March 9, 1926. 1,575,819

W. H. CARRIER

REFRIGERATING SYSTEM

Filed April 5, 1921 3 Sheets-Sheet 1

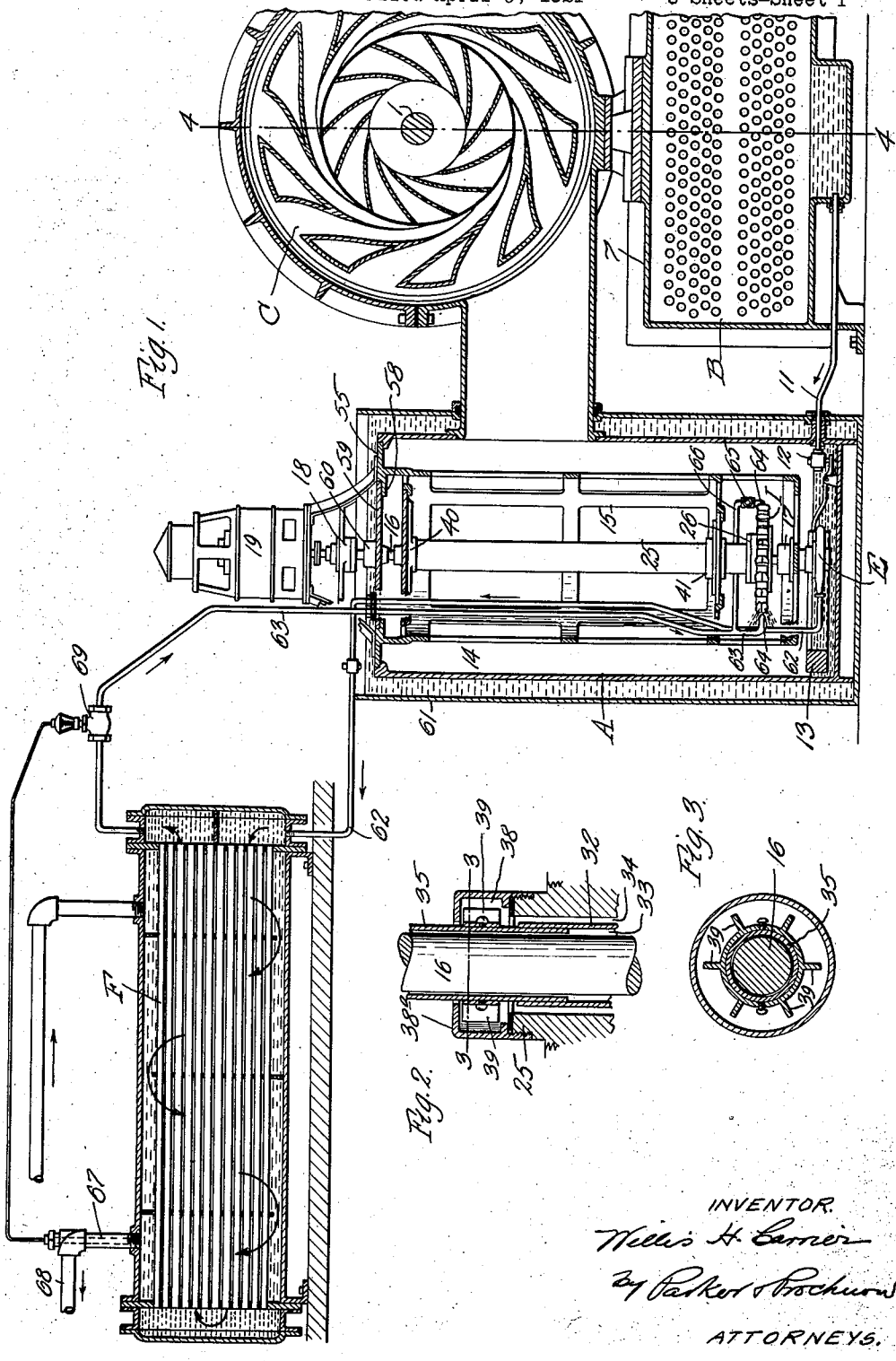


Fig. 1.



