

D. C. SMITH.
PROCESS OF REFRIGERATION.
APPLICATION FILED JUNE 8, 1911.

1,038,220.

Patented Sept. 10, 1912.

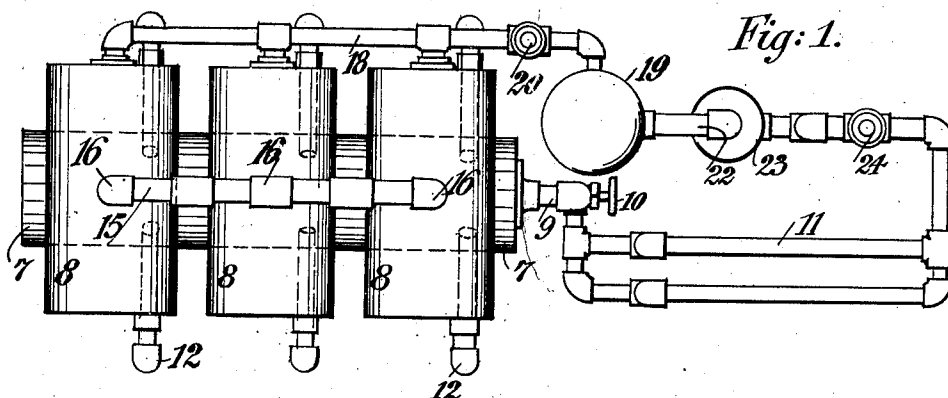


Fig. 1.

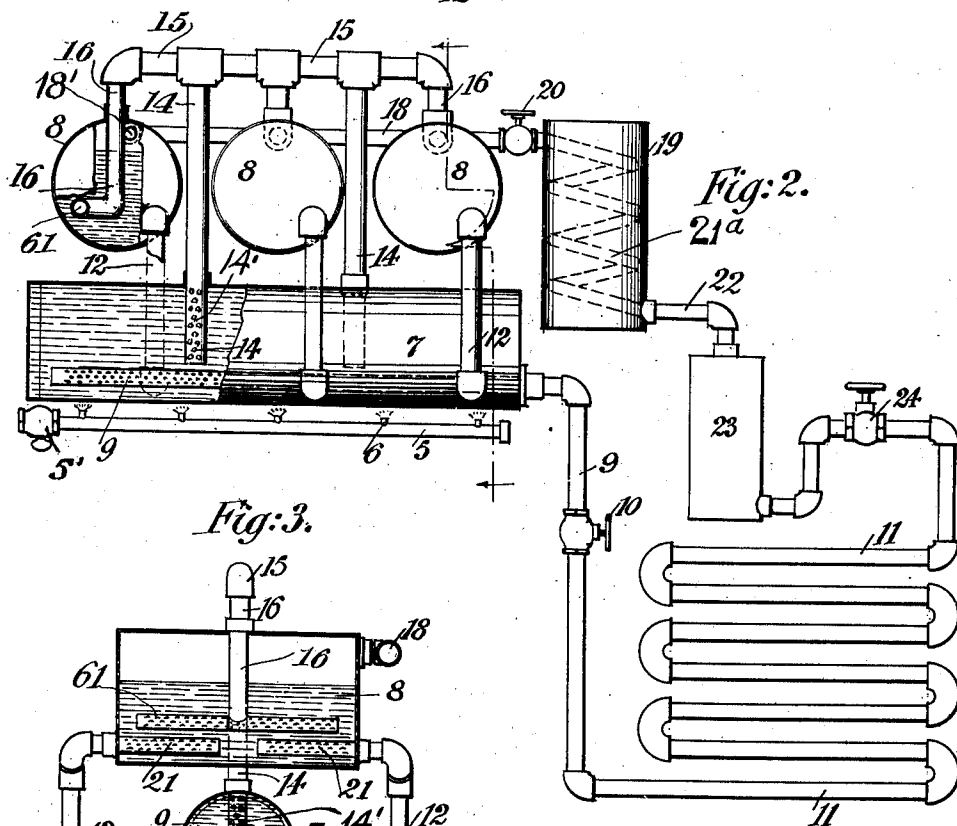
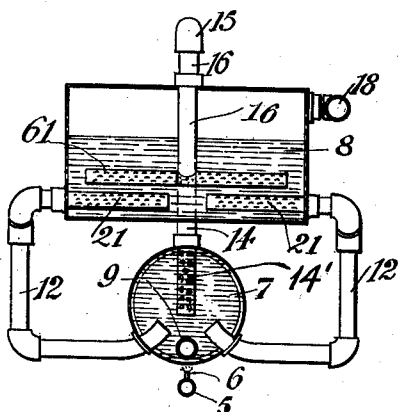


Fig. 2.

