

March 9, 1965

A. J. MIRANTE
REFRIGERATION SYSTEMS

3,172,270

Filed Jan. 19, 1961

3 Sheets-Sheet 1

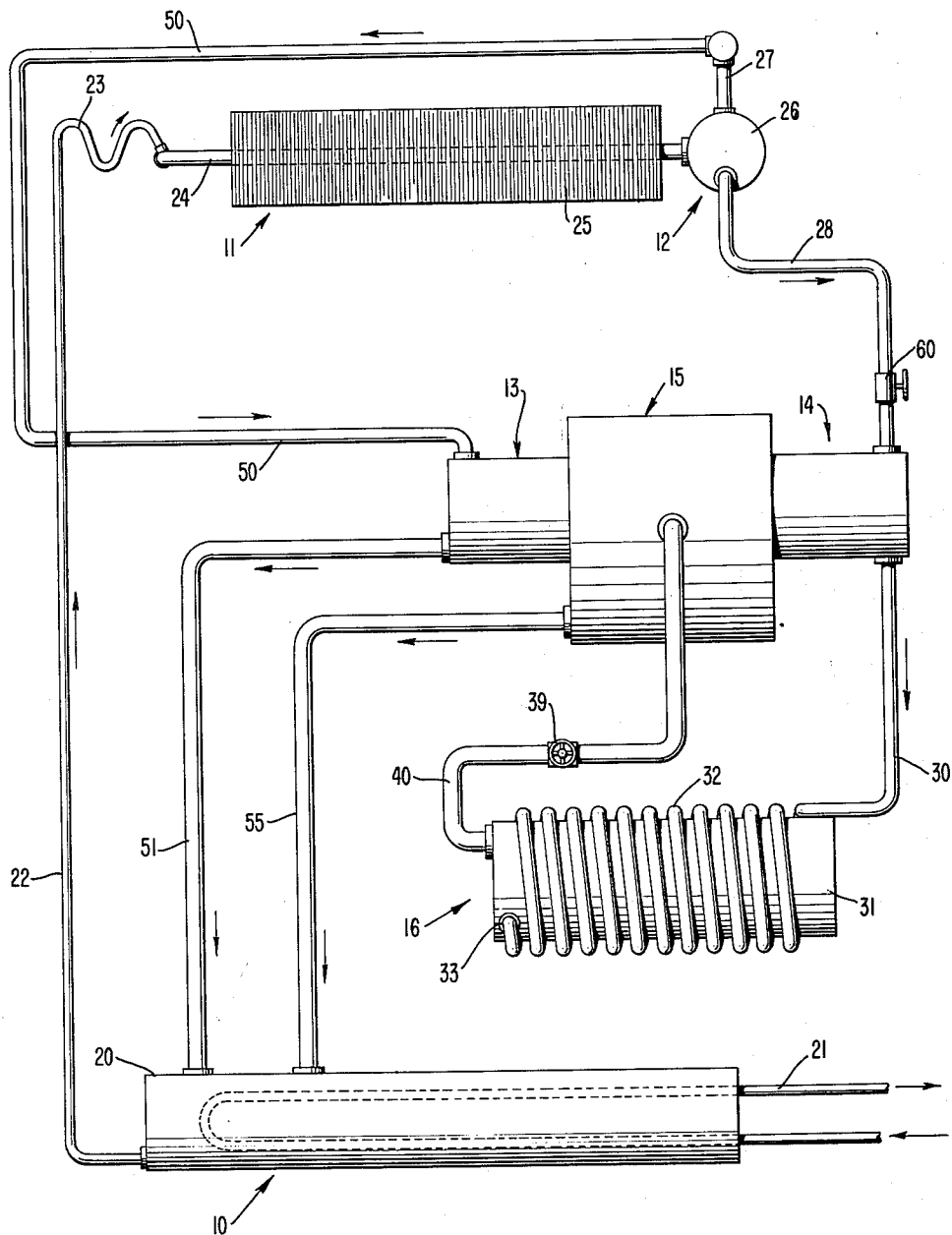


