

March 1, 1949.

D. L. MOODY
INERT GAS ABSORPTION REFRIGERATION
SYSTEM, INCLUDING A FAN

2,463,409

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2 Sheets-Sheet 1

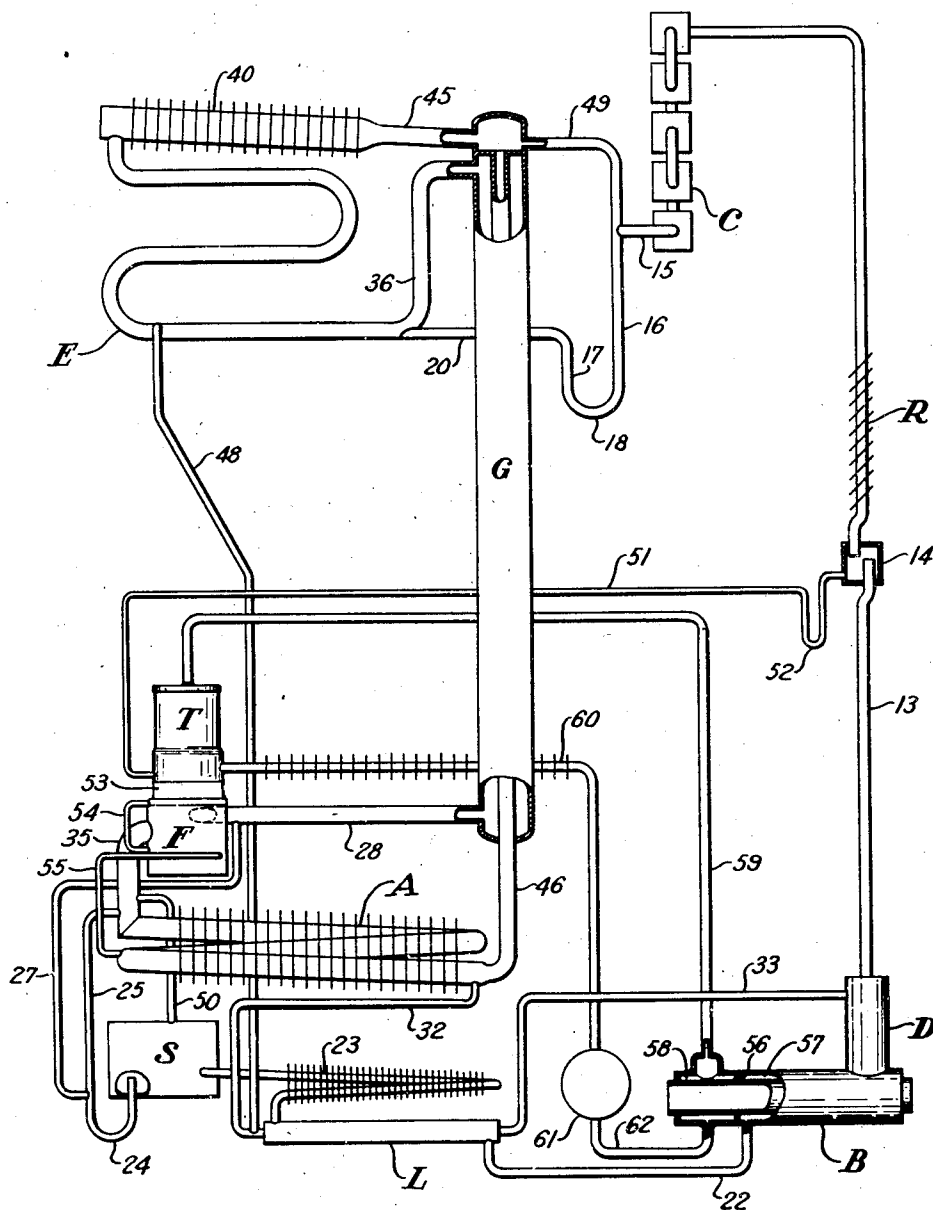


Fig. 1

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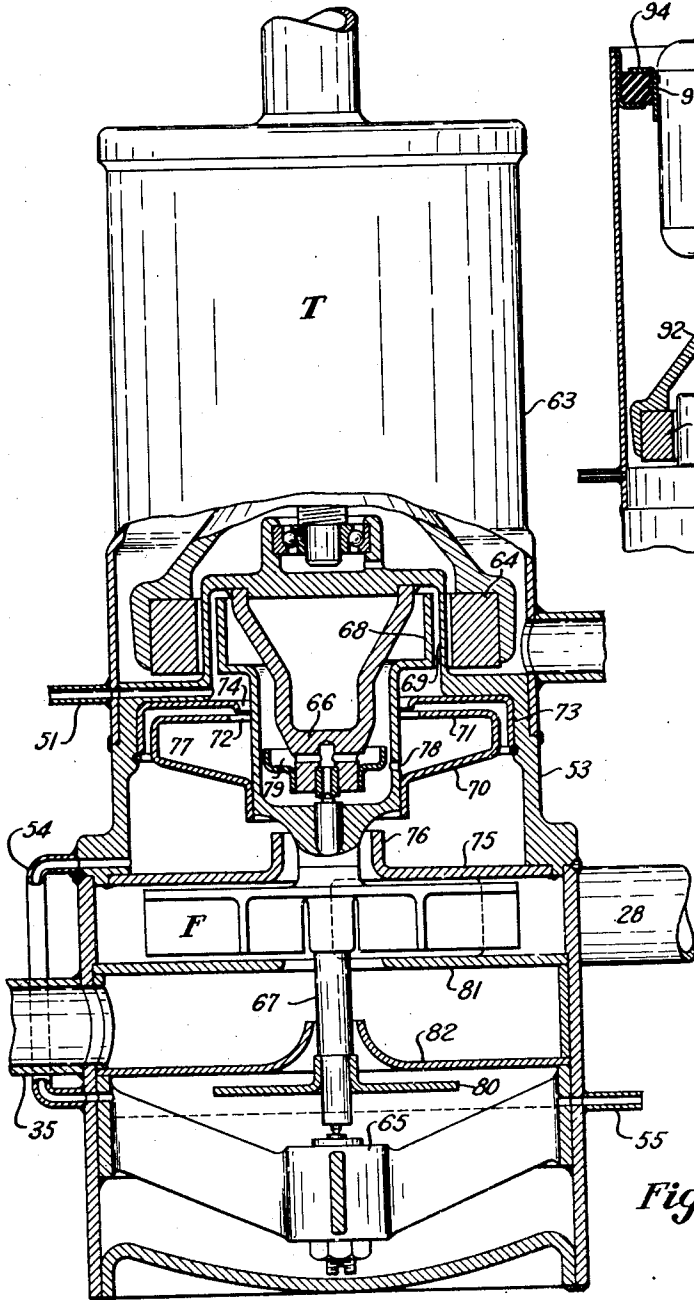


Fig. 2

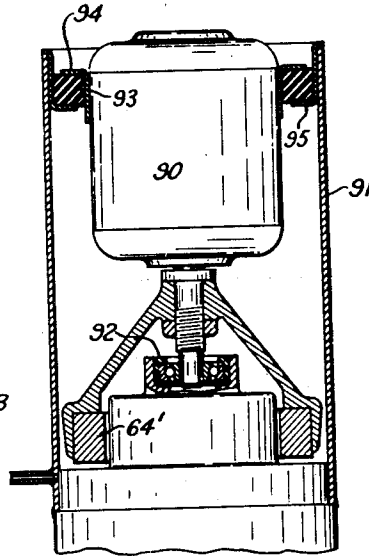


Fig. 3

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INERT GAS ABSORPTION REFRIGERATION
SYSTEM, INCLUDING A FAN

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4 Claims. (Cl. 62-119.5)

1

This invention relates to refrigeration and more particularly to means for circulating the mediums in an air-cooled three-fluid absorption refrigerating machine using ammonia as the refrigerant, water as the absorbent and an inert pressure equalizing medium such as nitrogen or hydrogen.

In such machines a closed circuit is provided between the evaporator and the absorber for the circulation of the inert gas therebetween. The inert gas is for the purpose of equalizing the pressures throughout the entire machine, all of the parts of which are in open communication, and for carrying refrigerant vapor from the evaporator to the absorber.