Fig. 3.



Witnesses:
John Murtagh
L. J. Murphy.

Inventor
Daniel C. Smith
By his Attorneys
Joseph E. Cooper.

UNITED STATES PATENT OFFICE.

DANIEL C. SMITH, OF MILFORD, CONNECTICUT, ASSIGNOR TO SMITH REFRIGERATING COMPANY, OF NEW ORLEANS, LOUISIANA, A CORPORATION OF LOUISIANA.

PROCESS OF REFRIGERATION.

1,038,220.

Specification of Letters Patent.

Patented Sept. 10, 1912.

Application filed June 8, 1911. Serial No. 631,933.

To all whom it may concern:

Be it known that I, DANIEL C. SMITH, a citizen of the United States of America, formerly a resident of Brooklyn, New York, and now a resident of Milford, Connecticut, have invented a certain new, useful, and Improved Process of Refrigeration, of which the following is a specification.

My invention relates to improvements in the art of refrigeration.

In my process the refrigerant is preferably ammonia, and my invention has special reference to those processes of refrigeration which are characterized by the distillation of ammonia from ammonia water, the condensing and storing of the ammonia under pressure, the expansion of the ammonia in a refrigerating element such as an expansion coil and, cyclically, the reabsorption of the ammonia by the water residue of the distillation. It has been proposed to conduct such processes without resort to mechanical power-actuated accelerating or relaying devices such as circulating and compression pumps, but up to this time, as I am informed, no project of the kind has ultimated in any process of a practical or commercial nature. The common purpose of inventors in this branch of the art has been to avoid the employment of moving parts, pumps, and the like, and, generally, to avoid the use of machinery and apparatus which would require expert knowledge or skill for its operation, and to devise a process or processes which would be reliable, safe, efficient, and economical, and yet require only such apparatus as could be obtained readily and at low cost. These have also been my objects, yet up to the time of making the invention and discoveries herein disclosed, my experiments, like those of my predecessors, were productive only of processes which were uncertain and unreliable, and which, if even approximately safe, were not efficient; and, if approximately efficient, were most dangerous and unsafe, even when carried out by persons thoroughly familiar with prior processes of ammonia refrigeration.

The process constituting the subject matter of this application may be carried out in and with apparatus comprising a number of constantly closed receptacles joined by a

simple system of pipes and which, except for a few valves in said pipes, is free from moving parts. My process is reliable as to results to be secured from time to time; is efficient and economical; and is entirely safe even when operated by persons having little skill in the art. The process is such that it is capable of employment in the small units which are desirable for household usage, as well as in the larger units required by factories and plants calling for more extensive refrigeration.

I attain reliability in operation by securing a substantially anhydrous distillate at each distillation of the ammonia water, and by maintaining the ammonia water in maximum absorptive condition during refrigeration. The efficiency of my process arises from this obtainance and use of anhydrous ammonia, coupled with the advantages which I secure through steps that result in yielding a maximum quantity of distillate for a minimum of heat employed in the distilling operation, and which also result in the reabsorption thereof during refrigeration.

Economy is assured by the small consumption of heat, by the simplicity of both the process and the apparatus and by the general avoidance of steps and parts which would require more attention or a higher degree of skill on the part of the user.

I attain safety by conducting the process in a completely closed system and, more particularly, by preventing the formation or accumulation of bodies of either steam or ammonia gas in that part of the system in which the distillation of the ammonia is initiated and to which heat at high temperature is necessarily applied.