FIG. 1

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FIG. 2

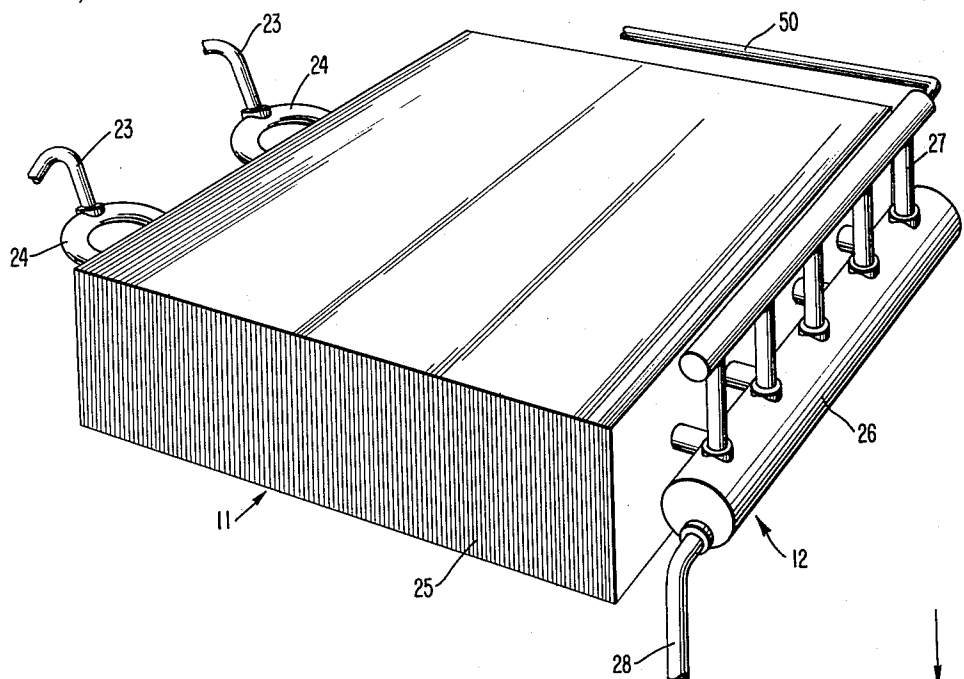
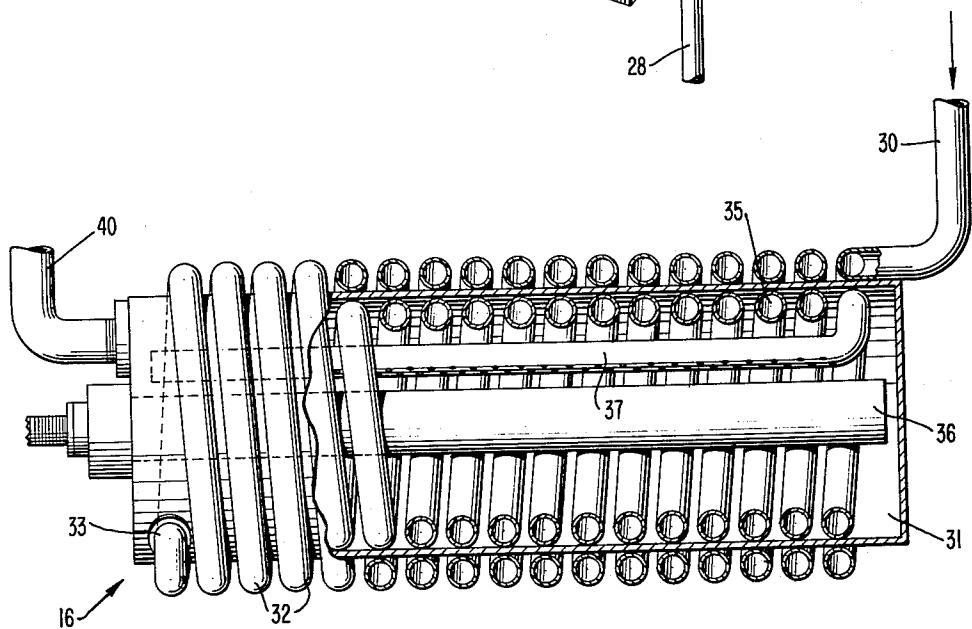


