June 3, 1930. L. F. WHITNEY 1,761,762

REFRIGERATING APPARATUS AND METHOD

Filed Jan. 6, 1927 2 Sheets-Sheet 1

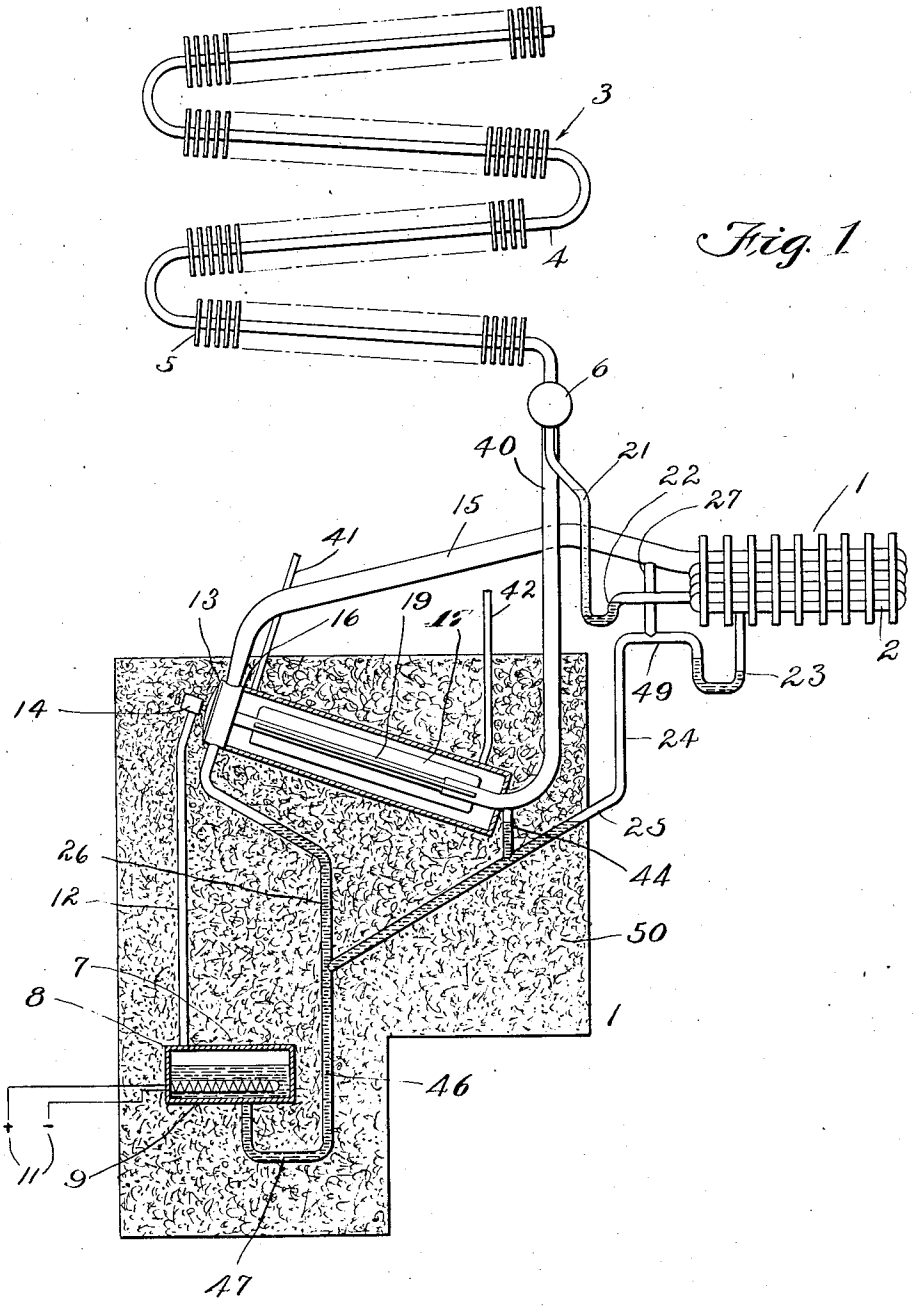


Fig. 1

Inventor:
Lyman F. Whitney
by Roberts, Cushman & Woodberry.
Att'ys

June 3, 1930. L. F. WHITNEY 1,761,762

REFRIGERATING APPARATUS AND METHOD