As more fully explained hereinafter, I attain these desirable and necessary effects and advantages chiefly by the manner in which I treat and manipulate the ammonia water at times of distillation and at times of absorption; that is, at times of distillation I treat and manipulate the ammonia water in such manner as to substantially preclude the escape of steam from the ammonia water; and, during the absorption period, and in the same manner, I preclude the escape of the ammonia gas from the

ammonia water. By insuring the complete absorption of the returned ammonia I make it possible to maintain an efficient vacuum above the ammonia water, and hence permit greater expansion of the ammonia gas. As will appear hereinafter, a partial vacuum is created by the cooling of the ammonia water in the interval between distillation and absorption, and by preventing the escape of ammonia gas during absorption the effect of this partial vacuum is preserved until the water becomes saturated. I divide the requisite quantity of ammonia water primarily into upper and lower bodies, in closed containers or tanks at different elevations, and place them in siphonic circulatory connection by means of suitable pipes or conduits. Whenever the temperature of the liquid in the lower tank exceeds that of the liquid in the upper tank or when the states of saturation are different, the liquid, through differences in specific gravity, will rise from the lower tank into the upper tank, and the cooler or heavier liquid in the upper tank will fall or flow downward into the lower tank to replace the lighter liquid rising therefrom. Thus the lower tank is always kept full of liquid. This circulation takes place in both the distilling and the absorbing periods of my process, differences of temperature existing at both times; for, as hereinafter explained, I apply heat to the lower tank, to distil the ammonia; and in the absorbing period, I admit the ammonia gas to the lower tank and hence the lower body of liquid is the first to receive the heat liberated therefrom. The rapidity of the circulation is primarily induced and determined by the differences of temperature in the two tanks and in the several parts thereof, but is augmented or accelerated by two forces which operate during the distilling and absorbing periods respectively, said forces being local differences of pressure in the two tanks. The first of these differences of pressure is occasioned by the vapors and gases that are rapidly evolved when the lower tank is externally heated, and the second difference of pressure is induced by the heat given off in the lower tank when the ammonia gas recombines with or is absorbed by the water; aided by a partial vacuum which I am careful to create and maintain above the liquid in the upper tank prior to and substantially throughout the absorbing period. The described circulation of the liquid hastens the liberation of the ammonia gas from the ammonia water when the lower tank is heated and at the same time prevents the attainment of dangerous temperatures or pressures. When the hot liquid rises from the lower tank its temperature is often sufficient to admit of the presence of steam bubbles, but in circulating through

the pipes and entering directly into the cooler water in the upper tank, much of this heat is lost by radiation and the steam is immediately condensed and not permitted to pass off with the ammonia gas. This goes far to explain the reliability and efficiency of my process, for it follows that the gas which is evolved or distilled is substantially anhydrous. While maintaining in the upper tank a temperature which causes the condensation of the steam, I at the same time hold that temperature at such point that there is substantially no reabsorption of ammonia gas in the upper tank after the first few minutes of distillation; this also has much to do with the efficiency of my process, inasmuch as waste of heat is thereby avoided. Similarly, the described circulation of the liquid during the absorption period insures the rapid dissipation or radiation of the heat caused by the absorption or recombination of the ammonia gas with the water and also insures the retention of the free gas in water until combination or absorption is complete. In my process I place little if any reliance upon the surface absorption of gas by the water in the upper tank, and on the contrary am careful to keep the gas immersed in the water until it is absorbed, to the end that the vacuum before referred to may be maintained substantially throughout the absorbing period, and efficiently, until the water has reached a state of substantially complete saturation with ammonia. These conditions being preserved, it follows that the reabsorption of the ammonia may be protracted over a very considerable period, and it also follows that the expansion of the gas in the refrigerating element will not be opposed by back pressure in the tanks and will be highly efficient.

To insure the described condensation of steam during the distilling operation, and to create and maintain the partial vacuum in the upper tank after distilling and during the absorption period, I am careful to prevent the free discharge of either ammonia water, steam or gas into the upper part of the upper tank, that is, above the surface of the liquid therein. In other words, I confine the circulation to and within the bodies of liquid. I accomplish this by means of one of the pipes before referred to, which pipe rises from the lower tank, enters the upper tank and opens below the surface of the liquid therein. That is, I insure such condensation, and insure and maintain the described vacuum by extending this pipe downward in the upper tank to a point considerably below the surface of the liquid therein. The pipe which conducts the liquid from the upper tank to the lower tank extends from the lower part of the upper tank to the lower part of the lower tank. In

this manner I effectually seal the upper tank against the entrance of steam or gas except through the medium of the liquid contained therein. This results in the elimination of steam from the distillate during the distilling operation, and further results in preventing the rise of vapors or gas into the vacuum space in the upper tank during the absorption period, the gases as before stated being held in a state of submersion and admixture with the water until absorbed thereby, so that the partial vacuum is not destroyed until, under normal conditions, the water has reached a state of substantial saturation. And by maintaining such partial vacuum I avoid the back pressure which has been one of the most objectionable features of previously proposed processes. It will now be clear that the steps and the means which I employ to insure the condensation of water vapor and consequent dehydration of the distilled gas are identical with the steps and means which I perform and employ to insure and preserve the described vacuum during the absorption period.