Fig. 2.



Fig. 3.

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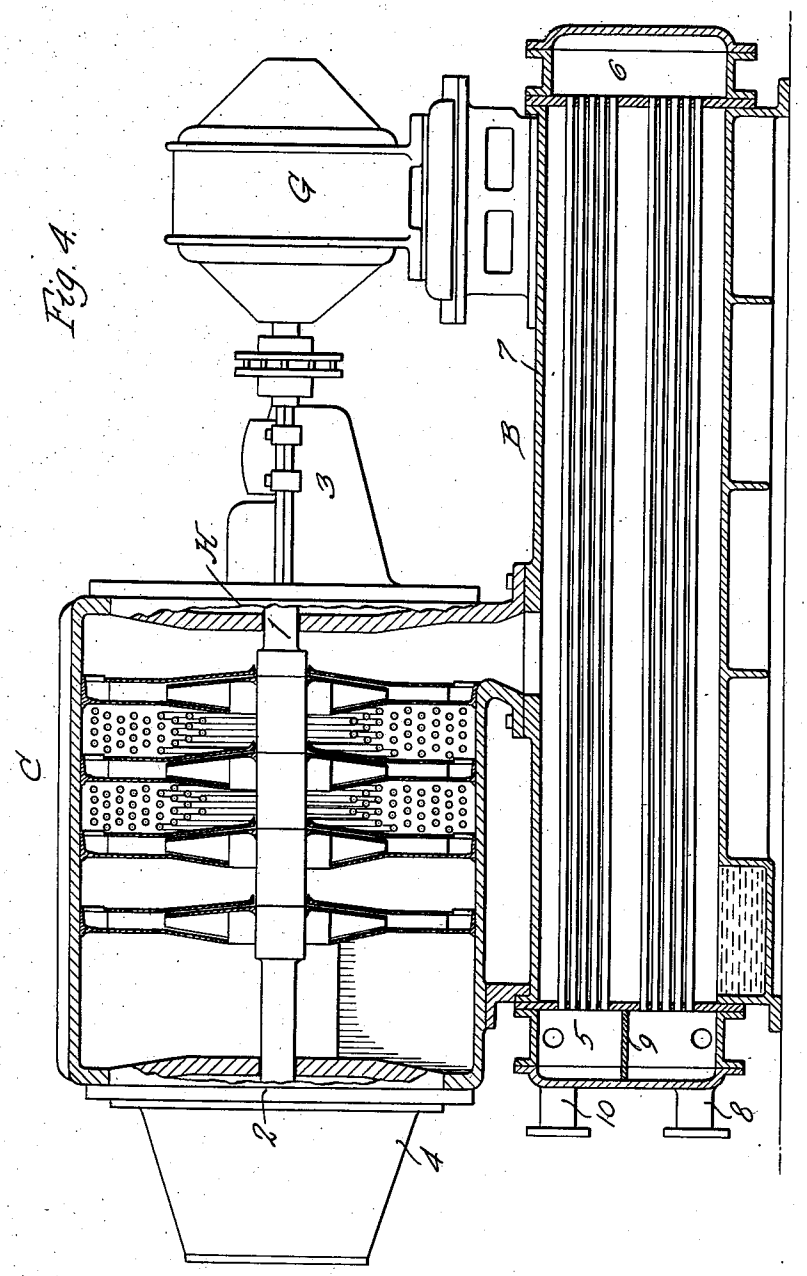
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Fig. 4.




