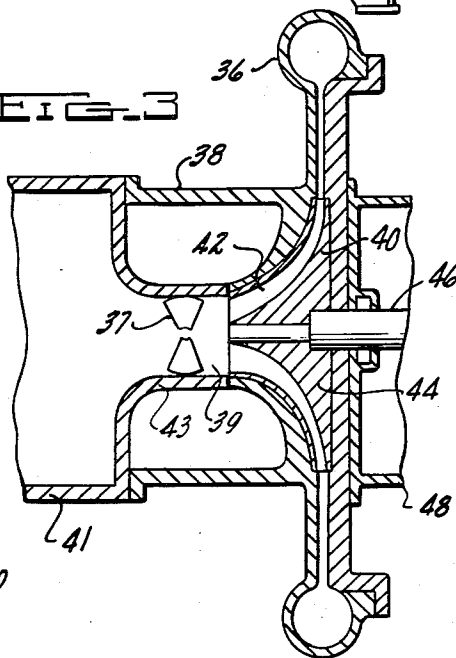


**3,118,290**

2 Sheets-Sheet 1



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Jan. 21, 1964

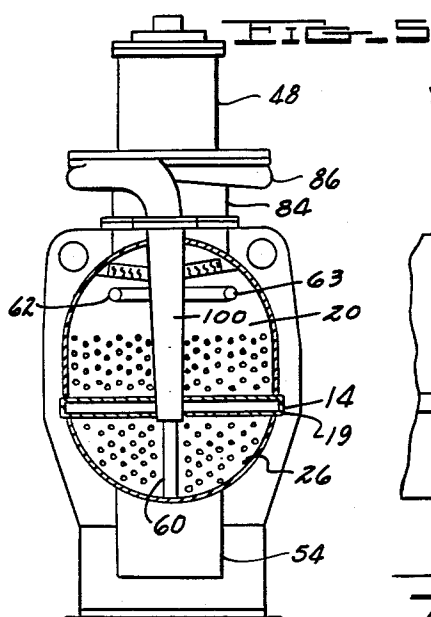
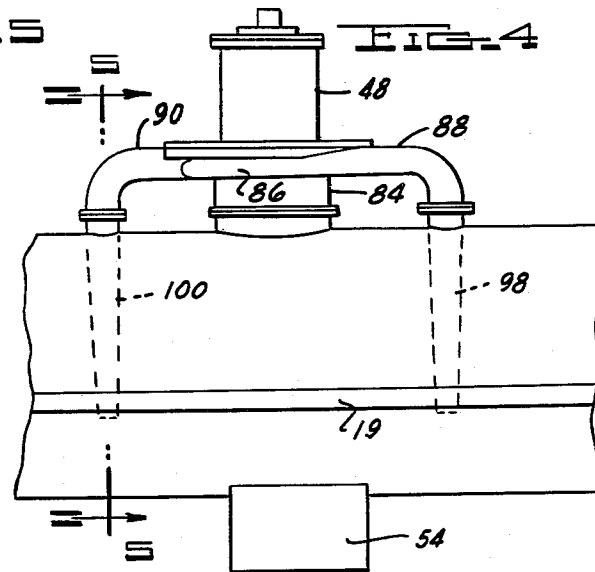
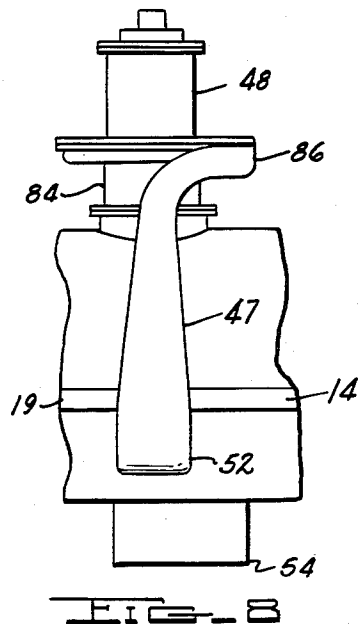
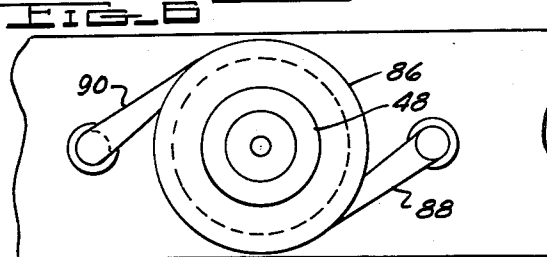
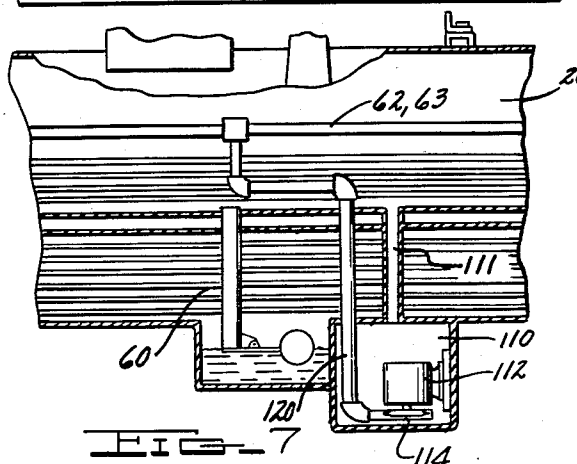
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3,118,290

