Feb. 21, 1928. 1,659,681

R. W. DAVENPORT

METHOD OF TRANSFORMING HEAT

Filed Sept. 25, 1925

Fig. 1

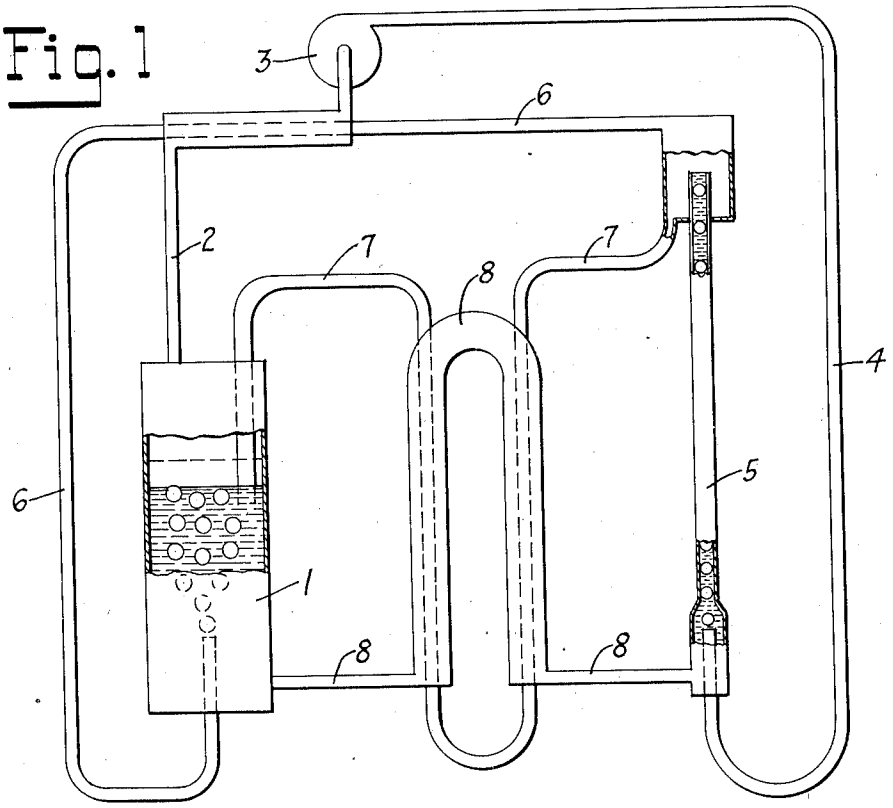
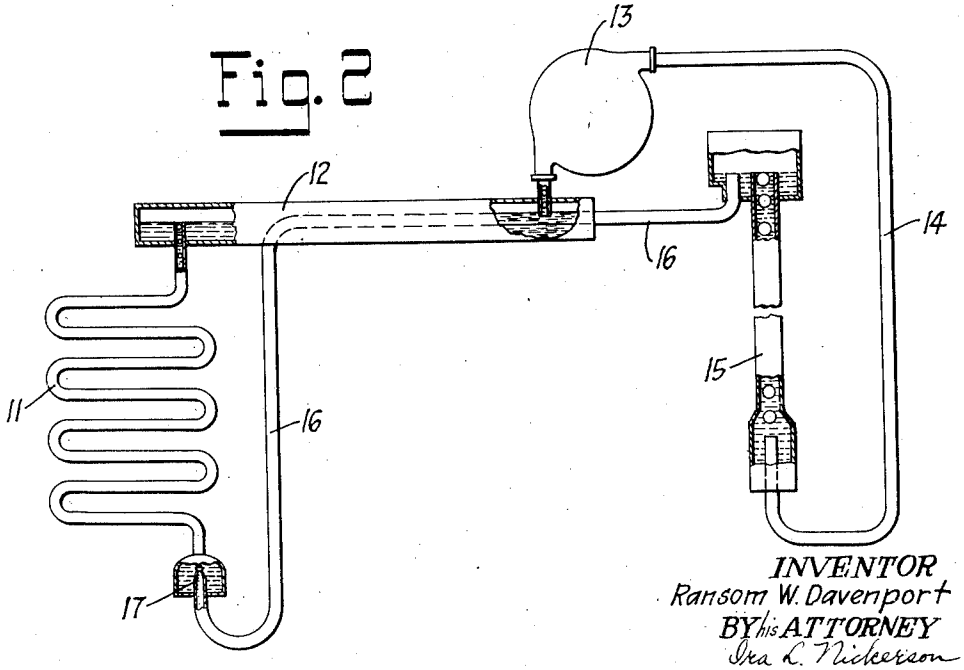


Fig. 2



INVENTOR
Ransom W. Davenport
BY his ATTORNEY
Ira L. Nickerson

Patented Feb. 21, 1928. 1,659,681

UNITED STATES PATENT OFFICE.