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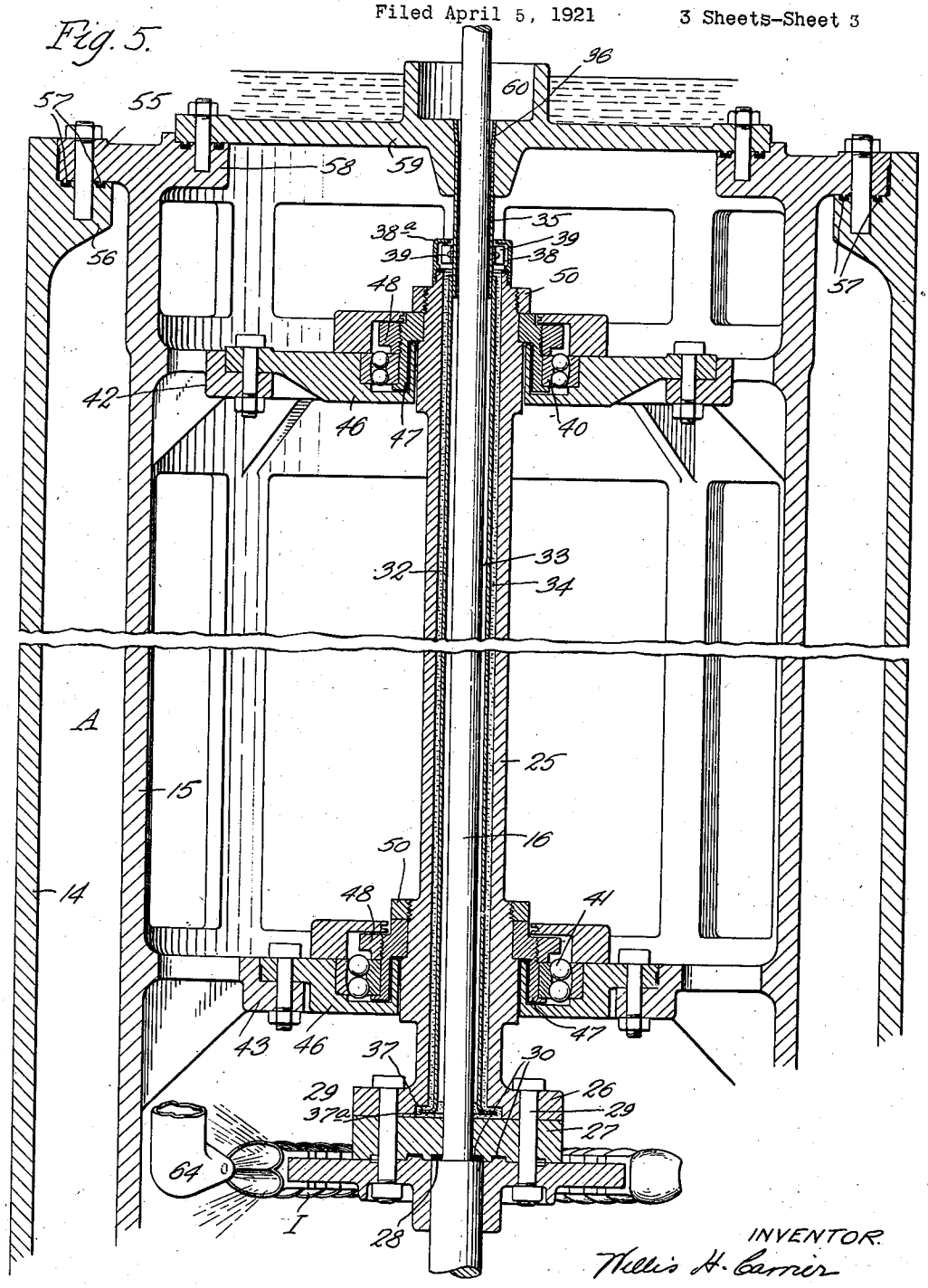
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Fig. 5.




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# UNITED STATES PATENT OFFICE.

WILLIS H. CARRIER, OF NEW YORK, N. Y., ASSIGNOR TO CARRIER ENGINEERING CORPORATION, OF NEW YORK, N. Y.

## REFRIGERATING SYSTEM.

Application filed April 5, 1921. Serial No. 458,680.

*To all whom it may concern:*

Be it known that I, WILLIS H. CARRIER, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented a new and useful Improvement in Refrigerating Systems, of which the following is a specification.

