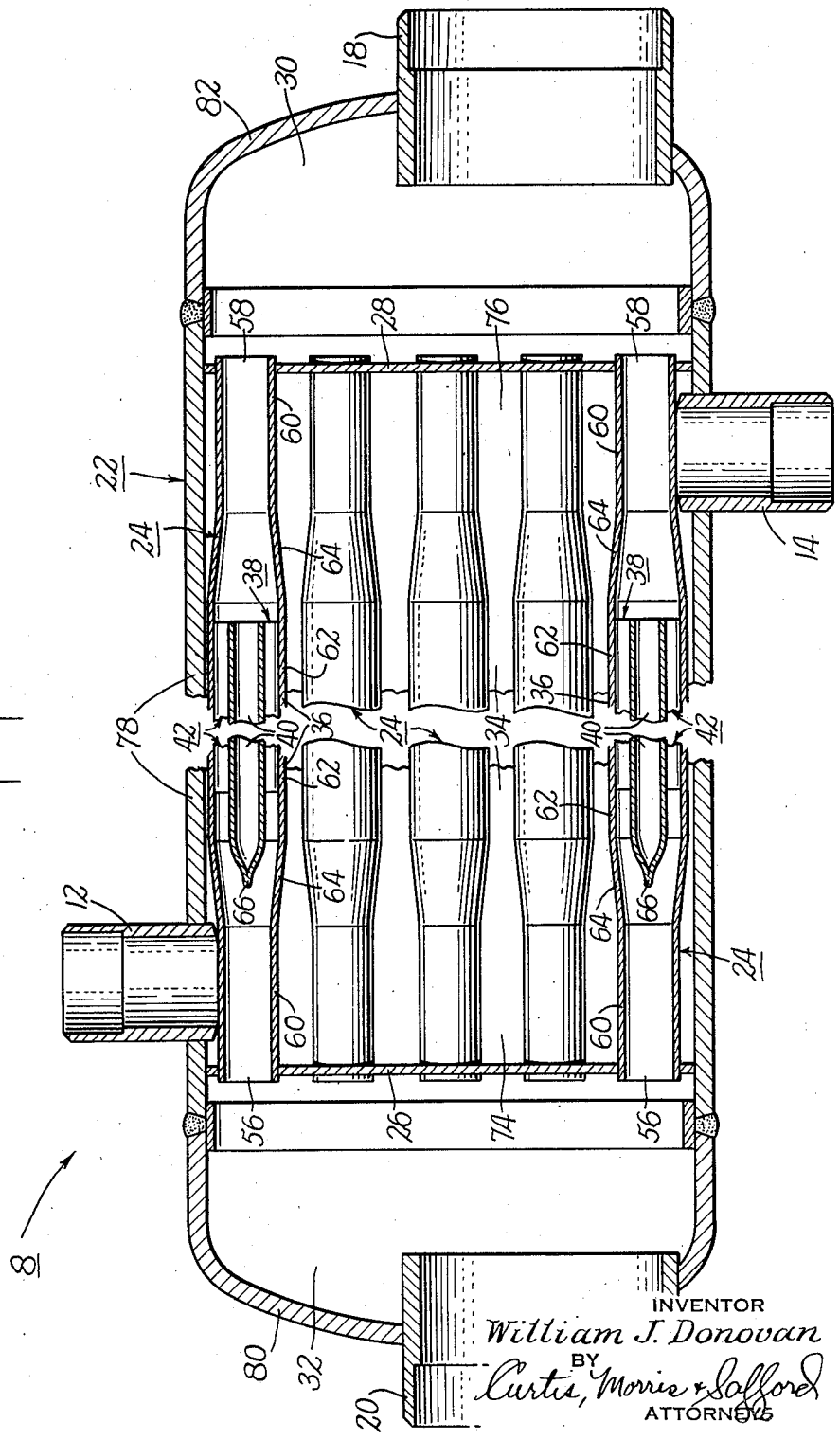


FIG. 5.