In the evaporator, the refrigerant liquid is vaporized by diffusion into the inert gas and in the absorber the refrigerant vapor is absorbed out of the inert gas. A closed circuit is also provided between the generator and absorber for the circulation of the absorption solution, usually consisting of a water solution of ammonia. In the generator, refrigerant vapor is driven from the solution by the application of heat and in the absorber the weak solution takes up refrigerant vapor from the inert gas. Some means must therefore be provided for circulating the inert gas between the evaporator and the absorber and the solution between the generator and the absorber.

In prior art machines it has been the usual practice to circulate the inert gas thermosiphonically or by differences in specific weights of different columns of the inert gas and to circulate the solution by heat operated vapor liquid lift pumps. Such machines operate satisfactorily under ordinary circumstances but in hot climates and in high room temperatures they are unsatisfactory because they operate inefficiently and have very low capacity. The problem could be solved if some means is provided for circulating the mediums within the apparatus which is not affected by changes in ambient temperature.

It has been proposed to use mechanical pumps for the purpose of circulating the mediums in such refrigerating systems, but the application of mechanical pumps to these systems is not a simple matter. The internal pressures of air cooled systems of this type vary from 250 to 400 pounds per square inch under normal operating conditions and under certain abnormal conditions they go to a much higher value. Before being put into use, such systems are hydraulically tested up to 800 pounds per square inch.

Thus it is practically impossible to use me-

2

chanical pumps having moving parts extending through the walls of the system.

In order to solve this problem a way must be found to hermetically seal the moving parts of the mechanical circulator unit on the interior of the apparatus and the present invention has to do with the solution of that problem.

In some localities a supply of electricity is not available and it is desirable to provide a refrigerating machine which can be operated by heat alone and still have some means for positively circulating the mediums within the apparatus which is not affected by changes in ambient temperature.

According to one aspect of the present invention a two part boiler is provided, one part for driving the refrigerant vapor from the solution and the other for generating steam which is used for driving the inert gas fan. A steam turbine is connected to the driver of a magnetic transmission and power so derived is transmitted directly through the walls of the apparatus to a magnetic follower connected to the inert gas fan and both the follower and the fan are hermetically sealed within the walls of the system.

In communities where electricity is available it is desirable to drive the gas fan by an electric motor so that the circulation of the mediums within the apparatus will be independent of ambient temperature and the capacity and efficiency of the machine will not be adversely affected by changes in ambient temperature.

According to another aspect of this invention the gas fan is driven by a small electric motor positioned entirely upon the exterior of the apparatus so as to be unaffected by the high pressures and corrosive atmosphere on the interior of the apparatus and the power developed by this motor is transmitted through the walls of the apparatus by means of a magnetic transmission. The motor is directly connected to the magnetic driver and the magneto-motive force of the driver is transmitted through the walls of the apparatus to a magnetic follower which is directly connected to the fan and both are hermetically sealed within the walls of the system.

In both cases the magnetic follower and fan can be made of a material which is not affected by the corrosive atmosphere on the interior of the apparatus. For example, the follower can be made of magnetic stainless steel which is very resistant to corrosion by ammonia. If the rotor of the motor itself were to be positioned in the interior of the apparatus some means would have

to be provided for protecting its windings from the corrosive atmosphere. In addition, the present invention makes it possible to reduce materially the load on the internal bearings whereby the bearing problem is simplified.

According to this invention the internal bearings are lubricated by liquid normally contained in the apparatus which simplifies the lubrication problem. A sodium chromate corrosion inhibitor is usually provided in refrigerating systems of the type to which this invention relates to protect the metal parts of the boiler and solution circuit from attack by ammonia. Ordinary lubricating oil will react with this chromate inhibitor to produce a soapy sludge which will interfere with the proper circulation of the mediums. Thus by positioning the entire power unit on the exterior of the apparatus and lubricating the internal bearings by a liquid medium normally contained in the apparatus, the lubrication problem is very much simplified.