This invention relates to refrigerating systems of the general nature disclosed in my application for patent filed of even date, Serial No. 458,679, in which a volatile liquid of low vapor pressure and high density, such for example as carbon tetrachloride or ethyl chloride, is employed as the refrigerant and the vaporized refrigerant is withdrawn from the evaporator or cooler in which the refrigerant is vaporized and delivered at a higher temperature to a vapor condenser by a centrifugal compressor which acts by centrifugal force to maintain a difference in pressure in the evaporator and condenser.

One of the objects of this invention is to produce a practical and efficient refrigerating system of this sort in which the reduction in temperature is produced by the direct expansion or vaporization of the refrigerant, and the cooled refrigerant is circulated through a coil or pipe circulating system which can be utilized for refrigerating water or brine, as bunker coils for cooling rooms, or in any other way by which the cooled refrigerating medium circulating through the coils or pipes can be utilized for cooling purposes. Such a system has the great advantage that the evaporator or chamber in which the refrigerant liquid is vaporized for lowering its temperature can be of comparatively small size and simple construction, avoiding the necessity for the tubes or other heat-transmitting surfaces and connections such as are required in systems in which the refrigerant is vaporized by heat abstracted from brine or other liquid which is being cooled and is circulated through the evaporator. In the present system, refrigerant liquid is discharged under pressure against a turbine, Pelton wheel or rotary device which finely atomizes the refrigerant and insures a complete, rapid vaporization and cooling of the same. The power developed by the impact of the jet or jets of refrigerant discharged against the turbine or Pelton wheel is utilized to supplement the driving motor for the pump that circulates the refrigerant through the refrigerating coil or piping so that only a small motor for the pump is necessary.

In the accompanying drawings:

Fig. 1 is a vertical sectional elevation of a refrigerating apparatus embodying the invention.

Fig. 2 is an enlarged sectional elevation of the upper end of the liquid seal for the pump shaft.

Fig. 3 is a horizontal section on line 3—3, Fig. 2.

Fig. 4 is a sectional elevation thereof on line 4—4, Fig. 1.

Fig. 5 is a fragmentary section on an enlarged scale, of the evaporator.

A represents the evaporator or chamber in which the refrigerant is vaporized, B a condenser and C a centrifugal fan, compressor or exhauster which exhausts the vaporized refrigerant from the evaporator and delivers it at a higher pressure to the condenser. The vaporized refrigerant is liquified in the condenser and the liquified refrigerant returned to the evaporator or expansion chamber. A pump E circulates the liquid refrigerant collecting in the evaporator or expansion chamber, and which has been cooled by the vaporization or expansion, through one or more refrigerating coils F or a closed pipe circuit and again discharges the liquid into the evaporator.

The condenser B and the compressor C for exhausting the vaporized refrigerant from the evaporator and delivering it to the condenser may be constructed and arranged in any suitable manner. Preferably the arrangement is substantially as disclosed in my application for patent above mentioned. The condenser is arranged horizontally and serves as a supporting base for the centrifugal compressor and its driving motor. The fan or compressor C is arranged with its axis of rotation horizontally, and the casing thereof is mounted on the condenser. A multiple stage contrifugal fan or compressor is shown, and is constructed and operates in a well known manner, described in said application, the vapor passing through the several rotors and the compartments forming the successive stages of the compressor and being delivered from the last stage to the condenser. G is the motor for driving the fan or compressor. The motor shaft is suitably coupled to the end of the compressor shaft 1. The shaft, as shown, is jour-

nalled at opposite ends in suitable bearings 2 and 3, mounted on opposite ends of the compressor casing. The bearing 2 and that end of the compressor shaft journalled therein are enclosed within a housing 4 secured by a suitable gas tight joint to the adjacent end of the compressor casing so that there is no possibility of leakage through the opening around the compressor shaft at this end of the compressor. Leakage of vapor from or air into the compressor casing at its opposite end, where it is necessary for the shaft to be exposed for connection with the driving motor, is prevented by a suitable stuffing box H. This stuffing box should be of some suitable construction adapted to prevent leakage into or out of the compressor without causing substantial friction when the compressor is in operation, and also to effect a tight closure of the shaft opening when the compressor is not running. Preferably a stuffing box of the construction described in said application is employed.