FIG. 3

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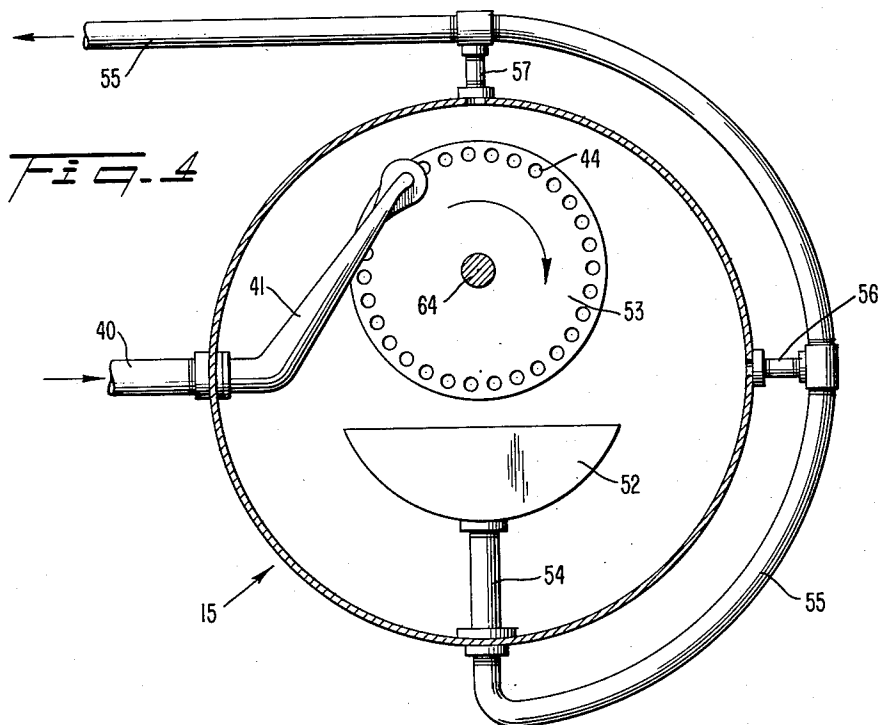
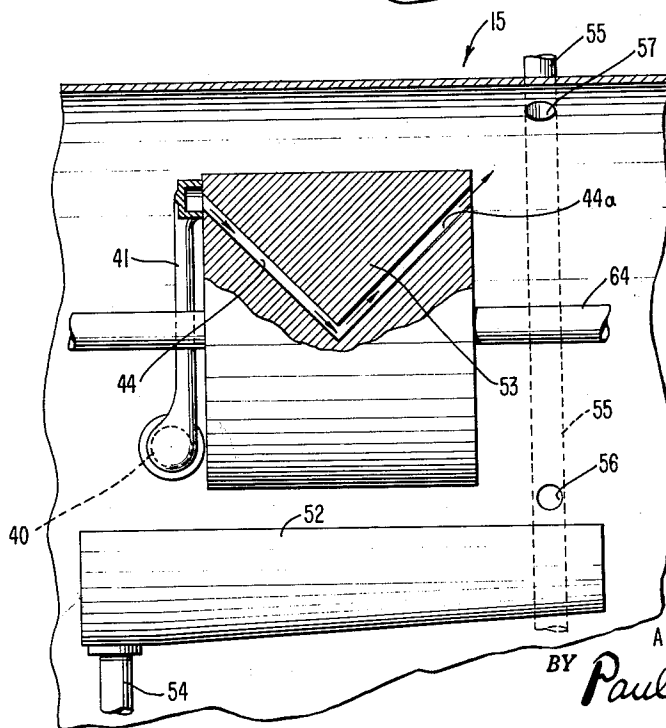
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3 Sheets-Sheet 3



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REFRIGERATION SYSTEMS

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12 Claims. (Cl. 62—116)

This invention relates to a refrigeration system and apparatus for the embodiment of such system, and more particularly is concerned with an improved refrigeration system and apparatus.

