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REFRIGERATING APPARATUS

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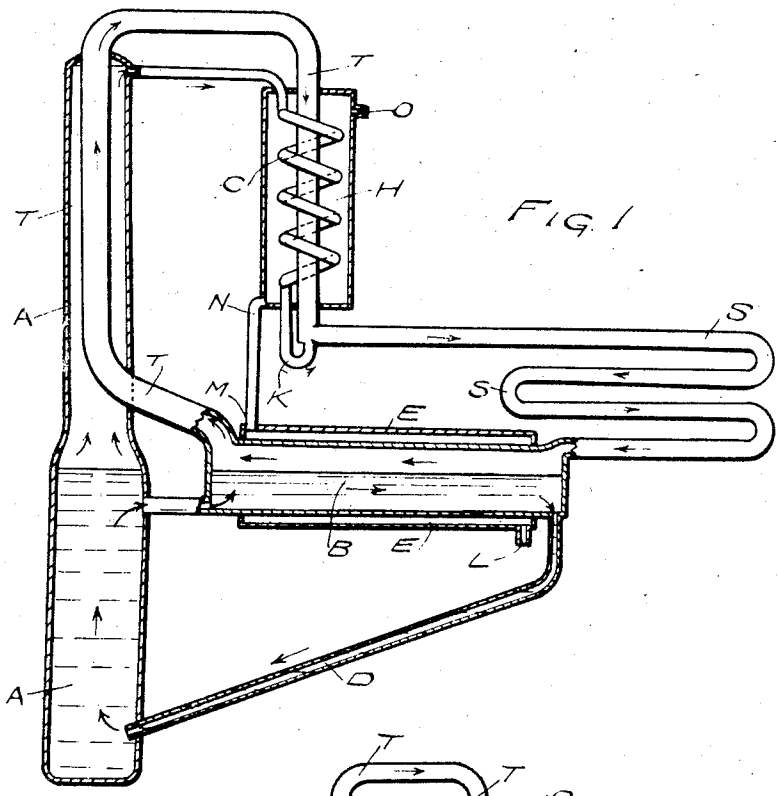


FIG. 1

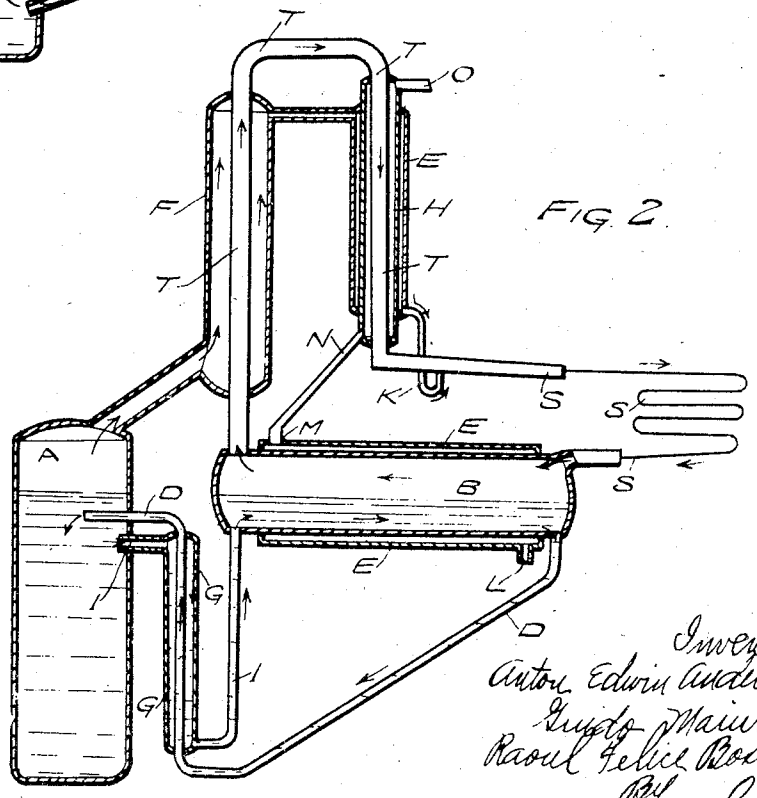


FIG. 2

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UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

Application filed January 23, 1926, Serial No. 83,292, and in Great Britain November 21, 1925.

This invention relates to improvements in refrigerating machines for absorption of ammonia or any other substance having the same properties.

It is well known that in a refrigerating machine of the absorption type it is possible to balance the pressure between the boiler, the condenser, the absorber and the refrigerator by introducing into the circulating system an inert gas at a definitely ascertained pressure.