REFRIGERATION MACHINE INCLUDING EVAPORATOR CONDENSER STRUCTURE

Filed Sept. 2, 1960

2 Sheets-Sheet 2



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3,118,290

## REFRIGERATION MACHINE INCLUDING EVAPORATOR CONDENSER STRUCTURE

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Filed Sept. 2, 1960, Ser. No. 53,747  
8 Claims. (Cl. 62-506)

This invention relates to refrigeration machines, and particularly to refrigeration machines of the "tube-shell" type, i.e. the type wherein the evaporator and condenser are constructed as relatively large elongated shell structures with heat transfer tubes extending therethrough.

Conventionally refrigeration machines of this type have been constructed with the evaporator built as one shell and with the condenser built as a second shell separately from the first shell. The energy level of the refrigerant is restored through the use of a refrigerant compressor means, and in most cases the compressor means has been located separately from the condenser shell and evaporator. The nature of the conventional apparatus is such as to require considerable floor space and relatively high installation cost. Additionally the conventional constructions are such as to require a relatively high fabrication cost with the utilization of much piping and refrigerant conduit mechanisms. The use of such conventional conduit mechanisms and the conventionally designed evaporators and condensers is such that in many cases the efficiency of the refrigeration process is impaired.

It is a general object of the present invention to provide an improved refrigeration machine having desired features of low cost, simplified construction, simplified installation, reduced size, and floor space requirements, and improved refrigerant action.

A further object of the invention is to provide a refrigeration machine wherein the condenser and compressor sections are disposed closely adjacent one another in a single shell structure.

An additional object is to provide a refrigeration machine wherein the compressor means is disposed atop the evaporator section in compact relation thereto.

Another object of the invention is to provide a refrigeration machine wherein the evaporator and condenser are disposed closely adjacent to one another, but wherein the evaporator and condenser are effectively isolated from the one another in a heat transfer sense.

Another object of the invention is to provide a refrigeration machine having relatively short paths for flow of refrigerant between the compressor, condenser, and evaporator.

A still further object of the invention is to provide a refrigeration machine wherein the evaporator heat transfer tubes are so arranged with respect to the flow of refrigerant as to permit relatively uniform distribution of refrigerant on the various tube surfaces.

An additional object of the invention is to provide a refrigeration machine wherein the evaporator heat transfer tubes may be disposed in position with respect to refrigerant distributing nozzles so that refrigerant may be sprayed relatively uniformly onto all of the various tube surfaces.

A still further object of the invention is to provide a refrigeration machine wherein the evaporator and condenser are constructed as part of a single unitary pressure vessel so as to permit economization on the amount of materials required to form the vessel walls.

A still further object of the invention is to provide a refrigeration machine wherein a relatively small refrigerant pump can be utilized for pumping refrigerant to the evaporator, the arrangement being such as to provide im-

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proved operating features while eliminating the necessity for undesirably modifying the installation, as by providing a pit in the floor or raising the machine above the floor surface.

A still further object of the invention is to provide a refrigeration machine having an improved refrigerant circulation path therethrough.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIG. 1 is a sectional view through one embodiment of my invention taken substantially on line 1-1 in FIG. 2.

FIG. 2 is a sectional view taken substantially on line 2-2 in FIG. 1.

FIG. 3 is an enlarged sectional view taken substantially on line 3-3 in FIG. 1.

FIG. 4 is a fragmentary elevational view of a second embodiment of the invention.

FIG. 5 is a sectional view taken substantially on line 5-5 in FIG. 4.

