March 6, 1934. L. F. WHITNEY 1,949,732

VACUUM INSULATION

Filed Dec. 17, 1930

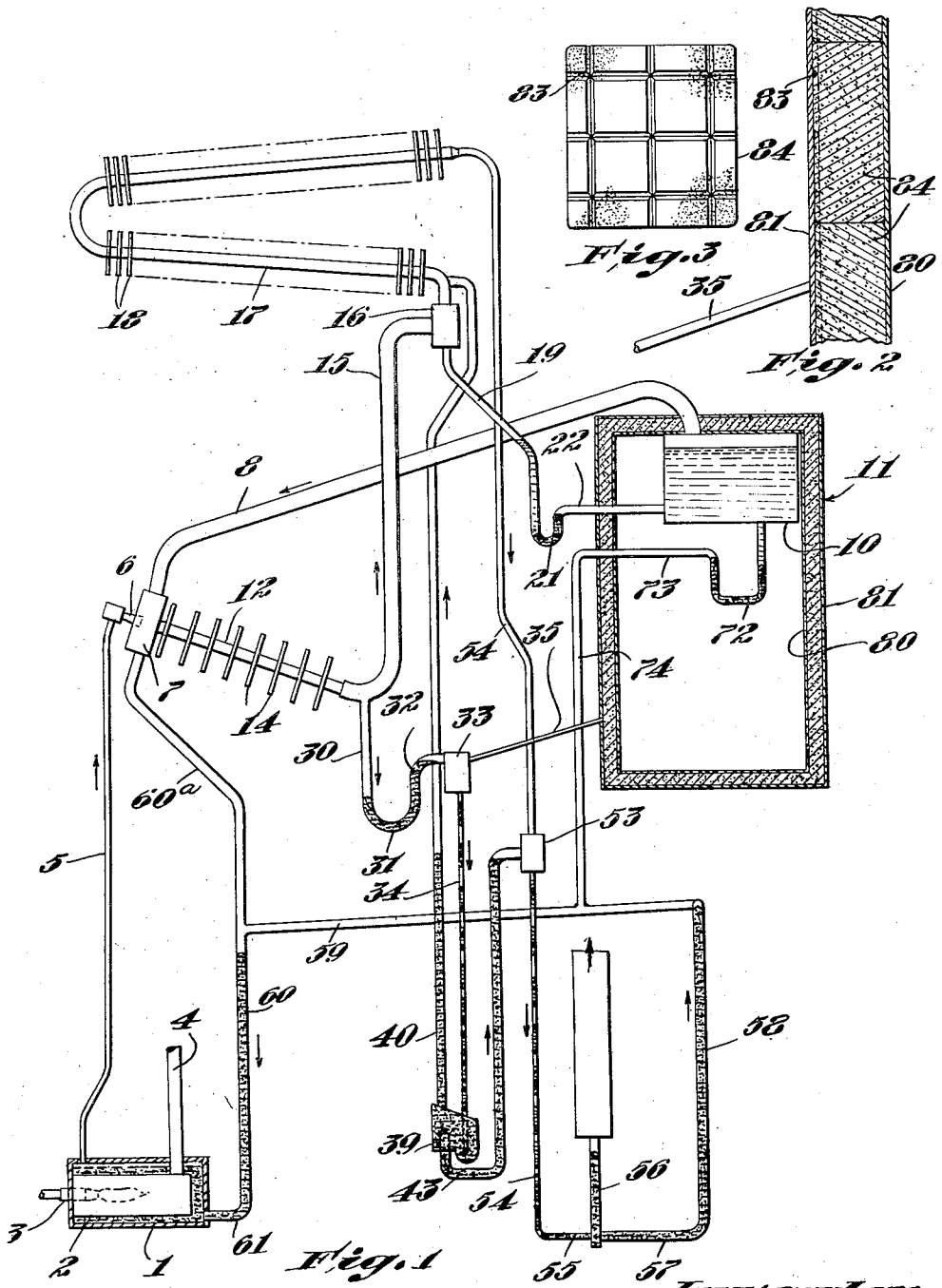


Fig. 3

Fig. 2

Fig. 1

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Patented Mar. 6, 1934 1,949,732

UNITED STATES PATENT OFFICE

1,949,732

VACUUM INSULATION

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Application December 17, 1930, Serial No. 503,005

7 Claims. (Cl. 62—115)

This invention relates to multi-stage pumping apparatus, and more particularly to improved refrigerating apparatus, for example, to the combination of a refrigerating system with a vacuum insulated refrigerator housing.