The condenser shown is of known construction, consisting of opposite heads 5 and 6 connected by horizontal flow tubes for the condensing water or medium, which tubes are enclosed within a casing 7 connecting the two heads. The water or condensing medium is admitted to the head 5 through a supply connection 8 and flows through the tubes below a transverse partition 9 in the head 5, and thence passes through the other head 6 and remaining tubes back to the head 5, from which it discharges through a discharge pipe or connection 10. The refrigerant vapor is condensed in the condenser by contact with the tubes and the liquefied refrigerant which collects in the bottom of the condenser is returned by the difference in pressure in the evaporator and condenser through a pipe 11 to the evaporator, in the bottom of which it collects. The liquefied refrigerant expands in discharging from the pipe 11 into the evaporator, thus causing a reduction in the temperature. The discharge from the pipe 11 into the evaporator is preferably controlled by a float-actuated valve 12 for maintaining a predetermined, desired level of the liquid in the evaporator. This float-operated valve may be of any suitable known construction. As shown, the float 13 is of segmental, annular form and arranged in the evaporator chamber between the cylindrical wall of the latter and a pump and turbine supporting frame suspended centrally in the chamber.

The evaporator or vaporizing chamber is preferably formed by an upright, stationary, cylindrical casing 14. The refrigerant circulating pump E and a turbine or atomizing wheel I are mounted in this chamber preferably on a skeleton frame or cage 15 which is suspended in the casing 14 from suitable supports at the upper part of the casing or is otherwise removably secured in the casing so that the frame with the pump and other parts mounted thereon can be readily secured in and detached and lifted vertically out of the stationary casing 14. As shown, the pump E is arranged horizontally in the bottom of the evaporator casing with its rotor secured to the lower end of a shaft 16 which extends vertically centrally through the evaporator casing and out through a shaft opening in the top or cover of the casing. As shown, this shaft is journalled at its lower end in a suitable bearing 17 on the lower end of the frame 15 and at its upper end in a bearing 18 suitably mounted on top of the stationary casing. The pump shaft 16 is suitably coupled to the shaft of a small driving motor 19 which is preferably suitably mounted on top of the stationary casing in such a way as not to interfere with the releasing and removal of the pump supporting frame 15 out of the upper end of the evaporator casing.

It is necessary to prevent leakage of air into the evaporator casing or the loss of vacuum through the opening through which the pump shaft extends out through the top of the casing. In order to accomplish this without the use of a stuffing box or gland, which in order to be gas tight would create undue friction on the revolving shaft, the pump and turbine or refrigerant atomizer are mounted in the evaporator chamber and a liquid seal provided for the shaft opening in the top of the casing, preferably by the following construction:

The turbine wheel I is fixed on the lower portion of the shaft 16 above the pump with a driving fit or otherwise so as to form a gas tight joint with the shaft. Surrounding the shaft above the turbine wheel is a sleeve or tube 25 provided at its lower end with a flange 26. The lower end of the sleeve is closed by a disk 27 which surrounds the shaft above an upwardly facing shoulder 28 thereon. The flange 26 and turbine wheel are tightly secured together as by bolts 29 passing through these parts, and the joint between the contacting faces of the disk 27 and turbine wheel is made gas tight in any preferred manner, as for instance by suitable packing gaskets 30 seated in grooves between the contacting faces and between the disk 27 and the shoulder 28 on the shaft. The sleeve or tube 25 is of larger internal diameter than the portion of the shaft which it surrounds thus leaving an annular space in the sleeve around the shaft. Extending lengthwise in this space is a stationary sealing tube 32 which divides the space into narrow inner and outer annular sealing cells 33 and 34. This sealing tube 32 is secured at its upper end to the lower end of a tube 35 which is brazed or otherwise secured by a gas tight joint in the opening 36 in the top of the