I employ a condenser to receive the gas from the upper tank, and this condenser delivers the liquid ammonia into a reservoir. The reservoir is in turn connected to a refrigerating element, such as a refrigerating coil, and a return pipe extends from the refrigerating coil to the lower ammonia water tank. A valve is interposed between the upper tank and the condenser. Another valve is interposed between the reservoir and the refrigerating coil, and a third valve is interposed between the refrigerating coil and the lower tank. Before beginning the distilling operation I close all these valves. When the pressure in the tanks rises to a point where it exceeds approximately ninety pounds, and exceeds the pressure in the reservoir, without which the gas would not flow toward the reservoir, I open the valve between the upper tank and the condenser and put the condenser in operation. The condenser remains in operation until distillation has been completed, whereupon said valve is closed and the heat is withdrawn from the tanks. At this stage I allow the tanks to cool until the liquid contents thereof have assumed a normal low temperature. As the tanks are completely closed during this period, the cooling and condensation of the contents cause the formation of a partial vacuum in the top of the upper tank and in the pipe leading therefrom to the condenser valve. Upon the appearance of a vacuum, as observed by any suitable means such as an ordinary gage, refrigeration and absorption may be started. At this time I slightly open the valve between the reservoir and the coil and permit the liquid ammonia to expand or

gasify therein. At the same time, I open the valve between the coil and the lower tank so that the expanded ammonia may pass back into that tank. The ammonia, expanding within the coil, reduces the temperature thereof; accomplishing the refrigeration which is the end and aim of the process.

When, through absorption, the liquid in the tanks becomes saturated, the further return flow of expanded gas will cause an accumulation of surplus gas in the tanks and the vacuum will be destroyed. In my process, the destruction of the vacuum by the accumulation of gas in the top of the upper tank rarely occurs prior to the substantially complete saturation of the water; and in fact can only take place when the reservoir valve is so widely opened as to permit the gas to rush back to the tanks in such large volume as to induce a high temperature therein and thereby greatly reduce the absorptive capacity of the water. In my process, therefore, the destruction of the vacuum normally marks the end of the refrigerating operation, inasmuch as further gas from the refrigerating coil will not thereafter be effectively absorbed. Further, if the return flow of gas were continued, back pressure would quickly build up and limit the expansion of the ammonia gas in the coil. In the case of apparatus of ordinary dimensions the absorption extends through many hours, whereas distillation may be accomplished in a much shorter time. At the end of the absorption period I again close all the valves before referred to and again heat the lower tank to institute a new distillation of the ammonia water.

My invention will be more readily understood by reference to the accompanying drawing, forming part of this specification, and in which I have depicted an apparatus of a kind which I prefer to use in carrying out my invention.

Figure 1 of the drawings is a plan view of such apparatus. Fig. 2 is a side view thereof, the condenser, the reservoir, the refrigerating coil and the return pipe being shown diagrammatically; it should be understood that in practice the coil is always placed above the liquid tank. Fig. 3 is a vertical transverse section of the lower and upper tanks and the circulation pipes.

This apparatus is novel, but is not claimed in this application, being fully described and claimed in my copending application filed June 29, 1911, Serial No. 635,996.