The copending application of Daniel F. Comstock, Serial No. 304,589, filed September 7, 1928, now Patent Number 1,898,977 bearing date of Feb. 21, 1933, discloses a general arrangement of this character in which a relatively high vacuum may be continuously maintained in a refrigerator housing by pumping means arranged to provide substantially continuous evacuation of the housing and thereby to compensate for minute leaks or the formation of gases from the metal walls of the vacuum chamber. That application also discloses an arrangement whereby a multi-stage pumping means is provided to permit the continued evacuation of the vacuum chamber, the first stage of this pumping means receiving non-condensable gases from the chamber and the second stage being arranged to receive not only the gases from the first-stage pumping means but also to effect continued evacuation or purging of a refrigerating system which operates at low or subatmospheric pressures.

The present invention is directed to an arrangement of the same general character, but more particularly to a simplified form of pumping means wherein a single working fluid may pass through a continuous circuit which includes pumping means in series, one of these pumping means being adapted to receive comparatively rarified gas from the vacuum chamber and thus to maintain a relatively high vacuum therein, and a succeeding pumping means being arranged to receive not only the gases from the first pumping means, but any gases which may have leaked into the low pressure refrigerating system with which the evacuating means preferably is associated. Such an arrangement is particularly adapted for employment with a low pressure refrigerating system of the general character disclosed in Patent No. 1,761,551 to Eastman A. Weaver, dated June 3, 1930, which preferably employs a heavy propellant liquid such as mercury, and a lighter, more volatile refrigerant such as water. Copending application No. 198,715 of Daniel F. Comstock, filed June 14, 1927, now Patent Number 1,892,869 bearing date of Jan. 3, 1933, shows a system of the general character provided with single-stage pumping means to exhaust non-condensable gases.

In accordance with the present invention, the multi-stage pumping means to maintain the vacuum in the vacuum chamber and the low pressure in the refrigerating system may be arranged in series in a single circuit, such as the main propellant circuit. Accordingly the propellant is first vaporized, being emitted from the aspirator nozzle to entrain refrigerant vapor from a cooler and to pump the refrigerant to a refrigerant condenser, and being condensed at a temperature above the temperature of liquefaction of the refrigerant. The condensed propellant then passes successively through a plurality of tubes of restricted internal diameter, wherein separate propellant globules are effective in entraining bodies of rarified gas from the vacuum chamber. This gas may be compressed by the propellant globules and then be emitted into a portion of the refrigerating system. The propellant may then pass to a succeeding tube of restricted diameter which is connected to the refrigerating system both to receive the gases from the first-stage pumping means and also any gases which may leak into the refrigerating system and tend to raise its pressure unduly.

Preferably the second-stage tube of restricted diameter is arranged to emit the gases into the atmosphere and to return the propellant to the upper end of a suitable pressure balancing column of the propellant, the lower end of which is connected to the boiler. It is evident that this arrangement may be effective in maintaining a comparatively high vacuum in the vacuum chamber, thereby permitting excellent heat insulation of the refrigerator and accordingly permitting the satisfactory employment of a refrigerating machine of lower capacity than would otherwise be feasible. Furthermore, this arrangement is so designed that it concomitantly permits the maintenance in the refrigerating apparatus of a low sub-atmospheric pressure, which, however, may be substantially higher than the pressure within the vacuum chamber.

In the accompanying drawing:

Fig. 1 is a diagrammatic representation of refrigerating apparatus associated with a vacuum walled refrigerator housing in accordance with the present invention;

Fig. 2 is a sectional detail of a typical wall portion of the refrigerator housing; and

Fig. 3 is a face or elevation view of a porous slab which preferably may be included between the inner and outer walls of the insulating chamber or housing.

Referring to the accompanying drawing, the numeral 1 designates a boiler which preferably may contain a relatively heavy propellant such

as mercury and which is provided with a combustion chamber 2 that is associated with a fuel burner 3 and an exhaust gas or outlet flue 4. Mercury vapor from the boiler 1 may pass upwardly through the tube 5 to an aspirator nozzle 6 which projects into a mixing or entraining chamber 7. The latter is connected by a vapor duct 8 with a cooler 10 that may be disposed in a refrigerator housing 11. The cooler 10 preferably is substantially filled with a body of liquid refrigerant such as water or a mixture of the same with a suitable ingredient such as salt to lower the freezing point of the refrigerant.