casing through which the pump shaft passes, and extends downwardly around the pump shaft into the upper end of the sealing tube 32. The tubes 32 and 35 are secured together by a brazed or other suitable gas tight joint. The sealing cells 33 and 34 are of sufficient length and contain enough mercury to form a mercury column preferably adapted to extend around the lower end of the sealing tube 32 and to a height of at least 32 inches in the outer sealing cell 34. A mercury seal is thus formed adapted to maintain a substantially perfect vacuum within the evaporator casing. The lower end of the sealing tube 32 is preferably flared or provided with a flange 37 which extends outwardly into an annular enlargement $37^a$ in the bore of the sleeve 25. An expansion chamber 38 or enlargement of the upper end of the outer sealing cell 34 is formed preferably by a removable cap $38^a$ screwed on the upper end of the sleeve 25. Secured on the lower end of the tube 35 is a stationary collar provided with blades 39 which project outwardly into the expansion chamber 38. The joint between the cap $38^a$ and the upper end of the outer sleeve 25 is made tight by a packing gasket of any suitable sort.

When the pump shaft is in rotation the centrifugal action of the body of mercury in the rotating chamber formed by the sleeve 25, and the difference in pressure in the inner and outer sealing cells causes the mercury column to rise in the outer chamber 34 to a height depending upon the vacuum or difference in pressure within and outside of the evaporator casing. The expansion chamber 38 at the top of the sealing cell provides an enlarged space in which the mercury can collect in case it rises above the top of the outer cell, and the stationary blades 39 in this chamber impede the rotation of the mercury in the chamber and prevent the mercury from being thrown out of the chamber by centrifugal force.

The sleeve 25, which rotates with the pump shaft 16 and turbine wheel, is preferably journaled in suitable upper and lower anti-friction bearings 40 and 41 which are supported by spiders or supports 42 and 43 respectively, projecting inwardly from the skeleton supporting frame 15 in the evaporator casing. Since the sealing sleeve 25 is rigid with the pump shaft 15, the latter is in part supported and steadied in its rotation by said bearings 40 and 41. The bearings 40 and 41 are preferably combined radial and thrust ball bearings, each constructed and mounted as follows: The outer race ring of the bearing is seated in a recess in a cup or shell 46 and the inner race ring is secured on a supporting collar 47 which is secured to the rotary sealing sleeve 25 and extends down into the shell 46. The inner race ring is secured on the collar 47 between a shoulder at its lower end and a nut 48 screwed on the collar, and the collar is secured at its upper end on the sleeve 25 between a shoulder 49 thereon and a nut 50 screwed on a threaded portion of the sleeve. The supporting collar 47 for the lower bearing 41 and its securing nut are of large enough diameter to be slipped into place on the shaft and removed over the securing shoulder for the supporting collar 47 for the upper bearing. The shells 46 of the upper and lower bearings are bolted or otherwise removably secured on their supports 42 and 43 and the shell of the lower bearing is of an external diameter, small enough to be inserted and removed through the opening in the support 42 for the upper bearing, thus enabling the ready assembling and disassembling of the parts.

The skeleton frame or cage 15 can be of any suitable construction adapted to afford the necessary support and rigidity for the bearings for the pump shaft. The frame is, however, as before mentioned, preferably constructed so that it, with the pump, turbine and other parts supported thereby can be inserted into and lifted out of the evaporator casing 14 through the open upper end thereof and be removably secured within the casing, while at the same time the necessary gas tight closure for the upper end of the casing is provided. As shown, the supporting frame 15 is provided at its upper end with an outwardly projecting annular flange 55 which rests upon and is removably bolted to an internal flange or shoulder 56 on the stationary casing 14. The joint between the flanges 55 and 56 is sealed or made gas tight in any suitable manner, as for example, by means of packing gaskets 57 compressed in grooves between the contacting faces of the flanges 55 and 56. The upper end 58 of the frame 15, which is annular and forms in part the top of the evaporator casing, is provided with a removable cover or sealing head 59 in which the hole 36 through which the pump shaft passes is formed. This head is bolted or otherwise removably secured on the top 58 of the frame 15 and the joint between the head and frame sealed by suitable packing gaskets or other suitable sealing means. The cover is provided on the top thereof with an upwardly projecting flange 60 surrounding the pump shaft opening 36 and forming a well within the flange around the shaft. This flange or well is provided for the purpose of enabling the evaporator casing to be submerged in a sealing liquid contained in an outer jacket or casing 61 with the sealing liquid at a level below the top of the flange or well 60 so as to prevent the sealing liquid from entering the mercury seal for the pump shaft.