FIG. 6 is a top plan view of the FIG. 4 structure.

FIG. 7 is a fragmentary sectional view through a third embodiment of the invention.

FIG. 8 is a fragmentary elevational view of a fourth embodiment of the invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to the drawings, and particularly FIGS. 1 through 3, there is disclosed a refrigeration machine 10 comprised in part of a horizontal elongated shell structure 12. As shown in FIG. 2 this shell structure is of generally elliptical cross-sectional configuration, with the major axis of the ellipse disposed vertically and with the minor axis thereof disposed horizontally. The shell structure is provided with a baffle or partition means indicated generally by numeral 14, said partition means in the illustrated embodiment taking the form of two parallel spaced plates 16 and 18 connected at their lateral edges by the vertical wall portions 17 and 19.

The space 20 above the partition means 14 constitutes an evaporator section, and the space 22 below the partition means constitutes a condenser section. Each of these sections has disposed therein a series of finned heat transfer tubes indicated in the drawings by the numbers 24 and 26. As shown in FIG. 1 the various tubes extend longitudinally through the shell so as to conduct fluid (such as water) between the two boxes indicated at 28 and 30. Each of these boxes is provided with a partition 32 to form the separate chambers 31 and 33. Suitable conduits (not shown) are connected to the boxes to permit circulation of heat transfer fluid, as for example water, through the tubes 24 and 26. It will be understood that in practice the fluid flowing through tubes 24 gives up heat to the refrigerant in space 20 so as to evaporate same, and that tubes 26 operate to extract heat from the refrigerant in space 22 so as to condense same.

In order to restore and raise the energy level of the refrigerant there is provided a compressor means indicated in FIG. 1 by the numeral 34. As illustrated in the drawings the compressor means includes a scroll-like casing structure 36 having a tubular extension 38 which mounts

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on an elbow-shaped duct 41. The duct 41 opens to space 29 and is provided with an extension 43 which defines an inlet eye 39 for impeller 40. The inlet eye is provided with the usual adjustable inlet vanes 37 for controlling the compressor output.

Power for rotating the impeller is obtained from a hermetically sealed electric motor 48 which may be water cooled or cooled by passing system refrigerant thereacross as shown in co-pending application, Serial No. 18,607, filed March 30, 1960.

Impeller 40 is provided with the usual vanes 42 extending from the conventional backwall 44, said backwall being suitably affixed to the driveshaft 46 which is directly driven from the electric motor 48. The weight of the motor and impeller is carried partially by duct 41 and partially by an upstanding bracket 49 suitably supported by shell structure 12.

Compressor scroll 36 connects with a discharge duct 47 which, as shown in FIG. 2, leads downwardly and then inwardly as at 52 to make connection with the condenser space 22. By this arrangement the compressed gaseous refrigerant is fed over the condenser tubes 26 so as to give up heat to the heat exchange fluid within tubes 26 and thereby be condensed. The condensed refrigerant collects in the lower portion of the condenser section and flows into the collector indicated generally by numeral 54. The liquid level in collector 54 is maintained at a satisfactory value by means of the valve 56 and connected float 58. As shown in FIG. 1 the valve 56 is mounted to open and close the conduit 60 which extends upwardly from collector 54 and through partition means 14 into the evaporation space 20. The upper end of conduit 60 connects with a cross pipe 61 and two elongated horizontal conduits 62 and 63 which extend lengthwise of the evaporator section 20. These conduits 62 and 63 carry nozzles 66 at spaced points therealong for spraying liquid refrigerant downwardly onto the evaporator tubes 24 as shown in FIG. 2. Preferably the nozzles 66 are of adjustable orifice size so as to enable an even spray pattern in all areas of the evaporator section irrespective of pressure differences due to the character of the conduit arrangement.

It will be seen from FIG. 2 that the evaporator tubes 24 are arranged in a horizontal tube bundle of generally rectangular configuration. The rectangular nature of the tube bundle is made possible by the generally elliptical cross section of shell 12. With the illustrated tube bundle configuration the tubes 24 are arranged in vertical, horizontally spaced rows, each vertical row having the same number of tubes therein. The number of tubes in each vertical row is relatively small so as to promote surface wetting of all tubes. By the illustrated arrangement the refrigerant is enabled to better wet the outer surfaces of all tubes so as to promote heat transfer from the refrigerant to the heat exchange fluid.