According to this invention the driver is a permanent magnet which may be made of a magnetic alloy having the proper proportions of nickel, aluminum, chromium and iron, purchasable on the open market under the trade name of "Alnico" or some other suitable permanent magnet material. The driver magnet is separated from the follower by a thin shell of non-magnetic stainless steel. The follower may be made of magnetic stainless steel or it may be a permanent magnet but in any event it should be very resistant to the corrosive atmosphere on the interior of the apparatus.

Other objects and advantages of this invention will become apparent when taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of a refrigerating apparatus according to this invention;

Figure 2 is a detail view partly in section, showing the details of the driver and follower arrangement for driving the circulating fan; and

Figure 3 is a modification showing an electric motor for driving the driver magnet.

Referring to Figure 1 of the drawings, there is disclosed a three-fluid absorption refrigerating system comprising a boiler B, an analyzer D, an air-cooled rectifier R, a tubular air-cooled vertically positioned condenser C, an evaporator E, a gas heat exchanger G, a tubular air-cooled absorber A, a solution reservoir S, a liquid heat exchanger L, and a circulation fan F which is driven by a turbine T. The way in which the turbine is driven will be described in more detail hereinafter.

The above-described elements are interconnected by various conduits to form a plurality of gas and liquid circuits constituting a complete refrigerating system to which reference will be made in more detail hereinafter.

The refrigerating system will be charged with a suitable refrigerant such as ammonia, a suitable absorbent such as water, having a suitable corrosion inhibitor such as sodium chromate dissolved therein and a suitable inert pressure equalizing medium such as nitrogen or hydrogen.

The boiler B will be heater in any suitable manner as by an electric cartridge heater or by a gas burner as may be desired and the burner or heater may be controlled by a thermostatic control responsive to evaporator temperature in any manner well known in the art.

The application of heat to the boiler B liberates

refrigerant vapor from the strong solution contained therein. The vapor so liberated passes upwardly through the analyzer D in counterflow relationship to strong solution flowing downwardly through the analyzer. Further refrigerant vapor is generated in the analyzer by the heat of condensation of absorption solution vapor generated in the boiler. The refrigerant vapor is conducted from the upper portion of the analyzer D to the upper portion of the condenser C, through a conduit 13 which includes the air-cooled rectifier R and a liquid collecting or gas separation chamber vessel 14. Any vapor of absorption solution passing through the analyzer is condensed in the rectifier R and flows backwardly through the conduit 13 into the collecting chamber 14. The purpose of collecting the liquid in chamber 14 will be described in more detail hereinafter. The refrigerant vapor is liquefied in the condenser by heat exchange relationship with atmospheric air and is discharged from the bottom portion thereof through a conduit 15 into a downwardly extending conduit 16. The bottom portion of conduit 16 connects to the bottom portion of an upwardly extending conduit 17 through a U-bend 18. The conduit 16 is appreciably longer than the conduit 17 for a purpose to be described in more detail hereinafter. Conduit 17 opens at its upper end into a conduit 20 which discharges into the evaporator in a manner to be described more fully hereinafter.

The weak solution formed in the boiler by the generation of refrigerant vapor therefrom is conveyed from the boiler through a conduit 22, the outer pass of liquid heat exchanger L, and a pre-cooler 23 into the solution reservoir S. The weak solution is conveyed from the solution reservoir S through a U-shaped conduit 24 opening into a vertically extending tube 25, of small diameter, forming a gas lift pump which discharges into the top of the absorber A. It is evident that the top of the absorber is materially above the solution level normally prevailing in the boiler-analyzer-reservoir system whereby some means must be provided to elevate the absorption solution to the top of the absorber A. For this purpose a small bleed conduit 27 is connected to the discharge conduit 28 of the circulating fan F and leads to the junction of the conduits 24 and 25, which junction is below the solution level normally prevailing in the reservoir whereby the weak solution is elevated into the top of the absorber by gas lift action.