In the drawings 7 represents the lower tank. This is preferably of considerably less diameter than length and occupies a horizontal position. Beneath the tank is a heater, preferably comprising a gas pipe having burners 6 and a regulating valve 5'. As indicated in the drawings, I may subdivide the upper tank into two or more

smaller tanks and thereby relatively increase the radiating surface. In the present case there are three such tanks indicated by the numeral 8. These tanks are also arranged horizontally and are parallel with one another and transverse to the longer lower tank. These tanks 8 collectively constitute the upper tank before referred to, and each thereof is connected with the lower tank by circulating pipes which perform the functions before described. Above the tanks 8 is a header 15. Pipes 14, 14 extend, preferably, from points about midway of the tank 7, through the top of the tank 7, and at their upper ends join the header 15, the lower ends, within the tank 7, being provided with a plurality of perforations 14'. Pipes 16, 16, 16' extend downwardly from the header, through the tops of the tanks 8 and downwardly therein to points near the bottoms thereof. The pipes 14, 15, 16, the inclosing tank 8, and the pipes 21, 12, constitute an effective siphon which insures the rapid interchange of cool water from tank 8 for the warmer liquid from tank 7. As clearly shown in Figs. 2 and 3, each pipe 16 is equipped at the lower end with a cross pipe 61, which is perforated and constitutes a diffuser. From each tank 8 two pipes 12 extend downwardly and are joined to and communicate with the lower part of the tank 7. The pipes 12, as shown in Fig. 3, extend within respective tanks 8 and are perforated as shown at 21. The pipes 14, 15, 16, 61, 21 and 12 constitute the circulating pipes before referred to. 18 is the gas exit pipe. It is connected with each tank 8, and the openings 18' leading from the tanks 8 to the pipes 18 are all above the highest level attained by the liquid in the tanks during the practice of the process. 19 is the condenser and 20 is the condenser valve. The condenser may comprise a simple water jacket for flowing water and an ordinary condensing coil 21^a indicated by dotted lines in Fig. 2.

23 is the reservoir, which is joined to the condenser coil by a pipe 22.

11 represents the refrigerating coil, and 24 is the expansion valve which is interposed between the reservoir and the coil.

9 represents the return pipe and 10 is the valve which is interposed between the refrigerating coil and the lower tank 7. The pipe 9 extends through the end of the tank 7 and to the other end thereof, being disposed near the bottom of the tank 7. The portion of the pipe 9 which lies within the tank 7 contains a large number of small perforations for diffusing the gas.

It should be understood that all joints between the tanks and pipes are tight joints, and that the tanks, coils and reservoir are closed and constructed to withstand high pressures.

One way in which to prepare the apparatus for use consists in closing the valves 10 and 20, temporarily opening the header 15, and filling the tanks 7 and 8 and connected pipes with ammonia water up to a working level in the upper tank. The air remaining in the upper tank may then be exhausted and the header closed. When this is accomplished, the apparatus will be found ready for use. All the valves being closed, the gas may be lighted under the tank 7. Obviously, the liquid which is in contact with the bottom and side walls of the tank 7 will be quickly raised in temperature. This heated liquid having no other escape will rise through the pipes 14 and then descend into the tanks 8 through pipes 16 and 61. As the hot liquid rises in this manner it is replaced by the cooler liquid which flows into the tank 7 through the diffusers 21 and pipes 12. As the temperature of the liquid increases, gas will be liberated and when the pressure in the tank becomes approximately ninety pounds, which appears to be the minimum condensation pressure, the valve 20 may be opened to permit the gas to escape from the tanks 8 and flow into the condenser. At this time the condenser coil is cooled, and through the action of its low temperature and the pressure of the gas, the latter is condensed and flows into the reservoir 23. It will be observed that the gases evolved in the upper tank or tanks, due to a sufficient rise of temperature therein, may bubble upward through the liquid therein and thence pass directly to the condenser. By reason of radiation the temperature of the upper tank is never sufficient to generate steam at the pressure existing therein, hence gases initially distilled in the upper tank are substantially free from water. It will be further observed that all steam and gas which ascend with the water in pipes 14 are discharged into the tanks 8 through the subdividing and admixing perforations of the pipes 61 located near the bottoms of the tanks 8, and hence relatively far below the surface of the liquid therein. By reason of the low temperature in the tanks 8 all steam thus discharged therein is immediately condensed, while the gas thus discharged may find escape at the surface of the liquid. In this manner the effective dehydration of the distilling gases is insured prior to their exit through the pipe 18. The substantially uniform withdrawal of the liquid from the several portions of the tanks 8 by the perforated pipes 21 insures a substantially uniform temperature throughout said tanks.