Filed Jan. 6, 1927 2 Sheets-Sheet 2

Fig. 2

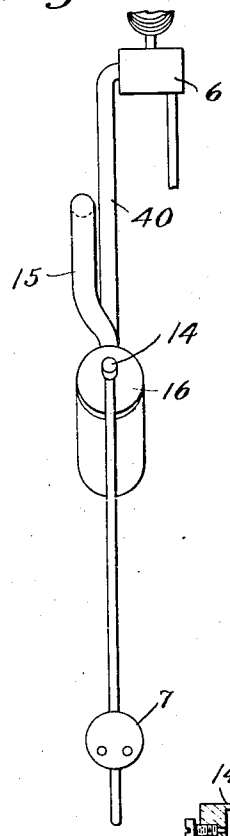


Fig. 3

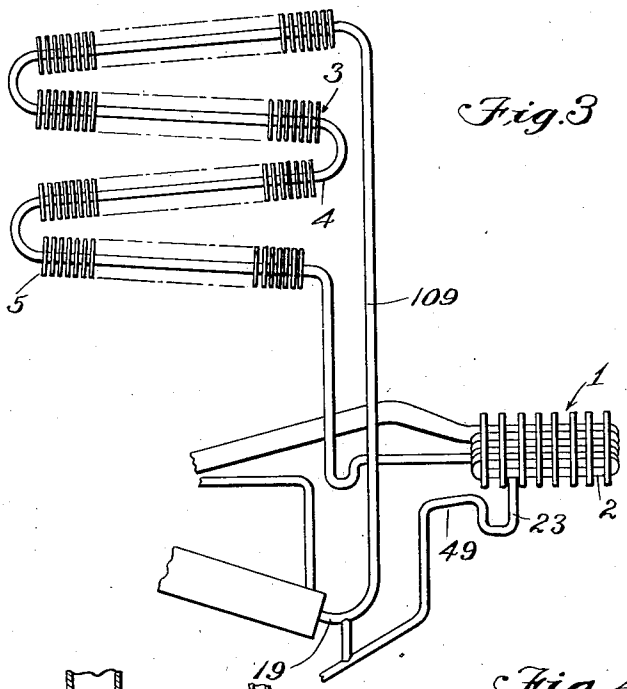


Fig. 4

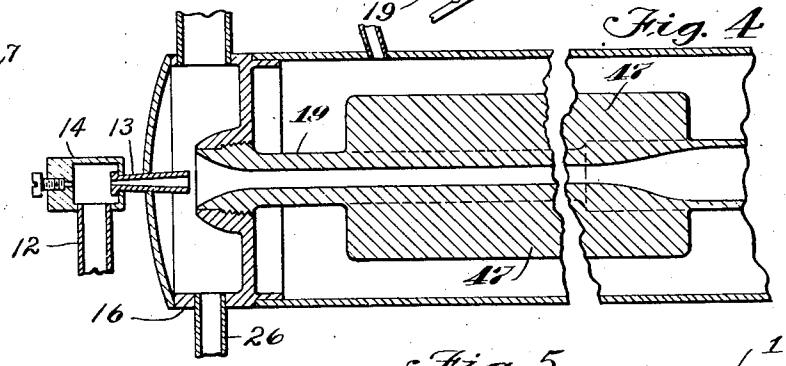


Fig. 5

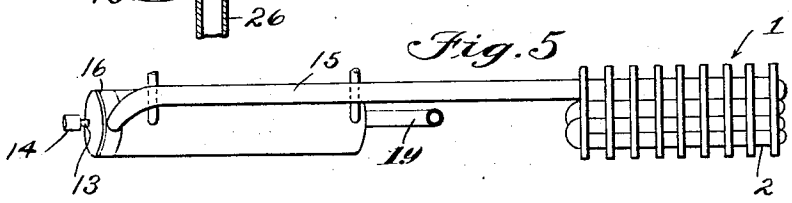
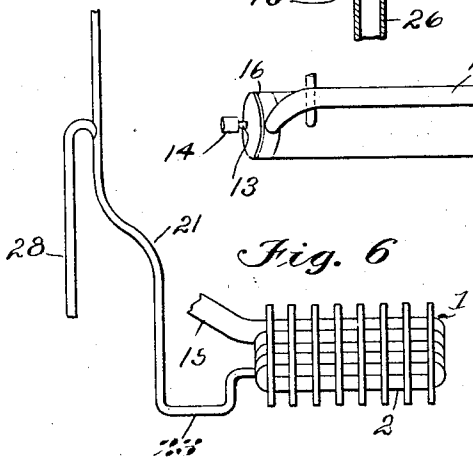