This is an application of Dalton's law, which proves that evaporation and condensation take place in the presence of an inert gas at the same temperature and pressure as in vacuo. The introduction of an inert gas along with the refrigerating agent into the circuit of refrigerating machines has been proposed and practised in different cases and with varied success, but this system has been proved to be difficult from a practical standpoint owing to the slow rate of evaporation obtainable in the presence of inert gas, especially when the latter is under pressure. This slow rate of evaporation is due to the difficulty of diffusion of the vapour into the inert gas, and the result is that, if the gas is not kept agitated by some mechanical means, the evaporation is so slow as to nullify the refrigerating effect of the apparatus.

In order to obtain a high efficiency in the apparatus it is necessary to provide a means to ensure the rapid circulation of the inert gas, this is necessary to assist the evaporation of the liquid ammonia in the coils of the refrigerator. Many systems of obtaining this result have been proposed, one of which is based on the difference in density of the inert gas and the ammonia vapour, but this has not only a very low efficiency, but necessitates a form of construction of the evaporator, which interferes with the abstraction of heat by the refrigerating coils from the refrigerating chamber, thus defeating the object of the apparatus.

Our invention makes it possible to set up a circulation of the inert gas as rapid as may be desired, and to secure an evaporation of the liquid ammonia in refrigerating coils of the same designs as employed in other refrigerating machines.

In our invention the circulation of the inert gas is forced, and this is effected by closing the circuit with a pipe of suitable diameter forming a reversed siphon, of which the rising pipe is heated in the boiler and the falling pipe is cooled in the condenser. By suitable proportions in the height and diameter of these pipes we obtain a difference of pressure, which is the means by which the circulation is obtained. The apparatus has to be so designed as to permit the circulation of the ammoniacal liquor and of the liquid ammonia by the difference in their specific gravity and levels, the circulation of the ammoniacal liquor can be accelerated by the ebullition in the boiler.

The forced circulation of the inert gas, which assists the evaporation of the ammonia, takes place in our apparatus at the cost of some of the heat of the ammoniacal vapour acquired in the boiler. It is evident that the gas circulating in contact with the liquid ammonia at low temperature decreases in temperature by this contact and that the refrigerating efficiency of the apparatus is thereby somewhat reduced. This reduction in efficiency, however, is trivial, especially in small apparatus, where simplicity of construction is much more important than the highest technical efficiency. The efficiency of the apparatus is still greatly in advance of that of any type of refrigerator depending upon intermittent action.

Machines in accordance with our invention can be constructed in many different forms, with or without heat recuperators.

In order that our invention may be properly understood and readily carried into effect, we have hereunto appended one sheet of drawings, descriptive of the two types of our apparatus, of which—

Figure 1 is a diagrammatic illustration of the simplest apparatus constructed in accordance with our invention.

Figure 2 is an apparatus of the same general type, but arranged for heat-recuperation.

In Figure 1, A is the generator, in which the ammonia solution gives off ammonia vapour when heated from 90 to 120 degrees C.

The ammonia vapour rises to the upper part of the boiler, displacing the compressed inert gas, which fills the whole apparatus, and passes to the coil C of the condenser H where it is condensed and, by the siphon K, is introduced into the evaporator S.

The compressed inert gas passes almost entirely into the closed circuit formed by the evaporator S, the absorber B and the connecting pipe T, and thus a balance of pressure is established between the gas circulating circuit, the generator and condenser. This result is arrived at by the exact calculation of the initial pressure to which the inert gas is compressed.

Any gas may be employed which has no chemical effect on the ammonia, as, for example, atmospheric air, nitrogen, hydrogen and such like.

The connecting pipe T has a vertical section passing through the upper part of the generator A, in which the gas becomes highly heated by the ammonia vapour, which is produced in the boiler at high temperature. The pipe T then passes vertically downwards through the condenser tank, where the gas is cooled by the action of the condensing water. The difference in temperature of the two columns of gas, ascending and descending, promotes active movement of the gas in the direction indicated by arrows. The gas circulation system is completed by the evaporator S and the absorber B.

At the point of its entering the evaporator S, this rapidly moving gas comes into contact with the liquid ammonia flowing from the condenser, promotes the evaporation of the liquid ammonia and carries forward the ammonia gas to the absorber B, where it is absorbed by the weak solution there present.

By designing the apparatus with suitable proportions for the generator, condenser and the rising and falling legs of the gas circulating system, that is, by suitably proportioning the heating and cooling surfaces, it is possible to obtain a circulation as rapid as is necessary for the efficient operation of the apparatus.

It is obvious that the pipe T may be in the form of a coil or any type of multi-tubular heater as may be required to provide the necessary heating surfaces.