RANSOM W. DAVENPORT, OF DETROIT, MICHIGAN, ASSIGNOR TO CHICAGO PNEUMATIC TOOL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

METHOD OF TRANSFORMING HEAT.

Application filed September 25, 1925. Serial No. 58,558.

This invention relates to an improved process for transforming heat and is in the nature of a continuation in part of the inventions set forth in my prior application, Serial No. 570,015 filed June 22, 1922. While the process is equally and identically applicable to heating or to refrigeration, it is herein set forth in its application to refrigeration.

In my improved process, a refrigerant, liquid at ordinary or room temperatures and atmospheric pressures, is caused to give off vapor while in thermal proximity to the thing to be cooled, by raising its own internal or partial vapor pressure relative to the total external pressure instead of merely reducing the external pressure of its own vapor upon its surface as was heretofore common practice. This is accomplished by expanding into the liquid one or more rapid currents of a mixture of vapor and air or other gas substantially insoluble in and inert to the liquid. The voids or bubbles of air formed within the liquid filled, by Dalton's law, with the vapor of the liquid extend the surface, break up the liquid, and liberate the vapor, thus cooling the remaining liquid from which the heat of vaporization necessarily comes.

This invention further consists in an improved method of removing the vaporized refrigerant from contact with its liquid. Instead of merely maintaining a reduced pressure upon the refrigerant at some distant point as was formerly essential, I may carry away the vapor along with and mixed in the rapid current of inert gas which liberated it within the liquid.

A further improvement embodied in this invention is the method of reversing the phase of the refrigerant or reliquefying it. This I may accomplish by sufficiently reducing the volume of the mixed gas and refrigerant vapor in contact with a second body of refrigerant in the liquid phase which is kept near ordinary temperatures by thermal contact with an external medium such as air or water. It is unnecessary to compress the refrigerant much above one atmosphere since, as before stated, I may use a substance normally liquid at common or room temperatures and atmospheric pressures, which separates as a "dew" in the case of a homogeneous liquid such as ethyl oxide or chloride, or may be absorbed into a weaker solution in case the chosen refrigerant is a complex liquid such as ammonium hydroxide.

This invention further includes the improved method of returning the reliquefied refrigerant to the refrigerating zone. This step I may perform by simple gravity, since the total pressure upon the refrigerant is not prohibitively higher at one point than at another.

This invention also includes the complete or closed cycle resulting from the substantially continuous repetition of the above described processes in a single approximately closed system.

The accompanying drawings illustrate possible applications of the invention in practice. For clearness, only simple combinations of elements are shown which may easily be elaborated by anyone skilled in the art.

In the drawings:

Fig. 1 is one form of apparatus for transforming heat in accordance with my improved process and

Fig. 2 is a view of simplified and more practical arrangement of apparatus. For the sake of clearness certain of the parts shown in both figures are partly cut away.

Both figures illustrate types of apparatus adapted to apply this process by bringing into contact with a relatively stationary liquid in the refrigerating zone, a high velocity air current, and by moving the liquid to a higher level and restoring it to its original condition by the action of a relatively stationary mass of gas pressed against it. Liquids of the type of ammonium hydroxide, consisting of solutions or loose combinations of a gas and a liquid, are employed partially to fill the system and the remainder of the system is filled with a gas substantially inert to and insoluble in the liquid. In the case of ammonium hydroxide air may be used as the inert gas.

The operation of the apparatus disclosed in Fig. 1 is as follows: The vessel 1 and its connecting system comprising the interchanger 8 and the air lift column 5 are filled

with aqua ammonia to the dotted line. The fan or centrifugal compressor 3 is started and air from its outlet is forced through pipe 4, air lift column 5 where saturated vapor is added, pipe 6 and suddenly expands into the liquid in 1 superheating the vapor and forcing ahead of it any liquid in the pipe. The now virtually superheated vapor and air mixture forms an emulsoid with the liquid, and evaporation from the enormously increased liquid surface into the voids results in lowering the temperature of the liquid, below the point practicable to reach by merely removing the vapor by the conventional method. Continuing to the surface the bubbles break and the ammonia is carried rapidly away along with the air to the fan 3 through the exchanger 2—6.