Propellant vapor flows out of the nozzle 6 at high speed and entrains vapor from the pipe 8, causing rapid evaporation at the surface of the liquid in cooler 10 and consequent maintenance of a low temperature in the refrigerator housing 11. The mixed propellant and refrigerant vapors flow into the compression and condensing funnel 12 where the propellant vapor is effective in compressing the refrigerant vapor and is concomitantly condensed out of the vapor mixture. Cooling means 14 such as fins may be provided to aid this liquefaction of the propellant.

The refrigerant, which has a much lower condensation point than the propellant, flows upwardly through the duct 15 and the chamber 16 to a refrigerant condenser 17 which has a larger cooling capacity than the condenser funnel 12, being provided, for example, with cooling fins 18. The condenser 17, as shown, may comprise a continuous inclined duct so that the liquefied refrigerant flows downwardly, through the same, returning to the chamber 16 and passing into the mouth of a downwardly extending duct 19 which is connected to the bottom of chamber 16.

The duct 19 is continued in a U-shaped trap 21 which has an extension 22 connected to the lower part of the cooler 10. The trap 21 may contain a relatively heavy fluid such as the propellant, e. g. mercury, and as a column of the condensed refrigerant piles up above this trap in the duct 19, a portion of the refrigerant will bubble through the liquid in trap 21 and thus return to the cooler. It is thus evident that the arrangement of the trap 21 permits the liquids to form pressure balancing means to permit the condenser to remain at a higher pressure than the cooler and yet to allow refrigerant to return from the condenser to the cooler.

The major portion of the condensed propellant is received by a duct 30 that is connected to the lower end of the condensing funnel 12. The duct 30 is continued in a U-shaped trap 31, the opposite leg 32 of which is connected to an entraining chamber 33. A gas duct 35 connects the chamber 33 with the interior of the hollow wall of the refrigerator housing 11; accordingly gas from this hollow wall passes through duct 35 to the chamber 33. A downwardly extending tube of restricted diameter or capillary dimensions, designated by numeral 34, is connected to the lower part of chamber 33. Tube 34 is so dimensioned that propellant from the duct 32 will pass down the same in the form of separate liquid globules which are in effect liquid pistons entraining bodies of gas therebetween, this gas being compressed as it passes downwardly to the lower open end of the tube 34 which is disposed adjoining the bottom of a separating chamber 39.

A gas duct 40 has an open lower end communicating with the upper part of chamber 39 so that gas may bubble through the liquid propellant in the chamber and the duct 40, passing upwardly through the latter. The upper end of duct 40 may be connected to a suitable part of the refrigerant circuit, such as the condenser 17. A duct 43 has an open end within the separating chamber 39 above the lower end of the capillary tube 34 and below the end of the duct 40. Accordingly propellant received by the chamber 39 tends to overflow into the duct 43 which is connected to an upwardly extending duct 45 which in turn is connected to an entraining chamber 53. The upper portion of the latter is connected to the upper part of the refrigerant condenser by a gas duct 54, while the lower part of chamber 53 is connected to a downwardly extending capillary tube 54 which is provided with a horizontal capillary continuation 55. Thus gases received from the refrigerant condenser 17 are entrained between liquid globules in the second-stage tube 54 and passes through the connection 55 into the standpipe 56 which contains a body of the propellant having its surface exposed to the exterior atmosphere. Since the standpipe 56 is of non-capillary dimensions, the gases can here separate from the propellant and bubble through the liquid in the standpipe and thus pass into the atmosphere, thus being exhausted from the hollow walled refrigerator housing and the refrigerating apparatus.

The propellant then passes into a tube 57 of non-capillary dimensions which is connected to the standpipe and which has an upwardly extending continuation 58. The upper end of duct 58 is connected to a downwardly inclined duct 59 which in turn is connected to a substantially vertically disposed pipe 60, having a lower continuation 61 communicating with the lower part of the boiler 1. Thus mercury or the propellant in the duct 60 forms a pressure balancing column which balances the pressure of the vapor in the boiler and yet permits the propellant to return to the same.