In the absorber the weak solution flows downwardly by gravity in counterflow to the rich pressure equalizing medium refrigerant vapor mixture flowing upwardly therethrough. The refrigerant vapor content of the mixture is absorbed in the absorption solution and the heat of absorption is rejected to the surrounding air by the air-cooling fins which are mounted on the exterior walls of the absorber vessel. Strong solution formed in the absorber discharges into a conduit 32 which opens into the inner pass of liquid heat exchanger L. From the inner pass of liquid heat exchanger L, the strong solution is conveyed to the upper portion of the analyzer D by conduit 33 whereby it flows downwardly through the analyzer in counterflow to upwardly rising vapors generated in the boiler.

The lean pressure equalizing medium refrigerant vapor mixture formed in the absorber A is taken from the upper portion thereof through

the conduit 35 into the suction side of the circulating fan F in which it is placed under pressure and discharged through the conduit 28 into the outer pass of gas heat exchanger G, through a downwardly extending conduit 36 into the bottom of the evaporator E.

The conduit 20 opens into the bottom portion of conduit 36 whereby the liquid refrigerant supplied to the evaporator enters the same simultaneously with the pressure equalizing medium which is placed under pressure by the circulating fan F. The diameter of the conduits of the evaporator are relatively small whereby the pressure equalizing medium flows through them at a relatively high velocity. The rapidly flowing pressure equalizing medium sweeps or drags the liquid refrigerant with it through the evaporator into the box-cooling conduit 40 as the refrigerant is evaporating by diffusion into the pressure equalizing medium to produce refrigeration. In the conduit 40 the velocity of the inert gas stream is relatively slow and by reason of the large diameter of that conduit, the liquid refrigerant flows therethrough by gravity.

The rich pressure equalizing medium refrigerant vapor mixture formed in the evaporator is conducted therefrom into the inner pass of the gas heat exchanger G through a conduit 45. The opposite end of the gas heat exchanger G communicates with the bottom portion of the absorber A through a conduit 46. In the absorber A the rich pressure equalizing medium refrigerant vapor mixture flows upwardly in counterflow to absorption solution whereby the refrigerant vapor content of the mixture is absorbed by the weak solution.

The bottom coil of the evaporator E is provided with a drain conduit 48 which opens into the strong solution return conduit 32. The conduit 48 opens into the top portion of the bottom coil of the evaporator whereby it will not completely drain said conduit. The upper portion of the discharge conduit 15 of the condenser is vented through a vent conduit 49 into the inner pass of the gas heat exchanger G. The solution reservoir S is vented through a conduit 50 into suction conduit 35 of the circulating fan.

The circulating fan F places the pressure equalizing medium discharged therefrom under small pressure in the neighborhood of a pressure of $4\frac{1}{2}$ inches of water. In order to prevent this pressure, which also prevails in the conduit 36, from being carried back through the condenser discharge conduit, the condenser and conduit 13 to the analyzer, conduit 16 has been made appreciably longer than the conduit 17 whereby a pressure balancing column of liquid is formed in the conduit 16 which extends above the point of connection between the conduit 17 and 20 a distance sufficient to overcome pressure produced by the circulating fan F in the conduit 36.

A conduit 51 including a liquid trap 52 leads condensate from the vessel 14 to the top of the casing 53 of the fan F. A conduit 54 leads the condensed solution vapor from the top portion of the casing 53 to the lower part thereof. The condensed solution vapor is led from the lower part of the casing 53 to the solution circuit by conduit 55. In flowing through the casing 53, the condensed vapor lubricates the moving parts of the fan F in a manner to be more fully described hereinafter.

A partition 56 divides the boiler B into two chambers 57 and 58. Chamber 57 contains the absorption solution for the refrigerating system

while the chamber 58 contains water so that when heat is applied to the boiler B, steam is generated in the chamber 58. The steam generated in the chamber 58 is led by conduit 59 to the reaction steam turbine T and passes therethrough to drive the same. From the turbine T the steam is led to the steam condenser 60 where it is condensed and flows by a conduit to the water reservoir 61. The water reservoir 61 is connected by conduit 62 to the chamber 58. The steam generating system is charged with sufficient water that the chamber 58 is always filled with water.

It is to be noted that when the boiler B is energized some time elapses before refrigerant vapor is being condensed in the condenser C and that a similar interval elapses before sufficient steam is led to the turbine T to drive the same. Thus neither the inert gas, the solution or the refrigerant will be circulated until refrigerant vapor is being condensed in the condenser C and all of the mediums in the apparatus will be circulated by the time that liquid refrigerant is being delivered to the evaporator E.