Fig. 6



Inventor
Lyman F. Whitney
by Roberts Cushman & Woodberry
Att'ys

Patented June 3, 1930

1,761,762

UNITED STATES PATENT OFFICE

LYMAN F. WHITNEY, OF BOSTON, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO STATOR REFRIGERATION, INC., A CORPORATION OF DELAWARE

REFRIGERATING APPARATUS AND METHOD

Application filed January 6, 1927. Serial No. 159,343.

This invention relates to a refrigerating system employing two kinds of fluid, namely a refrigerating and a propellent fluid, the latter being used to pump refrigerant vapor from a cooler to a condenser, and more particularly relates to a system having a boiler for generating propellent vapor, a duct leading from the boiler to the aspirator, and a liquid duct leading from a propellent condenser to the boiler, whereby the propellent fluid may return to the boiler and wherein it may form a liquid head to balance the boiler pressure. This invention in some aspects therefore relates to refrigerating apparatus of the character disclosed in application No. 733,699 filed August 23, 1924 by Eastman A. Weaver, but comprises an improvement thereover, by presenting a system of higher thermal efficiency, characterized more particularly by a more advantageous disposition and arrangement of the component factors of the refrigerating system and by the provision of spaced condensing elements for the propellent and refrigerating media, thus not only permitting a greater thermal efficiency but also allowing a marked decrease in the total condensing area and corresponding necessity for applying a cooling draft or current to the condensing surfaces. Further advantageous uses and desirable combinations of various features of the present invention are shown in my copending applications Nos. 159,342, 159,344, 159,345, and 159,346, filed on even date herewith.

While the preferred embodiment of the invention illustrated herein is designed to employ a propellent liquid having a materially higher density than the refrigerant liquid, such a condition is not essential to the advantageous use of the principles of this invention; and in certain installations, it may be found desirable to use a refrigerant which has a different composition in the liquid than in the vapor phase, certain solvents being suspended in the refrigerant in its liquid phase. The condensers may be cooled in any suitable way, either one or both thereof being merely exposed to the atmosphere or to a current of cooling fluid. The principles of this invention will thus be found advantageous under various operating conditions and in widely varying types of installations.

Further objects and advantages of the invention will be apparent to those skilled in the art upon a reading of the subjoined description and claims in conjunction with the accompanying drawings in which:

Fig. 1 is a diagrammatic view of the improved refrigerating system;

Fig. 2 is an end elevational view of a portion of the system, heat insulating material being removed;

Fig. 3 is a diagrammatic view of another form of refrigerating system;

Fig. 4 is a central longitudinal section through the aspirator and related parts;

Fig. 5 is a plan view of a part of the system; and

Fig. 6 is a broken diagrammatic view of a modified piping arrangement desirable with a refrigerating system of this type when certain kinds of propellent fluid are used.

Referring to the accompanying drawings and more particularly to Fig. 1 thereof, the improved refrigerator system is provided with a suitable cooler 1, which may be located within the conventional household refrigerator or in any other suitable region which is to be cooled. Spaced from the cooler 1 and below the same is a vaporizer 8 for boiling the propellent liquid such, for example, as mercury. This boiler may be heated in any desired manner and as shown is provided with an electric heating unit 9 which may be energized through suitable leads 11 from any conventional source of current. Vaporizer 8 is provided with an upwardly extending outlet 12 which terminates in a high pressure chamber or elbow 14 in which is inserted the small or inlet end of aspirator nozzle 13. This nozzle may preferably be of conventional tapered form and is designed approximately to permit adiabatic expansion of the propellent vapor to a much lower pressure and temperature, thus giving it a high velocity, as it enters mixing chamber 16. A vapor duct

15 connects cooler 1 with mixing chamber 16, whereby evaporation of refrigerant may take place in the cooler, due to the suction caused by the rapidly moving stream of propellent vapor through the mixing chamber.