An upward extension 60^a of the duct 60 is connected to the mixing chamber 7 to receive any particles of propellant which may condense in this portion of the system. A trap 72 containing propellant may be connected to the lower part of the cooler so that stray propellant particles will pass into the trap and thence into a continuation 73 thereof which has a downwardly extending connection 74 with pipe 59. Thus as stray propellant is received from the cooler it will eventually cause overflow of propellant from the trap 72 into the pipe 73 and thus its return through ducts 59 and 60 to the boiler.

It is to be noted that the chamber 33 is disposed above the chamber 53, the difference in the levels of these chambers substantially determining the amount of gas which is entrained in the first-stage tube 34.

It is evident that the gas received from the refrigerator housing 11 through the tube 35 may have a very low pressure and that this gas is compressed in the tube 34 so that it has a pressure substantially corresponding to or slightly higher than that in the lower pressure condenser 17. While the condenser 17 is at a pressure which has but a fraction of atmospheric pressure, the pressure in this part of the apparatus is much higher than that in the hollow walled housing 11. Accordingly the tube 54 receives the gases at the pressure of the refrigerant condenser and compresses them until they are at substantially atmospheric pressure when emitted into the standpipe 56.

Preferably the refrigerator housing 11 may be

of the general type disclosed in the copending applications of Daniel F. Comstock, Serial No. 304,589, filed September 7, 1928, and Serial No. 437,377, filed March 20, 1930. The vacuum housing may have an inner metal shell 80 and an outer shell 81 which may define a hollow vacuum chamber, the shells preferably having their edges joined by suitable heat non-conductive means such as are fully disclosed in the above-identified application. Preferably the hollow vacuum walls may be filled with porous material to aid the insulating ability of the housing; for example silocel bricks 84 may be employed for this purpose, preferably having their outer faces provided with small intercommunicating recesses or scores 83, Figs. 2 and 3, which communicate with each other and with the tube 35. Thus gas from any part of the interior of the vacuum wall may pass through the porous brick to one of the scores and thus along the various scores to the mouth of tube 34.

In the operation of apparatus of this character, it is evident that mercury vapor from the boiler 1 being emitted from aspirator nozzle 6 entrains refrigerant vapor from cooler 10, thus causing the rapid evaporation of the refrigerant and the consequent low temperature within the refrigerator housing 11. Substantially all of the mercury vapor condenses in the funnel 12 and is then received by the trap 31 and the chamber 33. The refrigerant vapor passes upwardly to the condenser 17 from which liquefied refrigerant passes through duct 19 and trap 21, thence returning to cooler 10.

The condensed propellant from trap 31 passing into chamber 33 forms separate globules in the tube 34 between which bodies of rarified gas from the pipe 35 are entrained, thus causing the constant exhaustion of gases from the hollow walled housing 11. This gas is compressed due to the increasing weight of the superposed mercury globules as the fluid flows to the lower end of tube 34. The gas separates from the propellant in the chamber 39 and duct 40, passing through the latter into the refrigerating system at a pressure of the order of that in the refrigerating system, while the propellant rises in the tube 46 to the second-stage entraining chamber 53 which is connected with a part of the refrigerating system where non-condensable gases are likely to occur, such as the upper end of the condenser 17. Accordingly gases received from the housing 11 as well as any other gases that may have leaked into the refrigerating apparatus are entrained in the tube 54 and compressed so that they may be emitted to the atmosphere through the standpipe 56. The propellant then rises through the duct 58 to the upper end of the inclined duct 59, it being noted that the juncture of ducts 58 and 59 is below the upper end of tube 54 so that the liquid head in the latter is effective in causing the mercury to flow into the tube 59 and thence overflow into the return duct 60.

From the foregoing it is evident that I have provided an arrangement whereby multi-stage pumping means may be included in series in a single circuit, as in a circuit of one of the working fluids of a refrigerating system, i. e., that of the propellant in an aspirator system, so that the working fluid is effective in maintaining a vacuum insulating chamber at low pressure and in maintaining the refrigerating apparatus itself at a low pressure which, however, is materially higher than that desirable for vacuum insulation.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. Apparatus of the class described, comprising a fluid circuit for a primary fluid, said circuit including upper and lower parts, means to cause the flow of fluid upwardly to the upper part of said circuit, said circuit including a tube of restricted diameter wherein the fluid passes downwardly in separate liquid globules, a duct communicating with the upper end of said tube to supply a second fluid for entrainment between the globules, a receiving duct communicating with the lower end of the tube to receive the entrained fluid therefrom, the circuit including a second duct communicating with the lower end of the tube and extending upwardly, a second tube of restricted diameter having its upper end communicating with the upper end of said second duct, the second tube being arranged so that fluid from the receiving duct is entrained between globules therein, the lower end of the second tube communicating with an outlet for the entrained fluid, and with a succeeding part of the primary fluid circuit.