In the past, refrigeration systems have included turbines which have been operated by a portion of the refrigerant which is heated, and the expansion of the refrigerant in its heated gaseous condition has been directed against the blades of the turbine and the turbine has been used to operate the compressor and pump for recycling the refrigerant. In such devices the portion of the refrigerant which is heated to high pressure for purposes of operating the turbine has been drawn from the condenser or from the liquid refrigerant receiver and has been passed through suitable heating means such as a heat exchange coil to the turbine used to motivate the compressor and pump.

It has been found that such systems, although having certain desirable features, may affect adversely the refrigeration efficiency because as the turbine is operated and the portion of refrigerant withdrawn from the liquid receiver to operate the turbine increases, the level of liquid refrigerant available in the liquid receiver to feed the evaporator may be reduced to the point where the evaporator is virtually starved. Furthermore the constant drain from the receiver of the portion of liquid to operate the turbine seriously reduces the pressure of the liquid left in the evaporator.

Another factor which has been observed is that in the usual refrigeration cycle of prior devices the effluent from the evaporator to the compressor is frequently a mixture of gas, wet vapor, and in some cases liquid. (This condition is sometimes referred to as a floodback.) The effluent is thereafter fed to the compressor for compression of a high pressure gas and is then returned to the condenser wherein it is liquified by removing the heat therefrom. The presence of the wet vapor and liquid in the effluent from the evaporator to the compressor requires heavier equipment and decreases the volumetric efficiency of the compressor.

When there is a serious floodback condition from the evaporator to the compressor the compressor is subject to breakdown.

It is an important object of this invention to provide a system and apparatus wherein the efficiency of the compressor is improved and the danger of compressor breakdown is reduced.

It is another important object of this invention to provide a system and apparatus wherein the demands upon the receiver for the evaporator are not interfered with by bleeding of liquid from the receiver for operation of the turbine.

A still further object of the invention is to provide a system wherein increased efficiency of evaporation and increased efficiency of compression and of turbine operation are achieved.

Other and further objects of the invention will be appreciated from a more detailed description of the invention.

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The invention comprises broadly the separation of the liquid and vapor phases of the effluent from the evaporator and the introduction of the vapor phase only into the compressor, and the saturated phase and any liquid present into the vaporizer for driving the compressor, the flow from the receiver being unilateral.

The invention includes a refrigeration cycle having a combination of elements which include a receiver, an evaporator which receives liquid refrigerant from the receiver and wherein the liquid refrigerant is evaporated into a gaseous phase, and a saturated or liquid phase, a separator which separates the gaseous refrigerant phase from the saturated or liquid refrigerant phase, a pump for pumping the liquid phase of the refrigerant to a vaporizer wherein the refrigerant is preheated, superheated and vaporized to a high pressure gas which drives a turbine. The turbine is the motive power for a compressor. The gaseous phase of the refrigerant from the separator is compressed in the compressor, and that compressed gas is fed to the condenser wherein it is cooled and liquified and is returned to the receiver for recycling.

For a more complete description of the invention reference is made to the drawings, wherein:

FIG. 1 is a schematic diagram of a refrigeration system and of a refrigeration apparatus embodying the invention;

FIG. 2 is a perspective view of a form of evaporator adapted for use in this invention, and a gas and wet vapor separator;

FIG. 3 is a side view, partly in section, of a vaporizer adapted for use with this invention;

FIG. 4 is a cross-sectional view of a form of turbine adapted for use in the invention; and

FIG. 5 is a view at right angles to the view shown in FIG. 4.