Referring to Figure 2, the turbine T is suitably mounted for rotation in a housing 63 rigidly connected to the fan housing 53 and is rigidly connected to a driving magnet 64 having either two or four poles. The driving magnet 64 is preferably a permanent magnet formed of any material from which permanent magnets can be made but is preferably made from an alloy having suitable proportions of nickel, aluminum, chromium and iron, purchasable on the open market under the trade-name "Alnico."

The fan F is supported for rotation in the housing 53 by bearing assemblies 65 and 66 and shaft 67. Rigidly connected to the upper end of the shaft 67 is a magnetic follower 68 having poles corresponding in number to the poles on the driving magnet 64. The magnetic follower 68 may be a permanent magnet or may be made of any magnetic material but is preferably made of a stainless magnetic steel which is very resistant to corrosion. The driving magnet 64 and the magnetic follower 68 are separated from each other by a thin shell 69 of non-magnetic stainless steel which hermetically seals the interior of the fan casing 53 from the housing 63. It has been found that the shell 69 may be made 0.20 inch in thickness and still withstand the high pressures within the interior of the system.

Secured to the lower end of the magnetic follower 68 and rotatable therewith is a conical member 70 having an inwardly extending portion 71 which forms with the follower 68 an annular opening 72. An annular baffle 73 is secured to the inner periphery of the casing 53 and has a downwardly turned lip 74 directly above the opening 72. A second annular baffle 75 having an upwardly extending annular lip 76 is secured to the inner periphery of the casing 53 to separate the fan F from the upper part of the casing 53.

The condensed absorbent vapor which flows by conduit 51 from the vessel 14 to the upper end of the casing 53 falls onto the baffle 73 and from thence flows over the lip 74 through the opening 72 and into the chamber 77 formed by the members 70 and 71. During rotation this solution will be held by centrifugal action in the outer periphery of the chamber 77 and eventually some of the solution will overflow from the chamber 77 and be thrown outwardly against the inner walls of the casing 53. However, when rotation stops the liquid trapped in the chamber 77 will

flow through an opening 78 and overflow into the cup-shaped member 79 which is secured to the bearing assembly 66 where it will be in a position to lubricate the bearing assembly 66 during the next running period.

The solution which is thrown outwardly against the inner wall of the casing 53 will be collected on the annular baffle 75 by the upstanding lip 76 which will cause it to flow through the conduit 54 into the lower part of the casing 53 so as to lubricate the lower bearing assembly 65. The lip 76 prevents liquid from contacting the fan F from above and the throw-off ring 80 prevents liquid from creeping up the shaft 67 from below. Excess liquid is led from the lower part of the casing 53 back to the solution circuit by conduit 55. Division plate 81 having an opening therein cooperates with the baffle 75 to form a pressure chamber for the fan F and with the division plate 82 to form a suction chamber.

When the boiler B is energized, the steam generated as previously described, will drive the turbine T and rotate the driving magnet 64. The magnetic lines of force will be transmitted through the non-magnetic shell 69 to the magnetic follower 68. If the magnetic follower 68 is a permanent magnet, its north poles will tend to follow the south poles of the driver 64 with the result that the follower 68 and the fan F will be rotated with the driver 64 and the mediums will be circulated as previously described. If the poles of the follower and driver tend to get out of step a considerable force will be produced, by the resistance to a change in magnetism of the magnets opposing this relative motion.

If the follower 68 is of magnetic material, such as magnetic stainless steel, magnetic lines of force will be set up in the follower forming magnetic circuits, a south pole opposite the north pole of the driver 64 and a north pole opposite the south pole of the driver. When the driver 64 is rotated the poles formed in the follower 68 will tend to follow the opposing pole of the driver 64 and tend to rotate the follower due to the resistance to a change in magnetism of the follower 68. If the follower 68 tends to get out of step with the driver 64 again considerable force will be produced to oppose such a relative movement.