The inert gas in the circulating system becomes thoroughly mixed with ammonia vapour in the evaporator S, but gives this up on coming into contact with the weak solution in the absorber B. The speed of circulation is calculated to give a definite mixture of refrigerating vapor and inert gas at the point of its reaching the absorber and so as to obtain the desired evaporation in the coil S, which has to be constructed so as to give a continuous fall in the direction of the absorber, so as to avoid any accumulation of water, which can be carried forward by the ammonia vapour and to facilitate the circulation of the gas.

As the rich ammonia solution in the absorber B is cooled by the water passing through the jacket E, entering at the connection L and passing through the connections M and N to the condenser, from which it flows out at the connection O, the temperature of the solution in the pipe D is about 20 degrees C., while that of the solution in the generator A is about 100 degrees C. The difference in the density of the solution at these two temperatures is approximately 4%, whilst the difference in the density of the rich and weak solutions is approximately 2%, so that the net difference in density available for circulating the liquid is 2% approximately and this ensures circulation in the direction indicated by the arrows. The amount of circulation is regulated by the diameter given to the pipe D.

The apparatus, which is represented in the drawing, Figure 2, contains a heat-interchanging device, which transfers the heat of the weak solution passing from the boiler to the absorber to the rich solution passing from the absorber to the boiler, and also shows a different construction of the heater T, the operation of the apparatus remaining unaltered, and in addition the condenser is shown as of the counter-current type employing concentric vessels.

The hot ammonia vapour from the generator A passes through the chamber F, surrounding the heater pipe T, and heats the gas contained in this pipe T. It then passes to the outer chamber E′ of the condenser, where it is cooled by the water flowing through the middle chamber of the condenser, this water cooling at the same time the gas in the central chamber of the condenser.

The operation of the apparatus follows the lines already described and the only alterations in the design shown in Figure 2, as compared with that shown in Figure 1, are the addition of the heat-recuperator G and in the form of the condenser. The difference in density, which is caused by the action of the heat-recuperator G in which the temperature of the weak solution in the pipe I is greater than that of the rich solution in the pipe D, is so slight as to have no effect upon the thermo-siphonic circulation.

The construction of the apparatus can follow any convenient design, the Figures 1 and 2 being diagrammatic only, and the concentric chambers of the condenser shown therein can be substituted by coils of tube or radiators of multi-tubular form. The absorber, which is shown as a horizontal vessel, can be replaced by a horizontal coil of tube, the lower half being filled with ammonia solution and the space formed by the upper half with the inert gas containing entrained ammonia gas

in circulation. The circulation of both elements, solution and gas, may be in the same direction or opposed. The heating of the ascending column of gas can be performed, in the case of large apparatus, in any efficient manner, when the heat contained in the ammonia gas is not sufficient for the purpose.

There is some loss of efficiency in the evaporator S, as the gas enters at a rather higher temperature than that of the condensing water and leaves at the temperature of the evaporation of ammonia, so it follows that, for a given refrigerating effect, there must be a greater evaporation of ammonia in evaporator S and a greater production of ammonia vapour in the generator A than are theoretically required. It is possible to reduce this loss to a minimum by introducing a heat interchanger between the outlet of the evaporator S and the inlet to the absorber B. In this manner the inert gases contained in the pipe T transfer their higher temperature to the ammonia vapour entering the absorber and it is thereby reduced in temperature to that of the ammonia in the evaporator S. The heating of the circulating gas at this point increases the efficiency of the apparatus because it reduces the loss due to the inevitable presence of water vapour in the condenser and evaporator. With this additional heat-interchanger the efficiency of the apparatus is equal to that of the most efficient forms of absorption refrigerators.

In place of ammonia and water the system can be operated by other substances of like properties.

Claims:

1. Absorption refrigerating apparatus of the constant pressure type in which an inert gas is circulated between the evaporator and absorber, comprising a generator, a condenser, an evaporator and an absorber connected to form a closed system, and a conduit connecting the absorber and the evaporator for the passage of inert gas from the absorber to the evaporator, said conduit comprising an upwardly extending portion passing through the generator and a downwardly extending portion passing through the condenser, whereby inert gas passing through said conduit will be heated in the upwardly extending portion and cooled in the downwardly extending portion.

2. Absorption refrigerating apparatus of the constant pressure type in which an inert gas is circulated between the evaporator and absorber, comprising a generator, a condenser, and evaporator and an absorber connected to form a closed system, and a conduit connecting the absorber and the evaporator for the passage of inert gas from the absorber to the evaporator, said conduit comprising an externally heated upwardly extending portion and an externally cooled downwardly extending portion, whereby inert gas passing through said conduit will be heated in the upwardly extending portion and cooled in the downwardly extending portion.

In witness whereof we affix our signatures.

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