Referring to FIG. 1, the refrigeration system of the invention comprises a condenser and liquid refrigerant receiver or reservoir 10, an evaporator 11, a separator 12, a compressor 13, pump 14, turbine 15, and a vaporizer or generator 16, arranged in the manner illustrated. The condenser 10, which may also serve as a reservoir or receiver for the liquid refrigerant, may be of any well known construction. As illustrated in FIG. 1 it consists of a chamber or tank 20 which receives high pressure refrigerant gas from the compressor and the turbine and, as will be explained hereinafter, the refrigerant is condensed in the chamber 20 by a water-cooled coil schematically illustrated at 21. The liquid refrigerant is forced through line 22 and regulated through well known capillary feeders schematically shown at 23 into evaporator tubes 24 where the cooling effect of the refrigerant occurs in the usual manner. The evaporator tubes, as shown in FIGS. 1 and 2, are passed through dissipator fins 25. The evaporator tubes are connected to a header 26 of the separator 12.

One form in which the separator is contemplated is shown in FIG. 2, the separator header 26 extending transversely to the ends of the evaporator tubes 24 and the evaporator tubes being connected to the header as indicated in FIG. 2. Gas is removed from the separator header 26 through gas vents 27 which are tapped into the upper side of the separator header 26. The saturated vapor phase of the refrigerant from the separator header is drawn off through conduits 28 provided in the bottom of the header. The saturated vapor phase of the refrigerant is carried in the line 28 to and through the pump 14, which may be of the usual vane type. The wet vapor is delivered from the pump through conduit 30 into a vaporizer or generator which is shown schematically in FIG. 1.

One form of vaporizer which is presently preferred is shown in FIG. 3, wherein the wet vapor received from

pump 14 is preheated in the coil which encompasses the body 31 of the vaporizer, and further preheating occurs when the wet vapor enters the body of the vaporizer through coupling 33 and is carried through inner coils 35.

The heating element which may, as illustrated, be a Calrod, and an electric resistance element 36 extend through the center of the body of the vaporizer 31. The wet vapor gas which has been preheated in outside coils 32 and inner coils 35 is thereafter directed through a drip tube 37, which is above and extends the length of the Calrod 36. The drip tube is provided with a series of apertures on its underside through which the wet vapor gas is spread on to the heating element 36. The contact of the wet vapor refrigerant with the heating element causes the wet vapor to be superheated and to expand, creating relatively high pressure.

The vaporizer is connected to the turbine 15 through a conduit 40 and the high pressure preheated refrigerant gas impinges on the blades of the working surface of the turbine through nozzle 41. It has been found desirable to provide a pressure valve 39 in line 40, set to open when the pressure of the heated refrigerant has reached a predetermined level, at which time the valve will open to operate the turbine.

The gas phase of the refrigerant which is separated from the effluent issuing from the evaporator, which passes through the gas vents 27, as shown in FIGS. 1 and 2, is carried through line 50 to the compressor 13 which may be a well known vane type compressor, wherein the gas is compressed and is delivered from compressor 13 through conduit 51 to the condenser for recycling.

Referring to FIG. 1 and to FIG. 4, the gas issuing from the conduit 40 and passing through the turbine 15 will give off most of its heat energy in performing work on the turbine. The continuous head of hot high-pressure gas in the line 40 at the pressure valve 39 will prevent any condensation inside the turbine. A sump 52 may be provided beneath the turbine rotor 53, as best shown in FIGS. 4 and 5. Any such condensate will be carried through extractor tube 54 in the conduit 55 by the hot exhaust gases issuing from the turbine and through extractor tubes 56, 57. The conduit 55 is shown in the schematic system drawing of FIG. 1. Any condensate from the turbine is thus returned to the condenser 10. The pressure of the gases in the conduits 51 and 55 provides a pressure head in the upper part of chamber 20 of the condenser sufficient to force the refrigerant which has been condensed to a liquid through the conduit 22 to the evaporator for the recycling of the system.