The separation of the gas from its solution in 1 results in cooling and diluting the solution, and this cooler and weaker and consequently heavier solution is drawn off through the pipe 8 which, with the pipe 7, forms a double-pipe heat-exchanger, into the column 5. Here the mixed air and ammonia gas from the fan 3, by the well known air-lift principle lifts the liquid to the air level in the upper part of 5. Meanwhile the weakened solution brought into contact with ammonia gas redissolves the gas added by the slight reduction in volume resulting from the pressure of the fan against the liquid head. The liquid in the column 5 does not "boil". It is merely lifted gently upward in contact with the walls of the vessel while each particle of it is brought into contact with the gas by a circulatory movement. The heat of solution—the complement of the heat which was abstracted from the liquid in 1—is imparted to the walls of the vessel 5, whence it may be transferred and utilized or rejected as desired. From the upper part of the vessel 5, the now strong aqua ammonia flows by gravity through the heat-exchanger 7—8 back to the vessel 1, and the mixture of air and unabsorbed ammonia is forced into pipe 6, into and through the aqua ammonia in vessel 1 as before, thus completing the cycle.

To operate the apparatus shown in Figure 2, the refrigerator pipe coil 11, and the condenser column 15, are properly filled with aqua ammonia and the fan or pump 13, of any well known type adapted to handle gas and liquid (such as the Nash "Hytor" for example) is started. The air and vapor, with some liquid, are taken into the pump from coil 11, through pipe 12 (which with pipe 16 forms a heat interchanger), and are discharged at a somewhat higher total pressure into condenser vessel 15, whence the liquid overflows into pipe 16, and is carried along with the air vapor mixture, through the interchanger, back into coil 11. The total pressure on the liquid in 11 is higher than that on the liquid in 12 by the equivalent of the resistance of the pipe 16, which, if insufficient for some particular temperature requirement, may be increased by restricting it as shown at 17. As the aqua ammonia travels upward through coil 11, carried by and emulsified with the air vapor mixture, it gives off ammonia and grows colder, and this cooled and weakened liquor cools the strong liquor coming from the condenser 15 at the condensing temperature, and then passes along with the air-vapor mixture into the pump. Thus there is maintained a circulation of aqua ammonia in contact with air, between the two bodies of liquid, and the aqua ammonia is alternately weakened and strengthened in the members 11 and 15 respectively, while absorbing heat in the former and ejecting heat in the latter. It will be understood that the partial ammonia pressure falls through the member 11 and rises through the member 15, though the total pressures therein may be practically constant, due to the time required for the ammonia to leave the liquid and enter the air, and to separate from the air and become absorbed in the liquid, respectively.

In utilizing my invention for heating purposes the column 5 of Fig. 1, or 15 of Figure 2, is placed in the room to be heated and the vessel 1 of Fig. 1, or the coil 11 of Fig. 2 may be placed outdoors, thus making a very economical heating system since the operating energy required is that represented by the difference in outdoor and indoor temperature and the outdoor heat is simply stepped up to the desired temperature by mechanical power. The losses inevitably attending the high-temperature combustion of fuels as a source of low temperature heat are hereby eliminated.

The process as applied to refrigeration simplifies the art beyond all comparison with prior processes. Working at practically atmospheric pressure throughout, this invention not only cheapens the plant in first cost, but renders its operation economical and safe to a degree hitherto impossible.

I claim as my invention:

1. The thermal process which comprises passing a current of inert and insoluble gas through two bodies of volatile liquid in succession in a closed cycle so that the gas is expanded in one body to absorb heat and compressed in the other to eject heat.

2. The thermal process which comprises passing a current of inert and insoluble gas through two bodies of liquid in succession in a closed cycle to cause change of state of said liquid so that heat is absorbed by one body and ejected by the other, and circulating the liquid between the two bodies.

3. The thermal process which comprises disposing a solution of a working substance and a liquid in spaced bodies, and passing

a gas substantially inert to and insoluble in said substance and said liquid through said bodies in succession in a closed cycle, thereby causing change of state of said liquid so as to absorb heat in one body and eject heat in the other.

4. The thermal process which comprises disposing a solution of a working substance and a liquid in spaced bodies, continuously weakening the solution in one body and continuously strengthening the solution in the other body by forcing a gas substantially inert to and insoluble in said solution and in and to the components thereof to pass through said bodies in succession in a closed cycle, and circulating the liquid between said bodies.

5. The thermal process which comprises disposing ammonium hydroxide in spaced bodies, continuously weakening one body by forcing a cool inert gass therethrough to carry away ammonia vapor therefrom and continuously strengthening the other body by forcing said vapor laden gas therethrough again to place said ammonia vapor in solution, and effecting movement of weak liquor from the first body to the second body and strong liquor from the second body to the first.

6. The thermal process which comprises circulating an inert and insoluble gas through two bodies of liquid in succession in a closed cycle, and causing the gas to withdraw vapor from one body and to redissolve said vapor at least in part in said other body, thereby producing an endothermic effect in said first body and an exothermic effect in said second body, and cooling the gas stream prior to its admission to said first named body.