Since the fan F only needs to create a pressure difference of about $4\frac{1}{2}$ inches of water in the inert gas circuit to circulate all of the mediums within the apparatus, a comparatively small driving magnet can be used and its magnetic force can be easily transmitted through the shell 69 to produce rotation of the magnetic follower 68 and the fan F.

In Figure 3 an electric motor 90 drives the driver magnet 64' and is supported in the casing 91 by a resiliently mounted bearing 92 and an annular rubber ring 93 bonded to the metal rings 94 and 95 which are secured to the motor 90 and the housing 91, respectively. If desired, the offset portions of the rings 94 and 95 may be omitted so that the rubber ring 93 will be stressed solely in shear by the weight of the motor 90 and the driver magnet 64'. It is to be understood that the motor 90 of Figure 3 is to be substituted for the turbine T of Figure 2 and that the remaining parts of the apparatus will remain the same as in Figure 2. When the motor of Figure 3 is used, the steam generating system of Figure 1 is omitted.

From the foregoing it will be evident that this invention has provided a simple means of posi-

tively circulating all of the mediums in a three-fluid absorption refrigerating machine independently of changes in ambient temperature in which all of the parts of the power-producing means are located exteriorly of the walls of the system so that they cannot be affected by the corrosive atmosphere within the system. At the same time power is transmitted through the walls of the system in a simple manner. The magnetic flux of the driven member in the form of a permanent magnet is transmitted through a thin portion of the walls of the system made of non-magnetic material to a magnetic follower hermetically sealed within the system, which follower drives the circulating fan. In addition, the internal moving parts are lubricated by a liquid medium normally contained within the system so as to eliminate lubrication difficulties.

While I have shown but a number of modifications of my invention, it is to be understood that these modifications are to be taken as illustrative only and not in a limiting sense. I do not wish to be limited to the particular structure shown and described but to include all equivalent variations thereof except as limited by the scope of the claims.

I claim:

1. An absorption refrigerating apparatus comprising a generator, a pump for circulating the mediums in said apparatus, said generator comprising a vessel divided by a partition into two chambers hermetically sealed from each other, one of said chambers containing a working fluid of said apparatus and the other containing an auxiliary motive fluid, means for heating said generator to produce vapor in each of said chambers and means hermetically sealed from said pump and utilizing vapor from said chamber containing the auxiliary motive fluid for driving said pump.

2. An absorption refrigerating apparatus comprising, a generator, a rectifier, means hermetically sealed within the walls of the apparatus for circulating the mediums therein, power means hermetically sealed from said circulating means for driving the same and means for transmitting motion through the hermetically sealed walls of said apparatus from said power means to said circulating means and means for leading liquid from said rectifier to said circulating means for lubricating the same.

3. An absorption refrigerating apparatus comprising, a generator, a condenser, an evaporator, an absorber, said condenser being positioned above said generator, conduits connecting said generator, evaporator and absorber to form an inert gas circuit and a solution circuit, a vertically extending conduit including a rectifier connecting said generator and condenser, a gas separation chamber below said rectifier, a fan hermetically sealed in said inert gas circuit for circulating gas and solution in said inert gas and solution circuits respectively, a magnetic follower directly connected to said fan, a driver magnet positioned exteriorly of the walls of said apparatus and positioned to drive said follower through the walls of the apparatus and means including a liquid trap for leading condensate from said gas separation chamber to said fan to lubricate the same.

4. An absorption refrigerating apparatus comprising, a generator, a condenser, an evaporator, an absorber, said condenser being positioned above said generator, conduits connecting said

generator, evaporator and absorber to form an inert gas circuit and a solution circuit, a vertically extending conduit including a rectifier connecting said generator and condenser, a gas separation chamber below said rectifier, a fan hermetically sealed in said inert gas for circulating inert gas and solution in said inert gas and solution circuits respectively, a magnetic follower directly connected to said fan, a driver magnet positioned exteriorly of the walls of said apparatus and positioned to drive said follower through the walls of the apparatus, means including a liquid trap for leading condensate from said gas separation chamber to said fan to lubricate the same, said generator including a chamber sealed from said circuit and containing an auxiliary motive fluid, means for heating said generator and means utilizing vapor generated from said motive fluid for driving said driver magnet.

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