A check valve 60 is provided in the line 28 between the pump 14 and the separator 12 so that when the system is satisfied (sufficient refrigeration has been achieved) there will not be a backup of hot high-pressure gases from the vaporizer. It will be understood that the usual standard control valves necessary for balancing the system will be employed to adjust the system, as desired.

By the employment of the system and apparatus of this invention high efficiency of operation has been achieved. The employment of a separator to separate the effluent from the evaporator makes it possible that only the gas phase of the effluent is directed to the compressor 13, so that more efficiency in compression can be achieved than would be possible if the entire effluent from the evaporator was passed to the compressor, for the wet vapor phase of the effluent will make compression of the gas more difficult and require more energy and, or, heavier equipment. It is quite usual for the effluent from the evaporator to contain both gas and wet vapor phases. The wet vapor which is separated from the gas is also used to advantage and to improve efficiency, in that it is much more economical to vaporize the refrigerant in wet vapor form than if it were drawn directly from the condenser receiver in the liquid state. Also by the arrangement of the system the parts are coordinated to achieve a high level of efficiency. As noted, by employing the wet vapor phase of the effluent

from the evaporator to operate the compressor, both the compressor and the vaporizer are operated in a more efficient manner. Also, the condenser is operated in a more efficient manner.

In previous systems in which turbines have been run by refrigerant which has been superheated to high pressure gas, the refrigerant has been drawn from the condenser as a liquid. Such an arrangement has reduced the liquid level in the condenser and also reduced the line pressure for liquid flowing in the refrigeration cycle from the condenser to the evaporator. In the system of this invention the wet evaporator from the separator which is on the effluent side of the evaporator is used. As noted herein the wet vapor from the separator may be vaporized and superheated with less heat energy than is required to vaporize liquid refrigerant used in the previous systems. Furthermore, in the system of this invention it is not necessary to draw any liquid from the condenser for the driving of the turbine and therefore the system works more efficiently by achieving a unilateral flow of liquid refrigerant from the condenser to the evaporator. No liquid is drawn off from the condenser and diverted to the turbine and the line pressure of the liquid from the condenser to the evaporator is increased rather than being dissipated as in the prior system.

One further advantage of employing a wet vapor or saturated gas to the vaporizer or generator, rather than employing the refrigerant in liquid form: The hot high-pressure gas delivered from the line 40 through the nozzle 41 is discharged from the nozzle into the passage 44 of the turbine wheel 53 and the spent gas exits through the passage 44a and thereafter issues through extractors 56 and 57. As noted above, any condensate will be received in the sump 52 and carried out to extractor 54.

The extractor tubes 56 and 57 receive the exhaust or spent gas from the turbine rotor which gas has been collected in the housing of the turbine 15. The exhaust gas has sufficient pressure to extract the condensate in the sump.

The refrigeration system of this invention may be entirely sealed and self-contained, merely being provided with heat through the element 36 which may be a Calrod or other sealed heating means. The water or other coolant which is carried in cooling coil 21 in the receiver condenser 10 may be re-cooled by passing the pipe 21 in heat exchange relation with the evaporator 11.

It will be noted from FIGS. 4 and 5 that the turbine rotor 53 is rotatably supported on a shaft 64. This shaft extends from the turbine housing 15 into the compressor housing 13 in one direction and into the housing of the pump 14 in the other direction, as shown in FIG. 1, the rotating shaft providing the motive means for the vane type compressor in the compressor housing 13 and providing the motive means for the vane pump in the pump housing 14. The entire assembly of the housings 13, 14 and 15 may be hermetically sealed without fear of contamination of the cycling refrigerant. Contamination is a serious problem, for customarily an electric motor is employed for pumping and compressing and is hermetically sealed with the housings for the compressors and pumps. Typically the stator and rotor and the wiring in such hermetically sealed electrical arrangement are accessible to the refrigerant of the system. When overheating occurs in the electric motor, caused by power failures or overloads on the motor due to condensation or other causes, resulting in excessive head pressure in the refrigeration system, the refrigerant becomes contaminated by carbon particles resulting from the breakdown of the insulation on the wiring of the electric motor parts. With such contamination of the refrigerant eventual breakdown of the system occurs.