The pump E, which draws the refrigerant

liquid from the bottom of the evaporator casing 14, delivers the liquid through a discharge pipe 62 to the refrigerating or bunker coil or coils F, and after circulating through the coil or other circulating system, the liquid is returned through a pipe 63 and discharges under pressure through one or more suitable nozzles 64 against the turbine or atomizing wheel I which thoroughly atomizes the refrigerant and causes a rapid vaporization of the liquid with a consequent reduction in temperature in the evaporator. The liquid which falls and collects in the bottom of the evaporator casing 14 for circulation by the pump E has the same temperature as the vaporized liquid. The discharge of the liquid against the turbine wheel I tends to rotate this wheel, and the power thus developed is utilized to supplement the motor 19 in driving the pump E, so that only a comparatively small driving motor 19 for the pump is necessary. 65 represents an automatic relief valve of any suitable construction for the return pipe 63. This valve is adapted to be opened by pressure in the refrigerant circulating system, when a predetermined maximum pressure is reached so as thereby to prevent back pressure in the circulating system. Preferably this relief valve is placed in a branch 66 of the return pipe, and this branch pipe is provided with a nozzle arranged to discharge against the turbine wheel I. Any vapor or liquid discharging through the relief valve is thus utilized in driving the turbine wheel. The boiling point of the refrigerant liquid used at atmospheric pressure is always above any natural atmospheric temperatures. Therefore, no vapor is formed in the refrigerating coil or circulating system. The cooling coil is operated at low pressure, preferably not above one or two pounds pressure.

When the refrigerating coil F is used in a cooler for cooling a liquid such as water, as illustrated in the drawings, an automatic control is preferably employed for preventing possible freezing of the water. For this purpose a vapor pressure thermostat 67 is shown in the water discharge pipe 68 of the cooler, said thermostat being operatively connected to a thermostatic valve 69 in the refrigerant return pipe 63. If the temperature of the water drops below the degree for which the thermostat is set, the valve 69 will be actuated to stop or reduce the circulation of the refrigerant through the coil F and thus prevent further reduction in the temperature of the water.

I claim as my invention:

1. In a refrigerating system employing a volatile liquid refrigerant, the combination of a vaporizing chamber, a condenser for the vaporized refrigerant, a centrifugal compressor which delivers the refrigerant vapor from the vaporizing chamber to the condenser, means for returning the liquefied refrigerant from the condenser to the vaporizing chamber in which a body of refrigerant liquid is maintained, a refrigerating coil, a rotary pump located in said vaporizing chamber for circulating the refrigerant liquid from the vaporizing chamber through said coil and discharging it into the vaporizing chamber, and an atomizing device in said vaporizing chamber and connected to rotate with said pump for atomizing the refrigerant liquid in the vaporizing chamber whereby it rapidly expands and lowers the temperature in said chamber by direct expansion.

2. In a refrigerating system in which a volatile liquid refrigerant is employed, the combination of a vaporizing chamber, a rotary wheel in said vaporizing chamber against which a jet of the refrigerant liquid is projected in a direction to rotate said wheel and which atomizes the refrigerant liquid, a condenser including means for condensing the refrigerant vapor, a compressor which withdraws the refrigerant vapor from the vaporizing chamber and delivers it to the condenser, a refrigerating coil, means for delivering the liquid refrigerant from the condenser to said vaporizing chamber, and a pump which circulates the liquefied refrigerant through said coil and discharges the same against said wheel, said pump being located in the vaporizing chamber and connected to said wheel so that the power produced by the rotation of said wheel is utilized in driving said pump.

3. In a refrigerating system in which a volatile liquid refrigerant is employed, the combination of a vaporizing chamber, a refrigerating coil, a pump which draws refrigerant liquid from said vaporizing chamber, circulates it through said coil and discharges it into the vaporizing chamber, a wheel in the vaporizing chamber which is rotated by said discharging refrigerant liquid and atomizes the refrigerant, said wheel having a driving connection with said pump, a condenser including means for condensing the vaporized refrigerant, means for delivering vaporized refrigerant from the vaporizing chamber to the condenser, and means for returning liquefied refrigerant from the condenser to the vaporizing chamber.