In concentric alignment with the aspirator jet is a combined condenser and compression duct 19, into which the mixture of propellent fluid and the impelled particles of refrigerant vapor pass, the kinetic energy of the former being consumed and the latter being compressed. Duct 19 is cooled by suitable fins 47 which may be exposed to the atmosphere, to an artificially induced current of air, or as shown in Fig. 1 may be enclosed in a water jacket so that the heat will be absorbed by circulating water which enters and leaves the jacket through connections 41 and 42 respectively.

Duct 19 is downwardly inclined and preferably terminates in an upwardly curved continuation which comprises a vertically extending duct 40. At the lowest part of pipe 19 is an outlet 44 which connects with an inclined pipe 25 which in turn joins a pipe 46 comprising a trap 47 which opens into the bottom of boiler 8, thus providing outlets for mercury or propellent fluid which may have been condensed in mixing chamber 16 or duct 19. Pipes 25, 26 and 46 are adapted to hold static liquid columns to provide a suitable liquid head to balance the vapor pressure in boiler 8. For example, after all fixed gases are exhausted from the system if the mercury is heated to a temperature such that the pressure in the boiler is 760 mm., liquid mercury will stand in pipes 46 and 25 approximately 30 inches above the liquid level in the boiler, thus permitting the installation of the system within a space of reasonable size and yet permitting the balancing of the boiler pressure by a suitable liquid head.

Pipe 40 has an in-curved upper end which is adapted to emit vapor into a seperating chamber 6 to the upper portion of which the condenser 3 is connected, as disclosed in Figs. 1 and 2. Condenser 3 may be of any desired form but preferably comprises single pipe 4 bent to provide oppositely disposed open loops having a general downward inclination, whereby condensed refrigerant will tend to flow downwardly through chamber 6 to pipe 21. Any suitable cooling means may be used for condenser 3. As shown, it is provided with the fins 5 which are adapted to give up heat to the atmosphere, but a forced circulation of air, water, or any other suitable medium may be used for this purpose.

At the lower part of tube 21 is a suitable liquid trap 22 with a horizontal continuation entering cooler 1. This trap may be filled with any suitable liquid such as the propellant itself. Under normal working conditions a column of condensed refrigerant tends to build up in the pipe 21 to a height sufficient to balance the liquid in the opposite leg of the trap, whereupon refrigerant leaks through the liquid in the trap and passes into the cooler. A trap of this type permits a difference of pressure between the condenser and the cooler which results from compression of the vapor taking place in duct 19. In order to allow drainage of any residual propellent fluid which may have remained in the refrigerant as it passes upward to condenser 3 and downward to tube 21, an outlet is provided at the lower part of cooler 1 with a suitable liquid trap 23 similar to trap 22 and joining the pipe 24 by a suitable continuation 49, a suitable connection 27 being provided between tubes 15 and 49 so that fluid in the trap will not be displaced when the system is subjected to certain special conditions, such as, when, after being evacuated, gas is admitted to the system and so that there will be no tendency for gas to pocket when the system is being evacuated.

In the operation of a refrigerating system of this character it has been found advantageous to use a propellent fluid with a comparatively high density and a high boiling point, such as mercury, and a refrigerant having about the characteristics of water or of a solution of salt or caustic and water, whereby the refrigerant may differ in its liquid and vapor phase.

Preferably the boiler, tubes 12, 44, and a portion of tube 25, as well as the aspirator and compression duct 19, are entirely enclosed with suitable insulating material 50, as indicated in Fig. 1. This heat insulation retards the leakage of heat to the atmosphere from the hot aspirator nozzle 13 and boiler 8, as well as from tubes 12, 25 and 26. Furthermore, the arrangement of the compression duct 19 with a moderate downward slope allows satisfactory drainage of condensed propellant, while permitting a compact system in which the hot pipe 12 is not unnecessarily long and thus does not cause needless heat losses.