By the use of refrigerant from the system as the motive force in this invention, contamination of the sort described is avoided.

In the system of the present invention the heating ele-

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ment 36, which may be electrically heated, is not subject to overheating because of any surges in the system and in the event of a power failure would not burn out.

It will be appreciated that the highly volatile nature of the refrigerant is employed as a substitute for the motive power usually employed for the compressor and pumps. By the expedient of heating the refrigerant in the saturated vapor phase, high pressure gas is readily obtained by the use of a heating element such as employed in the vaporizer such as shown in FIG. 3. By vaporizing and heating the gas to high pressures, economies of operation have been achieved, particularly when the refrigerant is vaporized from the saturated vapor condition in which it is received from the separator 26.

The outside heat source which for illustration in the foregoing description has been shown as a Calrod, may also be steam or hot gases which would be passed in heat exchange relationship through the vaporizer in a similar manner as the Calrod.

The term "refrigerant" as used herein contemplates any well known suitable composition used in refrigeration systems.

In accordance with the provisions of the patent statutes, the principle of operation of this invention, together with the elements which are now considered to constitute a preferred embodiment thereof, are described, but it should be understood that the structure disclosed is only illustrative and the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combinations and relations described, some of these may be altered and modified without interfering with the more general results outlined.

What is claimed is:

1. A refrigeration system comprising a receiver condenser for liquid refrigerant, an evaporator, means for delivering liquid refrigerant from the receiver condenser to the evaporator wherein the liquid refrigerant is evaporated into a first gaseous phase and a second saturated gas and liquid phase, a separator adapted for separating the first gaseous phase from the second saturated gas and liquid phase, a vaporizer and a pump for pumping the second saturated gas and liquid phase to the vaporizer, means in the vaporizer for heating and vaporizing the said second phase to a high pressure gas, a turbine connected to receive high pressure gas from said vaporizer and deliver its exhaust gas to said condenser, a compressor connected to receive said first gaseous phase from said separator and deliver compressed gas to said condenser, said compressor and pump being connected to said turbine for drive thereby, and means in the condenser to cool and liquefy the returned compressed gas.

2. A refrigeration system comprising a reservoir for liquid refrigerant and an evaporator adapted to receive the refrigerant from the reservoir and to evaporate the refrigerant, means for separating the evaporated refrigerant into a first gaseous phase and a second saturated gas-liquid phase, means for compressing the first gaseous phase and returning it to the reservoir, means in the reservoir for cooling the refrigerant therein, means for heating and vaporizing the second saturated gas-liquid phase to a high pressure gas, and means driven by the high pressure gas to operate the compressor and means for collecting and returning the gas exhausted from the driven means to the reservoir.

3. A refrigeration system comprising a receiver condenser for liquid refrigerant, a body of liquid refrigerant, means for continuously evaporating a portion of said liquid refrigerant into a first gaseous phase and a second saturated gas and liquid phase, means permitting separation of said first and second phases, means for compressing and returning the first gaseous phase to the receiver condenser, and means for heating and vaporizing the second saturated gas and liquid phase into a heated pressure gas, motive means operated by said heated high pressure gas, said motive means being used to compress

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the said first gaseous phase and to move the second saturated gas and liquid phase from the separator means to the vaporizer means, and means for delivering the spent high pressure gas to the liquid refrigerant reservoir and means in said reservoir for cooling the refrigerant therein.

4. A refrigeration system comprising means for receiving and condensing a refrigerant to liquid, means for evaporating successive amounts of the liquid refrigerant into a first gaseous phase and a second saturated vapor-liquid phase, means adapted for separation of said first and second phases, means for compressing and returning the first gaseous phase to the receiving and condensing means, and means for delivering the second saturated vapor-liquid phase for use as the motive force in the system.