In a conventional evaporator section constructed in a cylindrical shell structure separate from the condenser section, the evaporator vertical tube rows are irregular in number, i.e., the vertical rows near the outer surfaces of the shell have very few tubes therein whereas the vertical rows near the center portion of the shell have a larger number of tubes therein. In the conventional arrangements, when the overhead sprays are used the refrigerant will be evaporated before it can reach the lower tubes of the center rows; when the flooded arrangement with distributed liquid entry along the bottom of the evaporator is used the tubes in the short vertical rows near the outer portion of the shell do not become wet because there are no tubes directly below them in the liquid to cause boiling up to them.

By contrast, in the FIG. 2 arrangement the various evaporator tubes are arranged in vertical rows of equal depth. Each of the rows has a comparatively small number of tubes therein so that when using the sprays the lowermost tubes in all of the rows can be fed with liquid

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refrigerant or when using the conventional flooded arrangement, a minimum depth of refrigerant is required to obtain uniform wetting of all tubes, each vertical row being equally submerged.

FIG. 2 illustrates an arrangement wherein the nozzles 66 discharge downwardly onto the tube bundle. It is contemplated however that within the broader aspects of the invention the refrigerant could be distributed to the evaporator tubes in the form of upwardly directed sprays, in which case the discharge from pipe 60 would be located immediately adjacent the partition means 14 so as to direct the refrigerant upwardly against the lower surfaces of the tubes. The conventional flooded arrangement with distributed liquid inlet also could be used.

It will be understood that operations are preferably carried out so as to minimize direct heat transfer between evaporator space 20 and condenser space 22. Thus, in the evaporator section the liquid refrigerant preferably takes heat exclusively from the liquid within tubes 24, and in the condenser section the refrigerant preferably gives off its heat content exclusively to the fluid within tubes 26. There is preferably no transfer of heat across the partition means 14. To avoid heat transfer across partition means 14 the partition means is formed as a hollow structure as by means of the spaced plates 16 and 18. As shown in FIG. 1 there is extended upwardly from plate 18 a duct or conduit 68. The arrangement is such that duct 68 admits gaseous refrigerant into the cavity 70 defined by the plates 16 and 18. The conventional refrigerants, such as Freon, when in the vaporous state form very excellent insulators at low pressures, and thus the use of a hollow refrigerant-filled space 70 serves as an excellent means of preventing heat transfer between evaporator space 20 and condenser space 22. The vapor space 70 is, as illustrated in FIG. 2, located in a horizontal plane so that convection currents are at a minimum. By this arrangement the insulator characteristics are suitably achieved.

It will be understood that plates 16 and 18 have minimum thermal contact with one another, inasmuch as such contact would allow heat from the condenser to be transmitted to the evaporator. In the illustrative drawings the plates are completely unconnected from one to the other except at their perimeters where they join the wall portions 17 and 19. The plates are maintained in their illustrated spaced positions by means of tube sheets 74 and tube sheets 76, said sheets being suitably affixed to the plates 16 and 18 as by conventional welding procedures. These sheets 74 and 76 of course also serve to support the transfer tubes 26 and 24 respectively. The plates 16 and 18 may further be reinforced against deformation by the use of longitudinally extending stringers, such as are shown at 78 in FIG. 2. If desired, plates 16 and 18 can further be reinforced against deformation by the use of short non-conductive posts placed between the plates at suitable points thereon. Such posts can transfer the load from plate 16 to plate 18 without transferring heat.

It will be seen from FIG. 2 that the illustrated construction represents a design of satisfactory strength, so that the walls thereof may be made of relatively thin gauge material. In this connection the shell structure constitutes substantially a pressure vessel, since its elliptical configuration is only slightly lower strengthwise than the cylindrical shell construction employed in pressure vessels generally. As indicated above, the illustrated configuration and arrangement is of advantage in that it permits a compact assembly of the condenser, evaporator and compressor, and provides an improved arrangement of tubes in the evaporator section.

The evaporator tubes are arranged beneath the conventional eliminators 80 in such manner as to provide an extensive discharge area for the evaporated refrigerant after it leaves the uppermost tubes. Because of this extensive area the vapor velocity leaving the tube bundle is relatively low, and the eliminators 80 can be of relatively

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simple construction, thereby reducing the cost of the assembly and minimizing service problems.