A refrigeration system having separate condensers for the refrigerant and propellent fluid respectively affords several advantages over a system wherein these fluids are condensed in a single condenser. When both fluids are condensed in a single condenser it is necessary to reduce their temperatures substantially to the temperature of condensation of that fluid which has the lower boiling point; for example, when mercury is used as a propellant and water as a refrigerant, the temperature of the mercury vapor must be substantially reduced to the temperature of condensation of the water vapor under the pressure condition existing in the system. The liquid mercury

at this comparatively low temperature must then be reheated to its boiling point in order to effect its revaporization. It is thus evident that considerable thermal loss is involved in the unnecessary cooling and reheating of the propellant in a system having a single condenser. Furthermore, separate condensation of the mercury and water, as disclosed by the present invention, permits a material saving in the cooling area of the condensers as compared with a system using a single condenser for both the propellant and refrigerant fluids, since it is not necessary to provide as much condensation capacity when the temperature of the mercury is only reduced below its own condensation point rather than substantially to the condensation point of the water vapor.

Fig. 6 shows an arrangement of piping which may be substituted for the separating chamber 6 and as particularly useful in conjunction with a propellant having a lower density than the refrigerant, for example, penta ethyl benzine. In this form of the invention the duct 28 corresponding to the duct 40 of Fig. 1 terminates in a substantially horizontal extremity which vents directly into pipe 21, this junction being located at such a height in relation to the cooler that a liquid column of refrigerant sufficient to balance the liquid in trap 23 will not overflow into pipe 28, but so that a column formed by the lighter propellant will overflow into pipe 28 rather than pass through the liquid trap to the cooler. The height of the outlet of pipe 28 should also be such that the weight of a column of refrigerant filling pipe 21 from the trap 23 up to the outlet of pipe 28 differs from that of a similar column of propellant by an amount corresponding to the maximum difference in pressure in the cooler and refrigerant condenser respectively for which the system is designed.

A slightly different arrangement of piping which permits a compact installation is shown in Fig. 3. According to this form of the invention, the compression duct 21 is connected by an upstanding pipe 109 to the upper end of the condenser 3, while the lower end of the latter is connected directly to pipe 19 and thus the separating chamber may be omitted.

I claim:

1. The art of refrigeration which comprises vaporizing a refrigerant in the region to be cooled, condensing the refrigerant vapor in another region, pumping the refrigerant vapor from the first to the second region by means of the vapor of a propellent liquid having a higher boiling point than the refrigerant liquid, and condensing the propellent vapor out from the refrigerant vapor in a region which is substantially out of heat-transfer relation with the region in which the refrigerant vapor is condensed.

2. The art of refrigeration which comprises vaporizing a refrigerant liquid in the region to be cooled, condensing the refrigerant vapor in another region, directly impelling the refrigerant vapor from the first to the second region by means of the vapor of a propellent liquid having a different boiling point than that of the refrigerant, and effecting the substantial condensation of the propellant and refrigerant vapors in regions which are spaced from each other.

3. The art of refrigeration which comprises vaporizing a refrigerant in the region to be cooled, condensing the refrigerant vapor in another region, drawing the refrigerant vapor from the first to the second region by means of the vapor of a propellant, which has a higher boiling point and a higher density than the refrigerant, conducting the mixture of fluids through a condenser at a comparatively high temperature whereby the bulk of the propellant only is condensed, and conducting the residue of the mixture which largely comprises the refrigerant to a condenser at a higher level and a lower temperature which is substantially out of heat transfer relation with the first condenser, whereby the fluids may be separately condensed.

4. Refrigeration apparatus comprising a cooler containing a refrigerant, a dissipator, a duct leading from the cooler to the dissipator, an aspirator operatively associated with said duct, means for supplying to said aspirator the vapor of a propellent liquid having a higher boiling point than the refrigerant liquid, and means for condensing the propellent vapor out from the refrigerant vapor intermediate said aspirator and dissipator, said means being so separated from said dissipator that the heat absorbed in condensing the propellent vapor is not transferred to the dissipator in large degree.