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HEAT EXCHANGER IN REFRIGERATION SYSTEM

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7 Claims. (Cl. 62—117.55)

This invention relates to refrigeration systems and components of the type used therein, and more in particular to improved heat-interchange equipment and operation, illustratively, so that the gas refrigerant flowing from the evaporator is passed into heat-interchange relationship with the liquid refrigerant flowing to the evaporator.

An object of this invention is to provide for the improved operation of refrigeration systems. A further object is to provide improved heat-interchange apparatus. Another object is to provide a unit for passing liquid refrigerant in heat interchange relationship with gas refrigerant without the difficulties which have been encountered with prior equpment for accomplishing the same purposes. A further object is to provide for the above with a structure which is light in weight and sturdy, and which is efficient in operation. These and other objects will be in part obvious and in part pointed out below.

In the drawings:

Figure 1 is a view showing the heat interchange unit in perspective, but representing the remainder of the system schematically;

Figure 2 is an enlarged sectional view on the line 2—2 of Figure 1;

Figure 3 is a fragmentary view with parts broken away of one of the individual heat-interchange assemblies of the unit of Figure 2;

Figure 4 is a sectional view on the line 4—4 of Figure 3; and,

Figure 5 is a sectional view on the line 5—5 of Figure 2.

Referring to Figure 1 of the drawings, a low temperature refrigeration system is represented schematically and in somewhat simplified form, with a motor-compressor 2, a condenser 4, a receiver 6, a heat interchange unit 8, an evaporator 10, interconnecting refrigerant lines, and controls. During operation, the refrigerant is compressed in condenser 2 and condensed in condenser 4, and the liquid refrigerant flows to receiver 6. From receiver 6 the liquid refrigerant passes to the liquid inlet connection 12 of unit 8 and passes through this unit and out through the liquid outlet connection 14 and through an expansion valve 16 to the evaporator 10. The gaseous refrigerant with accompanying oil flows to the gas inlet connection 18 of unit 8, and through the unit and out through the gas outlet connection 20 from which it returns to the compressor.

Unit 8 is formed by a cylindrical steel shell 22 having the connections referred to above, and no other openings. Referring to Figures 2 and 5, shell 22 encloses twenty-seven individual tube assemblies 24 which are rigidly mounted at their ends (Figure 5) in a pair of end plates or partitions 26 and 28. These partitions are welded to the surrounding wall of shell 22, and each of the tubes extends through each of the plates and is welded thereto. Hence, the partitions divide the space within the shell into a right-hand header 30, a left-hand header 32, and a central space 34 which is mainly occupied by the tubes 24.

Each of the tube assemblies 24 is formed of an outer tube 36 and an enclosed cylindrical fin assembly 38. The fin assembly is shown best in Figure 3 and 4 and comprises a fin structure 42 wound around a central tube 40. The fin structure 42 comprises a series of substantially flat radial fin portions 44 and 46 interconnected at the inner

surface of tube 36 by bends 48 and interconnected at the outer surface of tube 40 by bends 50. During manufacture, the fin structure is formed by bending or corrugating a flat strip of sheet metal thus to form a strip which is corrugated by an angle to its side edges. This corrugated strip is wound around tube 40, and the strip and tube are inserted into the outer tube 36. The inner tube 40 is then expanded so as to place the fin structure under radial compression and this insures high heat conductivity between the entire fin assembly and the outer tube 36. The inner U-bends 50 on the fin structure are of smaller radius than the U-bends 48 and this provides alternate passageways 52 and 54 between the fin elements which differ in cross-sectional configuration, but which are of similar fluid-carrying capacity.