5. A refrigeration system comprising a refrigerant, means for receiving and condensing the refrigerant to liquid, means for evaporating successive amounts of said liquid refrigerant into a first gaseous phase and a second saturated vapor and liquid phase, separator means for separating the said first gaseous phase from the second saturated vapor and liquid phase, means for compressing the first gaseous phase and returning it to the receiving and condensing means, a turbine, and means for heating and vaporizing the said second phase to a heated high pressure gas for driving the turbine, and an extractor means for receiving any condensate and exhaust high pressure gas and returning it to the receiving and condensing means.

6. The refrigeration system of claim 5 wherein the turbine is comprised of a housing, a turbine rotor mounted in the housing, said rotor having a plurality of high pressure gas receiving passages and connected exhaust gas discharge passages, each of said receiving and discharging passages being shaped so that high pressure gas passing therethrough will rotate the rotor, a high pressure gas delivering means, the said receiving passages being arranged to pass successively into position to receive high pressure gas from said delivery means, sump means for collecting condensate from the discharge passages, and extractor means for extracting condensate from the sump means, said extractor means having extractor tubes for receiving exhaust gas from the turbine housing whereby the condensate is extracted by the pressure of the exhaust gas.

7. The refrigeration system of claim 5 wherein said separator means for separating the said first gaseous phase from the second saturated vapor and liquid phase comprises a header defining a chamber for receiving both phases from the said evaporator means, vent means in the upper side of the header for removing the said first gaseous phase and conduits in the bottom of the header for removing the said second saturated vapor and liquid phase.

8. A refrigerator system comprising a refrigerant, a refrigerant receiver condenser, cooling means in said receiver condenser, an evaporator, a conduit for delivering liquid refrigerant to the evaporator where it is evaporated into a first gaseous phase and a second saturated vapor and liquid phase, a separator for receiving refrigerant from the evaporator and separating the first gaseous phase and the second saturated vapor-liquid phase, means including a compressor for compressing the first gaseous phase and delivering the compressed gas to said receiver condenser, a vaporizer for heating and vaporizing the second phase into a heated high pressure gas, a pipe and a pump for pumping the second phase from the separator through the pipe to the vaporizer, a turbine, a conduit for delivering the heated high pressure gas to drive the turbine, an extractor for returning the exhaust gas and any condensate to the receiver condenser.

9. The refrigeration system of claim 8 wherein a pressure valve is disposed in the conduit for delivering the heated high pressure gas from the vaporizer to the turbine,

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said valve being adjustable to open when the pressure of the heated and vaporized refrigerant has reached a predetermined level.

10. The refrigeration system of claim 8 wherein a check valve is provided in the pipe between the separator and the vaporizer to prevent back flow of any of the second saturated vapor-liquid phase to the separator.

11. The method of using a refrigerant in a refrigeration system comprising holding and cooling a reservoir of refrigerant in liquid form, evaporating successive amounts of the liquid refrigerant into a first gaseous phase and a second wet vapor-liquid phase, separating the two phases, heating and vaporizing the second wet vapor-liquid phase to form a heated high pressure gas using the high pressure gas as motive means to compress the said first gaseous phase and returning both the compressed first gaseous phase and the exhausted high pressure gas together with any condensate thereof to the reservoir of refrigerant for recycling.

12. In a refrigerating system of the type including an evaporator, a condenser receiver for delivering liquid refrigerant to the evaporator, a compressor, a refrigerant

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gas operated drive means for the compressor and a heated vaporizer for heating and vaporizing refrigerant for the drive means, the improvement comprising means for separating the exhaust from the evaporator into a gaseous phase and a saturated gas-liquid phase, means directing said gas phase through the compressor to the compressor reservoir and means for directing said saturated gas-liquid phase to the heated vaporizer for delivering high pressure heated gas to the gas operated drive means.

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