7. The thermal process which comprises circulating an inert and insoluble gas through two bodies of liquid in succession in a closed cycle, causing the gas to withdraw vapor from one body and to redissolve said vapor at least in part in said other body, thereby producing an endothermic effect in said first body and an exothermic effect in said second body, and cooling the gas stream prior to its admission to said first named body by bringing it into thermal contact with the gas stream issuing from said body.

8. The thermal process comprising placing a solution of ammonia gas in water in proximity to the thing to be cooled; passing a current of a second gas substantially cool, inert to ammonia and insoluble in the solution, into and through the solution; conducting the mixture of inert gas together with the ammonia gas detached from the solution, and the solution weakened by the detaching of the ammonia gas, to a position in proximity to the thing to be heated, separating the ammonia gas from the inert gas by dissolving the ammonia gas in the weakened solution; and returning the strengthened solution and the inert gas into proximity with the thing to be cooled.

9. The thermal process comprising placing a solution of ammonia gas in water in proximity to the thing to be cooled; passing a current of a second gas substantially cool, inert to ammonia and insoluble in the solution, into and through the solution; conducting the mixture of inert gas together with the ammonia gas detached from the solution, and the solution weakened by the detaching of the ammonia gas, separately to a position in proximity to the thing to be heated and then bringing them into contact; separating the ammonia gas from the inert gas by dissolving the ammonia gas in the weakened solution; and returning the strengthened solution and the inert gas separately into proximity with the thing to be cooled.

10. The art of refrigeration comprising passing a current of inert and insoluble gas through two bodies of volatile liquid in succession so that the gas is compressed in one body and expanded in the other, one body being in the refrigerating zone and one body outside the refrigerating zone.

11. The process of producing refrigeration which comprises forcing a vapor mingled with an insoluble gas in a closed cycle in succession through bodies of liquid from which the vapor is derived by expansion and imparted thereto by compression.

12. The process of producing refrigeration which comprises passing a vapor mingled with an insoluble gas in a closed cycle in succession through bodies of liquid from which the vapor is derived, thereby withdrawing more vapor from one of said bodies with an endothermic effect and restoring at least a part of the vapor to solution in the other body with an exothermic effect, and moving the weakened liquid from the first body to the second body and the strengethened liquid from the second body to the first body.

13. The refrigerating cycle comprising boiling a refrigerant liquid in the refrigerating zone at a temperature below that at which its normal vapor pressure exceeds the pressure upon its surface by passing a current of substantially cool inert gas through it, removing the mixture of gas and refrigerant vapor resulting from said boiling, reliquefying the refrigerant vapor, and returning the liquid refrigerant by gravity to the refrigerating zone.

14. The continuous absorption process of transforming heat which comprises utilizing as a vehicle for the working substance a gas, substantially inert to and insoluble in the working substance and in and to its liquid solution, by passing said gas continuously in a closed cycle into and through two bodies of the liquid solution of the working substance

thereby withdrawing the vapor of the working substance from one of said bodies with an endothermic effect and restoring said vapor to solution in said other body with an exothermic effect.

15. The art of refrigeration comprising the separating of the vapor from a refrigerant liquid in the refrigerating chamber and the transporting of the vapor to a distance from the refrigerating chamber by a current of substantially inert and insoluble gas passing through the liquid, separating the vapor from the inert gas by reliquefying the refrigerant, and returning the refrigerant and the inert gas separately to the refrigerating chamber.

16. The thermal process which comprises forcing a mixture of vapor and an inert and insoluble gas in a closed cycle in succession through interconnected bodies of liquid from which the vapor is derived, the vapor being released from one body and reabsorbed in the other body, thereby producing different thermodynamic effects in said bodies of liquid, and maintaining the pressures in said system substantially atmospheric.

17. The refrigerating process which comprises disposing a complex liquid having a volatile component in spaced bodies, and causing said volatile component to undergo change of state by forcing a gaseous incondensible medium to pass through said bodies in succession in a closed cycle, said medium being caused to expand into one of said bodies to effect vaporization of said component with absorption of heat by said body, and said medium being thereafter compressed into the other body to effect condensation of said component with ejection of heat.

18. The refrigerating process which comprises disposing a complex liquid having a volatile component in spaced bodies, and causing said volatile component to undergo change of state by forcing a gaseous incondensible medium to pass through said bodies in succession in a closed cycle, said medium being caused to expand into one of said bodies to effect vaporization of said component with absorption of heat by said body, and said medium being thereafter compressed into the other body to effect condensation of said component with ejection of heat, and providing for movement of the liquid between said bodies so that the liquid weakened by the vaporizing of said component may pass to the body in the heat ejection zone to be strengthened and again pass back to the heat absorption zone to be again weakened.

Signed by me at Detroit, Wayne County, Michigan this 21st day of September, 1925.

RANSOM W. DAVENPORT.