On completion of distillation the valve 20 is closed, and then, as before stated, the tanks and contents are either cooled or permitted to cool in order to prepare the weak liquor or residual water for the absorption

of. or recombination with the ammonia. When the temperature has dropped sufficiently, the valves 24 and 10 may be opened to permit the gradual return of the ammonia to the tank 7, with the important effect of refrigeration in the coil 11. At this point I call attention to the large amount of radiating surface presented by the upper and lower tanks and circulating pipes. Circulation obviously continues after the heat is shut off, and the heat is dissipated quickly so that only a short time is required to reduce the weak liquor to a temperature admitting effective absorption of the gas.

As the gas enters the tank 7 through the perforated portion of the pipe 9, it is subdivided into a great number of streams of minute bubbles, and quickly enters into combination with the water. This combination gives off heat, and through the rise of temperature thus occasioned an active circulation of the liquid is set up in the circulating pipes and tanks. As the liquid which contains the bubbles of gas ascends through the pipes 14 and thence downwardly into the liquid in the upper tanks, it is thoroughly agitated and admixed with the gas, and it is to be assumed that very little of the gas returns to the lower tanks through the down pipes 21, 12. The perforated pipes in the tanks 8 obviously facilitate the admixture and absorption of the gas by the water. As best shown in Fig. 3, I prefer that the down pipes 12 shall discharge at points immediately adjacent the region of the admission of gas to the tank 7, for the purpose of keeping down the temperature of the water surrounding the perforated pipe 9. Absorption goes on in this way until the whole body of liquid in the tank is saturated with ammonia, whereupon the valves 24 and 10 may be again closed preparatory to the next heating of the liquid. No danger and no bad results attend any manipulation of the valves or of the heat.

Having thus described my invention I claim as new and desire to secure by Letters Patent:

1. The herein described ammonia absorption refrigerating process which is characterized by the division of the ammonia water into upper and lower connected bodies, the attainment of higher temperatures in the lower body than in the upper body during both distillation and absorption, and the inducing of circulation wholly within and between said bodies.

2. The herein described ammonia absorption refrigerating process which is characterized by the division of the ammonia water into upper and lower siphonically connected bodies, the heating of the lower body during both distillation and absorption, the confining of circulation to and between said bodies and the communication and dissipa-

tion of heat from the lower body to and in the upper body through the agency of such circulation.

3. The herein described ammonia absorption refrigerating process which is characterized by the division of the ammonia water into relatively remote but siphonically connected bodies, the maintenance of the surface of one body above the top of the other, the attainment of higher temperatures in the latter than in the relatively remote and higher body during distillation and absorption, the inducing thereby of siphonic circulation within and between said bodies, the accumulation of gas under pressure at the surface of the higher body during distillation and the maintenance of a partial vacuum at the surface of the higher body when ammonia gas is being absorbed.

4. The herein described ammonia absorption refrigerating process which is characterized by inclosing bodies of ammonia water at different heights in connected closed tanks joined by circulation conduits arranged at different heights, keeping the openings of the conduits submerged at all times, the application of external heat to the contents of the relatively lower tank, and the maintenance of the contents of the upper tank at a lower temperature during the application of heat to the lower tank, whereby to condense the evolved steam while driving off ammonia gas at pressures sufficient to cause its condensation when cooled.

5. The herein described ammonia absorption refrigerating process which is characterized by inclosing bodies of ammonia water at different heights in connected closed tanks joined by circulation conduits arranged at different heights, keeping the openings of the conduits submerged at all times, the application of external heat to the contents of the relatively lower tank, the maintenance of the contents of the upper tank at a lower temperature during the application of heat to the lower tank, whereby to condense the evolved steam while driving off ammonia gas at pressures sufficient to cause its condensation when cooled, the lowering of the temperature of the residual water in the tanks after such distillation, the formation thereby of a partial vacuum above the higher body, the subsequent admission of ammonia gas to the lower tank and the absorption thereof by the residual water without materially reducing such partial vacuum.

6. The herein described ammonia absorption refrigerating process which is characterized by inclosing the ammonia water in closed tanks connected by circulation siphons, raising the temperature of the contents of one tank by alternately applying external heat and the heat liberated in the

absorption of ammonia gas, maintaining the liquid in the other tank always at a lower temperature, and thereby causing the submerged circulation of the ammonia water through said tanks to exclude steam from the distilled ammonia gas and to accelerate absorption of ammonia gas during respective periods of heat application.

7. The herein described ammonia absorption refrigerating process which is characterized by the division of the ammonia water into upper and lower connected bodies, applying heat to the lower body, maintaining the upper body at a lower temperature and causing the vapors and gases liberated by the heat to pass into the upper body of ammonia water.