Referring now again to Figure 5, each of the tubes 36 has its ends 56 and 58 extending beyond the ends of the enclosed fin assembly. Each of these tube ends has a cylindrical end portion 60 which is of substantially lesser diameter than the diameter of the central portion 62 of the tube. The end portions 60 are connected to the central portion 62 of the tube by tapered portions 64. The end of each of the central tubes 40 (at the left in Figure 5) is closed at 66 by pinching the end of the tube together after the tube assembly has been completed. This prevents the fluid from flowing through the central passageway in each tube 40 so that the flow is only in the annular passageway occupied by the fin structure 42. This insures a rapid flow of the fluid and the fluid is distributed between the various passageways 52 and 54. The proper distribution of the fluid is insured by the reduced diameter ends 58 and 56 of the tube 36.

The refrigerant gas entering header 30 from inlet connection 18 tends to distribute itself evenly as it flows to the left into the tube ends 60. At the left of these tube ends, the gradual increasing diameter permits the fluid to flow radially outwardly in an evenly distributed annular stream into the ends of passageways 52 and 54. This flow is promoted by the stoppage of flow through the central tube 40 and yet there is no mechanical obstruction to the flow which would tend to cause eddy currents and cavitation. At the left-hand end of the fin assembly the fluid flows a somewhat annular passageway at the end of the central tube 40, and the fluid then forms into a cylindrical stream and passes into header 32 from which it is discharged through outlet connection 20. The flow through the tube assemblies is at a substantial velocity and yet the resistance to flow is not excessive. Furthermore, oil which accompanies the refrigerant gas is not trapped and it does not form in films upon the heat transfer surfaces.

It has been indicated above that the liquid refrigerant enters the tube shell 22 through the liquid inlet connection 12 and it flows from the shell at the bottom through the liquid outlet connection 14. As shown best in Figure 2, the central portions 62 of the tubes 36 are substantially in contact with each other, but the cylindrical shape of the tubes provides longitudinal passageways 68, 70 and 72 of somewhat regular patterns through which the liquid flows along the tube assemblies. However, at the ends of the tube assemblies the reduced diameter tube ends 60 provide liquid headers or header zones 72 and 76 (see Figure 5). Hence, the liquid entering at 12 to the header zone 74 flows freely around the tube ends 60 and distributes itself evenly with minimum resistance to flow. It then enters the pasageways 68, 70 and 72 and flows in somewhat thin streams and at an even rate along the tube assemblies to the right hand header zone 76 to the outlet 14.

The central space 34 within the shell is formed by the inlet header zone at the left, the longitudinal passageways 68, 70 and 72, and the right-hand outlet header zone 76.

The cylindrical confining wall of shell **22** and the tapered portions of the tubes **64** insure against pockets, eddy currents and cavitation, and there is a smooth even flow with minimum resistance and flash gas does not appear. It is thus seen that the liquid is cooled and the gas is heated in an efficient and dependable manner. The substantial fin surfaces along which the gas flows, and the creation of thin even streams of gas flowing at a rapid rate, insures good heat conductivity between the gas and the fin structures. It has been indicated above that the fin structures are in good heat-conductive relationship with their tubes **36** and the liquid on the outer surface of the tubes picks up the heat in an efficient manner.

The manner of fabricating the fin and tube assemblies has been discussed somewhat above and reference may be had to the co-pending application to Cecil Boling, Serial No. 310,820, filed September 22, 1952, where there is a further disclosure. After the fin assembly and its central tube **40** have been properly positioned in the outer tube and the central tube has been expanded, the end of the central tube is pinched together. The ends of the tube **36** are "spun" to form the reduced ends **60** and the tapered portions **64**. The tubes are then assembled within the end plates **26** and **28** and each tube end is brazed to its end plate. This entire tube and end plate assembly is placed into the central cylindrical portion **78** of shell **22** and end bells **80** and **82** are welded in place as shown. The liquid inlet and outlet connections **12** and **14** are also welded in place at this time.