Referring now to FIGS. 4 through 6, there is illustrated an arrangement wherein the compressor means is arranged on a vertical axis as distinguished from the horizontal axis arrangement of FIG. 1. In the FIG. 4 arrangement the vaporous refrigerant from the evaporator is fed upwardly to the condenser via an inlet duct 84 which is suitably connected with the eye of the scroll 86. As will be seen from FIG. 5 the scroll 86 is provided with two substantially diametrically opposed outlet ducts 88 and 90 arranged to receive the compressed gas and discharge same toward the condenser.

Ducts 88 and 90 extend longitudinally of the shell structure 12, and thence downwardly as at 98 and 100. As will be seen from FIGS. 4 and 5, the downwardly extending duct portions 98 and 100 lead through the evaporator section 20 and discharge into the condenser section 22 at longitudinally spaced points therein. By this arrangement the gaseous refrigerant is circulated substantially uniformly in the condenser space so that it enjoys an improved heat transfer relation with the fluid flowing through tubes 26. The improved relationship in some cases will permit the improvement of a lower number of tubes in the condenser section, thereby enabling cost reduction, both in tube material and as a result of reduction in size of the shell structure.

It will be understood that the FIG. 4 arrangement has the same general path of refrigerant flow therethrough as the FIG. 1 arrangement. Thus, the refrigerant is drawn upwardly from evaporator section 20 into the duct 84, through the vanes of the impeller into the compressor outlet ducts 88 and 90, and thence downwardly through the tubes 98 and 100 into condenser section 22, where it is condensed and collected in the collector device 54. The condensed refrigerant is then directed upwardly through the conduit 60 and into the spray pipes 62 and 63 as previously discussed in connection with the FIG. 1 embodiment.

The FIG. 7 embodiment is similar to the FIG. 1 embodiment except for certain features of construction involved in distributing refrigerant to the evaporator space 20. In the FIG. 7 arrangement there is provided a booster mechanism for assisting the machine in its job of circulating refrigerant onto the evaporator tubes. The arrangement comprises a small chamber 110 which receives excess liquid refrigerant from space 20 via a vertical pipe 111. The chamber houses an electric motor 112 and pump 114, preferably of the vane type. The pump outlet connects with the vertical duct 120 which feeds the overhead spray pipes 62 and 63.

In the FIG. 7 embodiment pipe 60 terminates just above partition 14 so as to remove refrigerant from the condenser and feed some refrigerant upwardly onto the evaporator tubes. By the arrangement of pump 114 and pipes 120 and 60, all of the evaporator tubes are maintained in a thoroughly wet condition.

The arrangement of the evaporator above the condenser and of pump 114 and ducts 60, 120 and 111 as illustrated in FIG. 7 requires small installation space, and enables a satisfactory spray pattern to be achieved without unduly increasing the overall height of the machine or providing a pit in the floor for housing a larger pump structure such as might otherwise be required in some installations.

The FIG. 8 arrangement is similar to the FIG. 1 embodiment in the disposition of duct 47 extending externally of the shell structure. However, in the FIG. 8 arrangement the compressor is disposed with the axis thereof vertical as in the FIG. 4 arrangement. It is believed that the operation of the FIG. 8 construction will be apparent without further elaboration.

It will be understood that, while the drawings herein illustrate various features of the invention which can be utilized in operative devices, yet certain variations in ar-

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rangements and construction can be resorted to without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. In a refrigeration machine, a horizontally elongated hollow shell, a hollow partition dividing said shell into an upper refrigeration evaporator compartment and a lower refrigerant condenser compartment, thermal insulation in said hollow partition, said evaporator and condenser compartments each having portions defined by said shell, heat transfer tubes positioned in said evaporator and condenser compartments for conducting a heat transfer fluid therethrough, means for transferring liquid refrigerant from said condenser compartment into said evaporator compartment, a refrigerant compressor mounted on top of said shell and having an inlet connected to said evaporator compartment, said compressor having an outlet, a vertically disposed tube extending through said evaporator compartment and into said condenser compartment, and means connecting said vertically disposed tube and said compressor outlet.

2. In a refrigeration machine, a horizontally elongated hollow shell, a longitudinally extending hollow partition sub-dividing said shell into an upper refrigerant evaporator compartment and a lower refrigerant condenser compartment, thermal insulation in said hollow partition, said evaporator and condenser compartments each having portions defined by said shell, heat transfer tubes extending in said evaporator and condenser compartments for conducting a heat transfer fluid therethrough, means for transferring liquid refrigerant from said condenser compartment to said evaporator compartment, and a refrigerant compressor mounted on top of said shell and having an inlet connected to said evaporator compartment and an outlet connected to said condenser.