5. Refrigeration apparatus comprising a cooler containing a refrigerant, a dissipator, a duct leading from the cooler to the dissipator, an aspirator operatively associated with said duct, means for supplying to said aspirator the vapor of a propellent liquid having a higher boiling point than the refrigerant liquid, and a condenser intermediate said aspirator and dissipator for removing the propellent vapor from the refrigerant vapor, said condenser and dissipator being arranged to operate at temperatures substantially independent of each other.

6. A refrigerating system comprising a cooler, means for pumping refrigerant vapor from the cooler to the condenser by propellent vapor, a condenser for one of said vapors, a second condenser between the pumping means and the first condenser for the

other vapor, said condensers being in substantially non-heat transfer relation with each other, whereby the vapor having the higher temperature of condensation may tend to liquefy in the first condenser and the other vapor may pass on to the second condenser to be liquefied.

7. A refrigerating system comprising a cooler, means for pumping refrigerant vapor from the cooler to the condenser by propellent vapor, a comparatively large condenser for one of said vapors, a second comparatively small condenser between the pumping means and the first condenser for the other vapor, said condensers being in substantially non-heat transfer relation with each other, whereby the vapor having the higher temperature of condensation may tend to liquefy in the first condenser and the other vapor may pass on to the second condenser to be liquefied.

8. A refrigerating system comprising a cooler, an aspirator, a duct for conducting refrigerant vapor from said cooler to said aspirator, means whereby aspirated propellent vapor may draw said refrigerant through said duct and become mixed with said refrigerant vapor and two condensers situated at different levels and connected with the outlet of said aspirator and said duct, the heavier of the two vapors collecting and condensing in the lower condenser and the lighter vapor separating from the heavier vapor and condensing in the upper condenser, said condensers being in substantially non-heat transfer relation with each other, whereby condensation therein may take place at widely differing temperatures.

9. A refrigerating system comprising a cooler, an aspirator nozzle, a vaporizer for propellent liquid connected to the aspirator, a vapor duct for directing evaporated refrigerant from said cooler to the outlet of the nozzle, a condenser receiving a mixture of the refrigerant vapor and propellent fluid and for condensing the latter, and a duct to drain the latter back to the vaporizer, a condenser for refrigerant above said first-named condenser and said cooler, an upstanding passageway to direct refrigerant vapor upward from the first condenser to the second condenser, and a pipe for draining liquid refrigerant from said condenser to the cooler, and means to prevent the return of condensed refrigerant through the upstanding passageway to the first condenser.

10. A refrigerating system comprising a cooler, an aspirator, a vaporizer for propellent liquid connected to the aspirator, a vapor duct for directing evaporated refrigerant from said cooler to the outlet of the aspirator, a condenser for receiving a mixture of the refrigerant vapor and an aspirated propellent fluid, and for condensing the latter, and a duct to drain the propellant back to the vaporizer, a condenser for refrigerant above said first-named condenser and said cooler, an upwardly extending passageway to direct refrigerant vapor upward from the first condenser to the second condenser, a pipe for draining liquid refrigerant from said condenser to the cooler, and means to prevent the return of condensed refrigerant through the upwardly extending passage to the first condenser, said means comprising a juncture of the passageway and pipe wherein the portion of the former which joins the latter has a substantially horizontal direction.

11. A refrigerating system comprising a cooler, containing a refrigerant with a moderate boiling point, an aspirator, a vaporizer, a pipe connection between the vaporizer and the inlet of the aspirator, a propellent fluid with a high boiling point in said vaporizer, a vapor duct for directing vaporized refrigerant to the outlet of said aspirator, a compression and condenser duct adjacent the outlet of the aspirator, means for cooling said duct to condense substantially all of the propellant therein, a condenser above said cooler and aspirator, a passageway for directing the vapor from said compression and condenser duct to said condenser and a layer of heat insulating material between the two condensers.

12. A refrigerating system comprising a cooler containing a refrigerant with a moderate boiling point, an aspirator, a vaporizer, a pipe connection between the vaporizer and the inlet of the aspirator, a propellent fluid with a high boiling point in said vaporizer, a vapor duct for directing vaporized refrigerant to the outlet of said aspirator, a compression and condenser duct adjacent the outlet of the aspirator, means for cooling said duct to condense substantially all of the propellant therein, a condenser above said cooler and aspirator, a passageway for directing the vapor from said compression and condenser duct to said condenser and a layer of heat insulating material between the vaporizer and each of the condensers.