4. In a refrigerating system in which a volatile liquid refrigerant is employed, the combination of a vaporizing chamber, a refrigerating coil, a pump which draws refrigerant liquid from said vaporizing chamber, circulates it through said coil and discharges it into the vaporizing chamber, a motor for driving said pump, a wheel in the vaporizing chamber which is rotated by

said discharging refrigerant liquid and supplements said motor in driving said pump, a condenser including means for condensing the vaporized refrigerant, means for delivering vaporized refrigerant from the vaporizing chamber to the condenser, and means for returning liquefied refrigerant from the condenser to the vaporizing chamber.

5. In a refrigerating system in which a volatile liquid refrigerant is employed, the combination of a vaporizing chamber, a refrigerating coil, a pump which draws refrigerant liquid from said vaporizing chamber, circulates it through said coil and discharges it into the vaporizing chamber, a wheel in the vaporizing chamber which is rotated by said discharging refrigerant liquid and atomizes the refrigerant, a branch discharge pipe connected to said refrigerating coil and arranged to discharge the refrigerant against said wheel, and a relief valve in said branch pipe which is opened by a predetermined pressure of the refrigerant and permits discharge from said branch pipe, a condenser including means for condensing the vaporized refrigerant, means for delivering vaporized refrigerant from the vaporizing chamber to the condenser, and means for returning liquefied refrigerant from the condenser to the vaporizing chamber.

6. In a refrigerating system employing a volatile liquid refrigerant having a low vapor pressure and a high specific density, the combination of a vaporizing chamber, a condenser for the vaporized refrigerant, a centrifugal compressor which delivers the refrigerant vapor from the vaporizing chamber to the condenser and maintains a relatively low difference of pressures in the vaporizing chamber and in the condenser, means for returning the liquefied refrigerant from the condenser to the vaporizing chamber, a refrigerating coil, means for circulating the liquid refrigerant from the vaporizing chamber through said coil and discharging it in the vaporizing chamber in a finely divided condition whereby it rapidly expands and lowers the temperature in said chamber by direct expansion, and a regulator which automatically regulates the quantity of the circulated liquid refrigerant discharged into the vaporizing chamber independently of changes in speed of the liquid circulating means to control the refrigeration.

7. In a refrigerating system employing a volatile liquid refrigerant having a low vapor pressure and a high specific density, the combination of a vaporizing chamber, a condenser for the vaporized refrigerant, a centrifugal compressor which delivers the refrigerant vapor from the vaporizing chamber to the condenser and maintains a relatively low difference of pressures in the vaporizing chamber and in the condenser, means for returning the liquefied refrigerant from the condenser to the vaporizing chamber, a refrigerating coil, means for circulating the liquid refrigerant from the vaporizing chamber through said coil and discharging it in the vaporizing chamber in a finely divided condition whereby it rapidly expands and lowers the temperature in said chamber by direct expansion, and means operating automatically under the control of the temperature produced by the circulating refrigerant for regulating the quantity of the liquid refrigerant discharged into the vaporizing chamber to control the refrigeration.

8. In a refrigerating system in which a volatile liquid refrigerant is employed, the combination of a vaporizing chamber, means for causing the refrigerant to vaporize in said chamber and lower the temperature in said chamber by direct expansion of the refrigerant, a condenser including means for condensing the refrigerant vapor, means for delivering vaporized refrigerant from the vaporizing chamber to the condenser and maintaining a pressure below atmospheric pressure in the vaporizing chamber, a refrigerating coil, and a pump which circulates the liquid refrigerant through said coil and returns it to the vaporizing chamber, said pump being located in the vaporizing chamber and having a drive shaft extending out of said chamber through a shaft opening, a liquid seal for said shaft opening, and a support on which said pump, shaft and liquid seal are mounted in the vaporizing chamber and which is removable from said chamber with said parts thereon.

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