3. In a refrigeration machine, an elongated hollow shell having its axis horizontally disposed, a generally flat hollow partition subdividing said shell into an upper evaporator compartment and a lower condenser compartment, heat transfer tubes in said compartments to conduct heat transfer fluids therethrough, means placing said heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, said hollow partition defining a cavity, conduit means connecting said cavity and a quiescent portion of said evaporator chamber whereby gaseous refrigerant can pass to said cavity to provide insulation against the flow of heat between said evaporator and condenser compartments, a powered compressor having an inlet and an outlet, a conduit means operably connecting said compressor inlet and outlet to said evaporator and condenser compartments respectively, and means connecting said condenser and evaporator compartments to convey liquefied refrigerant from said condenser compartment to said evaporator compartment.

4. In a refrigeration machine, a hollow shell, a hollow partition subdividing said shell into an evaporator compartment and a condenser compartment, heat transfer tubes positioned in said compartments to conduct heat transfer fluid therethrough, means placing the heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, said hollow partition defining a thin horizontal cavity completely isolating said compartments in a horizontal plane, means for introducing gas into said cavity to provide

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insulation against the flow of heat between said compartments,  
 a powered compressor having an inlet and an outlet,  
 conduit means operably connecting said inlet and outlet to said evaporator and condenser compartments respectively,  
 and means for transferring liquefied refrigerant from said condenser compartment to said evaporator compartment for evaporation therein.  
 5. In a refrigeration machine,  
 an elongated hollow shell having the axis horizontally disposed,  
 a generally flat hollow partition extending longitudinally and horizontally in said shell and subdividing said shell into an evaporator compartment and a condenser compartment with the compartments vertically spaced,  
 heat transfer tubes in said compartments to conduct heat transfer fluid therethrough,  
 means placing said heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, said partition including vertically spaced, horizontally disposed, flat plates defining a generally closed cavity,  
 gaseous means in said cavity thermally isolating said evaporator and condenser compartments from one another,  
 a powered compressor having an inlet and an outlet,  
 conduit means operably connecting said compressor inlet and outlet to said evaporator and condenser compartments respectively,  
 and means for transferring liquid refrigerant from said condenser compartment to said evaporator compartment for evaporation therein.  
 6. In a refrigeration machine,  
 an elongated hollow shell,  
 said shell being of substantially elliptical cross section with the major axis of the ellipse vertically disposed and the minor axis horizontally disposed,  
 an axially extending flattened, hollow partition defining a closed cavity and subdividing said shell into an evaporator compartment and a condenser compartment,  
 heat transfer tubes in said compartments to conduct heat transfer fluid therethrough,  
 means placing said heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, a powered compressor having an inlet and an outlet,  
 conduit means operably connecting said compressor inlet and outlet to said evaporator and condenser compartments respectively,  
 and means for transferring liquid refrigerant from said condenser compartment to said evaporator compartment for evaporation therein.  
 7. In refrigeration apparatus,

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an elongated hollow shell having the axis horizontally disposed,  
 a generally flat, hollow partition extending longitudinally and horizontally in said shell and subdividing said shell into an evaporator compartment and a condenser compartment, with one of said compartments uppermost,  
 conduit means between the interior of said hollow partition and the gaseous space of a compartment whereby gas is conducted into the partition to provide insulation against the flow of heat between said compartments,  
 heat transfer tubes in said compartments to conduct heat transfer fluids therethrough,  
 means placing said heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, a compressor having an inlet and an outlet,  
 conduit means operably connecting said compressor inlet and outlet to said evaporator and condenser compartments respectively,  
 and means to convey liquid refrigerant from said condenser compartment to said evaporator compartment.  
 8. In refrigeration apparatus,  
 an elongated hollow shell having the axis horizontally disposed,  
 a generally flat, hollow partition extending longitudinally and horizontally in said shell and subdividing said shell into an evaporator compartment and a condenser compartment, with the compartments vertically spaced and isolated,  
 gaseous means within said flattened, hollow partition to reduce heat transfer between said compartments,  
 heat transfer tubes in said compartments to conduct heat transfer fluids therethrough,  
 means placing said heat transfer tubes in heat-exchange relation with fluid to be cooled by the evaporator compartment and cool the condenser compartment, a refrigeration compressor having an outlet connected to said condenser compartment and an inlet connected to said evaporator compartment,  
 and means for transferring liquid refrigerant from said condenser compartment to said evaporator compartment.

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