2. Multi-stage evacuating means, comprising a fluid circuit having a plurality of downwardly extending tubes of restricted diameter wherein a primary fluid passes in liquid globules between which gas is entrained, and an upwardly extending duct between each of said tubes and the next succeeding tube, a connection from a region to be evacuated connected to the upper end of one of said tubes and means for shunting gas from the lower end of this tube and supplying the same to the upper end of another of said tubes, and a gas outlet pipe connected to one of said tubes, said pipe containing a column of the primary fluid for sealing the same.

3. Method of concomitantly maintaining a vacuum in an insulating wall and a low sub-atmospheric pressure in a fluid system comprising the circulation of a primary fluid through a circuit, entraining bodies of rarified gas from the insulating wall between liquid globules of fluid in said circuit and thus compressing the gas, emitting the compressed gas into the fluid system and withdrawing the gas from the system and introducing the same into another part of the circuit and there employing globules of the circulating liquid to compress the gas substantially to atmospheric pressure and then exhausting the gas to the atmosphere.

4. Method of concomitantly maintaining a vacuum in the hollow housing of a refrigerator and producing refrigeration at low pressure comprising the circulation of a primary fluid by its evaporation entraining a stream of refrigerant from a body of liquid refrigerant within the refrigerator in the vaporized primary fluid, condensing the primary fluid and condensing the refrigerant and returning the latter to the cooler, directing the condensed primary fluid into a tube of restricted diameter and there entraining bodies of rarified gas from the refrigerator housing between globules of the fluid, thus compressing the gas, then separating the gas from the primary fluid and introducing it into the refrigerating system, then passing the primary fluid through another tube of restricted diameter and entraining bodies of gas from the refrigerating system in said second tube, thereby compressing the gas and rais-

ing its pressure substantially to that of the atmosphere, then separating the compressed gas and the primary fluid and exhausting the gas to the atmosphere and returning the primary fluid to the region of evaporation.

5. Apparatus of the class described, comprising a refrigerant circuit and a propellant circuit, said refrigerant circuit including a cooler and a refrigerant condenser, said propellant circuit including a vaporizer, an aspirator nozzle and a propellant condenser, said circuits having a part in common adjoining the outlet of the aspirator nozzle, said propellant circuit including multi-stage pumping means wherein tubes of restricted diameter receive separate globules of the propellant, a vacuum housing surrounding the cooler, a connection between said housing and one of the tubes arranged so that gas from the housing is entrained between the propellant globules in the tube, a duct between the outlet of said tube and a part of the refrigerant circuit, a portion of the propellant circuit connected to the tube of restricted diameter including a second similar tube, said tube being connected with the refrigerant condenser and receiving gases supplied to the system from the vacuum housing and by leakage into the system, said second tube being connected to an open receptacle containing a column of liquid, whereby gas compressed between the globules in the second tube may be exhausted, said second tube having a duct continuation arranged to return propellant to the vaporizer.

6. Apparatus of the class described, comprising a heavy liquid circuit, said circuit having an upper portion where the fluid is normally in its liquid phase, a plurality of tubes of restricted diameter arranged to receive the liquid from the upper portion of the circuit in the form of separate globules, the liquid passing upwardly from one of said tubes to another tube in the succeeding part of the circuit, a vacuum wall connected to the upper part of one of said tubes, a gas shunting duct connected to the lower part of said tube end to the upper part of a succeeding tube, whereby the gas is pumped and compressed by the liquid globules in a plurality of said tubes, the tube last receiving the gas being provided with means arranged to exhaust the gas from the system.

7. Multi-stage pumping means, comprising a liquid containing system including a plurality of downwardly extending tubes of restricted internal diameter to receive the liquid in successive falling globules, the first of said tubes having a duct connection to supply rarified gas at its upper end, a shunt connection to receive compressed gas from the lower end of said tube and introduce the gas into a succeeding tube, and means for separating gas from liquid at the end of the last tube, the upper end of the first tube being above the upper end of the tube next receiving the liquid, whereby the resulting differences in liquid head substantially determine the amount of gas entrained in the first tube.

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