8. The herein described ammonia absorption refrigerating process which is characterized by the division of the weak or residual ammonia water into upper and lower siphonically circulatory bodies, admitting ammonia gas to the lower body of water, thereby raising the temperature of the lower body, and thus inducing circulation or interchange of the water in said bodies and causing the gas which is not absorbed by the lower body to pass into the upper body and to be therein absorbed.

9. The herein described ammonia absorption refrigerating process which is characterized by the division of the weak or residual ammonia water into upper and lower siphonically circulatory bodies, creating a partial vacuum above the upper body, admitting ammonia gas to the lower body of water, thereby raising the temperature of the lower body, and thus inducing circulation or interchange of the water in said bodies and causing the gas which is not absorbed by the lower body to pass into the upper body and to be therein absorbed without materially reducing said vacuum.

10. The herein described ammonia absorption refrigerating process which is characterized by inclosing the weak or residual ammonia water in closed tanks connected by circulation conduits, maintaining one tank full of said water and maintaining the level of the water in the other tank below the top thereof but above the openings of the conduits, creating a partial vacuum above the said level, admitting ammonia gas to the completely filled tank, thereby raising the temperature therein and setting up the circulation of the water through the tanks and conduits, and maintaining said partial vacuum until said water is substantially saturated with ammonia.

11. That improvement in the process of refrigeration by ammonia expansion and absorption which consists in separating the ammonia liquid into a plurality of closed bodies, remote from each other and in intermediate, attenuated, unbroken circulatory

communication, and subjecting said liquid substantially throughout the absorbing period and during circulation from one body to another, to the action of a vacuum or partial vacuum, whereby back pressure is avoided.

12. The herein described ammonia absorption refrigerating process that is characterized by the division of a requisite quantity of ammonia water into distinct bodies siphonically connecting said bodies for wholly submerged circulatory interchange, causing a higher temperature in one than in the other during both distillation and absorption periods and preventing the escape of steam and gas from the water during the distilling and absorbing periods respectively.

13. The herein described ammonia absorption refrigerating process, characterized by maintaining a requisite quantity of ammonia water is relatively remote, segregated bodies and in uninterrupted, closed, circulatory communication, causing a higher temperature in one of said bodies than in the other and thereby inducing active circulation within and between said segregated bodies for the purposes specified.

14. The herein described ammonia absorption refrigerating process which comprises maintaining a requisite quantity of ammonia water in relatively remote, segregated bodies and in uninterrupted, closed circulatory communication, applying heat to one of said bodies to distil ammonia gas and set up an active circulation within and between said bodies to retain and condense the steam and drive off ammonia gas, then allowing the residual ammonia water to cool, and thereby preparing the water for absorption of ammonia gas and subjecting the water to a partial vacuum, and thereafter admitting ammonia gas to the body previously heated and thereby reinducing the described circulation within and between the bodies to retain the gas within the water until absorbed thereby.

15. The herein described ammonia refrigerating process, including the distillation, condensation, expansion and reabsorption of ammonia gas, and characterized by maintaining the upper surface portion of the ammonia water at a steam-condensing, ammonia-gas-evolving temperature during distillation, and by creating and maintaining a partial vacuum at said upper surface during expansion and absorption, whereby substantially anhydrous ammonia gas is distilled under pressure and is subsequently reabsorbed without back pressure.

16. The herein described ammonia distillation and absorption refrigerating process, characterized by dividing the requisite quantity of ammonia water into upper and lower bodies, distilling both bodies by application

of heat to the lower body and liquid inter-
change, limiting the upper body to a steam-
condensing, gas-distilling temperature by
heat radiation, and diffusing all vapors and
5 gases from the lower body in the cooler up-
per body, then cooling both bodies and thus
creating a partial vacuum above the upper
body, establishing liquid interchange and
diffusing all gases not absorbed by the lower
10 body in the upper body, whereby substan-

tially anhydrous ammonia gas is distilled
under pressure and subsequently reabsorbed
without back pressure.

In testimony, that I claim the foregoing
as my invention, I have signed my name in 15
presence of two subscribing witnesses.

DANIEL C. SMITH.

Witnesses:

L. J. MURPHY,
JOHN MURTAGH.