13. A refrigerating system comprising a cooler containing a refrigerant with a moderate boiling point, an aspirator, a vaporizer, a pipe connection between the vaporizer and the inlet of the aspirator, a propellent fluid with a high boiling point in said vaporizer, a vapor duct for directing vaporized refrigerant to the outlet of said aspirator, a compression and condenser duct adjacent the outlet of the aspirator, means for cooling said duct to condense substantially all of the propellant therein, a condenser above said cooler and aspirator, a passageway for directing the vapor from

said compression and condenser duct to said condenser, a drain for returning condensed refrigerant to said vaporizer, and a layer of heat insulating material separating said drain and the pipe between the vaporizer and aspirator.

14. A refrigerating system comprising a cooler containing a refrigerant with a moderate boiling point, an aspirator, a vaporizer, a pipe connection between the vaporizer and the inlet of the aspirator, a propellent fluid with a high boiling point in said vaporizer, a vapor duct for directing vaporized refrigerant to the outlet of said aspirator, a compression and condenser duct adjacent the outlet of the aspirator, means for cooling said duct to condense substantially all of the propellant therein, a condenser above said cooler and aspirator, a passageway for directing the vapor from said compression and condenser duct to said condenser, and a drain for returning condensed refrigerant to said vaporizer, a layer of heat insulating material separating said drain and the pipe between the vaporizer and aspirator, and heat insulating material separating the said pipe from the refrigerant condenser.

15. A refrigerating system comprising a cooler containing a refrigerant, a refrigerant condenser, an aspirator, a vapor duct leading from the cooler to the outlet of the aspirator, a vaporizer connected to the aspirator inlet, a supply of propellent liquid having a high boiling point in the vaporizer, a condenser duct aligned with the aspirator outlet and being adapted to receive a mixture of the refrigerant and propellent fluids, said condenser having a restricted cooling area whereby the part of the mixture having the highest temperature of condensation, e. g. the propellant, may be condensed out of the mixture, and a connection for conducting the residue of the mixture to the refrigerant condenser.

16. A refrigerating system comprising a refrigerant circuit and a propellent circuit with a part in common, an aspirator in said common part, said common part including a propellent condenser, said propellent circuit including a vaporizer, said refrigerant circuit including a cooler, a duct extending from the cooler to the aspirator, a refrigerant condenser and a duct from the refrigerant condenser to the cooler, said last-named duct being joined intermediate its ends by a pipe from the propellent condenser, and an outlet duct from the propellent condenser forming a part of the propellant circuit, said pipe being arranged to drain propellant into said outlet duct but joining the duct leading to the refrigerant condenser in such a manner that liquid refrigerant from the refrigerant condenser normally will pass to the cooler rather than to the propellent circuit.

17. A refrigerating system comprising a cooler, means for pumping refrigerant from the cooler to a refrigerant condenser, a propellent condenser between the pumping means and refrigerant condenser, a single duct connecting the refrigerant condenser with the rest of the system, said duct having a branch connected to the cooler and a branch connected to the propellent condenser.

18. A refrigerating system comprising a cooler, means for pumping refrigerant from the cooler to a refrigerant condenser, a propellent condenser between the pumping means and refrigerant condenser, a duct connected to the lower part of the refrigerant condenser, a branch of said duct extending to the propellent condenser and adapted to direct refrigerant vapor to the refrigerant condenser and another branch of the duct connected to the cooler and adapted to return condensed refrigerant to the same.

19. A refrigerating system comprising a cooler, means for pumping refrigerant from the cooler to a refrigerant condenser, a propellent condenser between the pumping means and refrigerant condenser, a drain for condensed propellant adjoining the propellent condenser, a duct connected to the lower part of the refrigerant condenser, a branch of said duct extending to the propellent condenser and adapted to direct refrigerant vapor to the refrigerant condenser and another branch of the duct connected to the cooler and adapted to return condensed refrigerant to the same, said first branch being arranged to return propellant condensing therein directly to the propellent drain.

Signed by me at Boston, Massachusetts this 20th day of December, 1926.

LYMAN F. WHITNEY.