I claim:

1. In refrigeration apparatus, a heat interchanger which comprises, a shell construction having a central chamber and a pair of headers positioned adjacent thereto, partition means separating said headers from said central chamber, a plurality of tube assemblies each rigidly mounted on said partition means with its respective ends opening into said headers whereby each tube assembly provides a passageway between said headers, each of said tube assemblies having its central portion contacting the corresponding portions of a plurality of the other tube assemblies thus to form cooperating walls of fluid passageways extending longitudinally along the outer surfaces of said tube assemblies, each of said tube assemblies having ends of reduced cross-section and spaced from the respective ends of the adjacent tube assemblies whereby a header zone is provided in said shell at each end of said tube assemblies, each of said tube assemblies including an internal fin assembly which provides for a heat interchange relationship between one fluid passing through said tube assemblies and another fluid passing through said central chamber in said shell externally of said tube assemblies, means to deliver a gas to one of said headers and to withdraw the gas from the other of said headers, and means to deliver a liquid to one of said header zones at one end of said central chamber in said shell and to withdraw a liquid from the other of said header zones.

2. In a refrigeration system which includes a compressor and a condenser and an evaporator, a heat interchanger having a central chamber connected in the system between said condenser and said evaporator and having a pair of gas headers connected in said system between said evaporator and said compressor comprising, a cylindrical shell having said gas headers at its opposite ends and having said chamber positioned between said headers, a pair of partitions dividing said central chamber from said gas headers, and a plurality of tube assemblies extending longitudinally of said shell and each rigidly mounted at its respective ends in said partitions with each tube end opening into one of said gas headers whereby the gas circuit is provided through said tube assemblies between said gas headers, each of said tube assemblies having its ends of reduced cross-section whereby there is substantially more space within said shell and outside of said tube assemblies adjacent said partitions than there is in the central portions of said tube assemblies whereby header zones are provided within said central chamber adjacent said partitions, fluid inlet and outlet connections to said shell at said header zones formed by the reduced ends of said tubes at opposite ends of said chamber, each of said tube assemblies including a fin assembly positioned in its central portion between said ends to increase the heat interchange relationship.

3. In a refrigeration system having separate paths of flow for a refrigerant, a heat interchange unit connected in said separate paths of flow comprising, a cylindrical shell, a pair of partitions mounted substantially in the ends of said shell, a pair of end bells positioned respectively at the ends of said shell and providing headers, and a plurality of tube assemblies extending longitudinal of said shell and mounted by their ends respectively in said partitions with each tube open at its ends to said headers and providing a fluid passageway between said headers, each of said tube assemblies having ends of lesser cross-section than its central portion and said central portions cooperating to provide longitudinal passageways along said tube assemblies between a pair of header zones formed respectively adjacent said partitions by the space between the ends of said tube assemblies, and fluid inlet and outlet connections to said shell at said header zones formed by the reduced ends of said tubes whereby to provide a uniform flow in thin streams over a large surface area at the exterior of the tubes.

4. Apparatus as described in claim 3 wherein each of said tube assemblies contacts a plurality of other tube assemblies substantially throughout its length except at said ends.

5. A heat interchange unit as described in claim 4 wherein each of said tube assemblies comprises a sheet metal fin structure at the central portions formed by substantially radially extending fin elements interconnected by U-bends, and a central element presenting a cylindrical surface and holding said fin elements in radial compression.

6. A heat interchange unit as described in claim 5 wherein said central element comprises a metal tube, and means closing said tube to flow of fluid therethrough.

7. In a refrigeration system having a compressor, a condenser and an evaporator connected in a refrigerating circuit, the combination with said system of a heat exchanger in said refrigerating circuit having separate countercurrent paths of flow for refrigerant flowing from the condenser to the evaporator and from the evaporator to the compressor comprising, a closed shell, a pair of transverse partitions adjacent the respective ends, and tubes extending between said partitions to provide one path of flow through said tubes, each of said tubes having an intermediate portion and end portions of reduced diameter extending from the intermediate portions outwardly to said partitions, said intermediate portions of said tubes contacting at least one adjacent tube tangentially to provide restricted passages therebetween, said shell having inlet and outlet openings at said reduced end portions of said tubes adjacent the opposite ends thereof and together with the restricted passages between the intermediate portions of the tubes providing the other path of flow.

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