March 5, 1929. R. W. DAVENPORT 1,704,177

HEAT TRANSFORMING APPARATUS

Filed Feb. 28, 1927

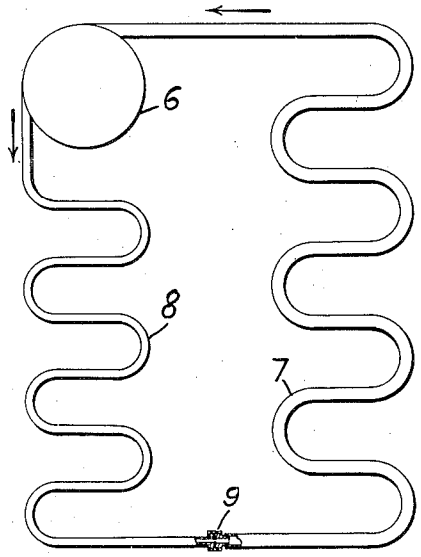


Fig. 1

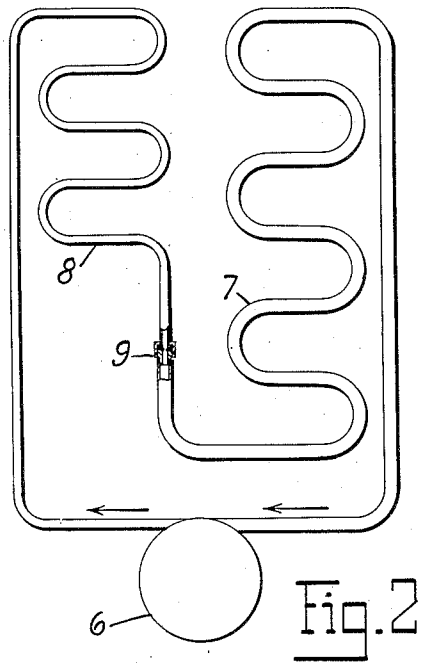


Fig. 2

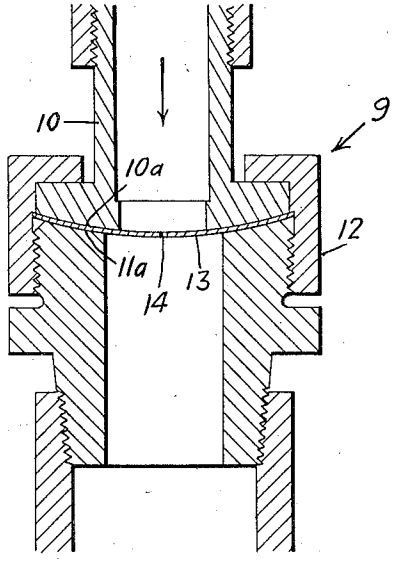


Fig. 3

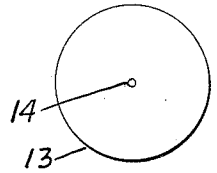


Fig. 4

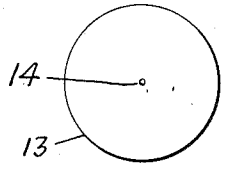


Fig. 5

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UNITED STATES PATENT OFFICE.

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HEAT-TRANSFORMING APPARATUS.

Application filed February 28, 1927. Serial No. 171,465.

This invention relates to apparatus for transforming heat, particularly refrigerating system of the closed cycle type. While the invention has general application, it has been developed with particular relation to small automatic and self-contained refrigerating outfits such as those intended for household use.

In a closed cycle refrigerating system of the condenser-compressor-evaporator type it is necessary to provide means for feeding condensed refrigerant from the condenser to the evaporator to make up for the liquid evaporated in the latter by the action of the compressor. If liquid alone is passed from condenser to evaporator the system operates upon the conventional or straight cycle. If the system contains a gas in addition to a volatile liquid and if the feeding means between the condenser and the evaporator passes the gas along with the condensed liquid the system operates upon the vapor gas principle, disclosed in my co-pending application Serial No. 15,172, filed March 12 '1, 1925.

In systems operating on the conventional cycle the feeding means usually takes the form of a valve or variable orifice, the variation being controlled by changes either in the vapor tension or in the level of the liquid in the evaporator and is generally called by the misleading name of "expansion valve". Such a valve is simply a boiler feeder, no vapor or gas and therefore nothing capable of expanding being allowed to pass, but only liquid which evaporates at a constant pressure in the boiler, a part at once and a part later.

One object of my invention is to provide a simplified form of apparatus for refrigeration by changes of state of the refrigerant fluid liquid. Another object is to permit easy control of the operating characteristics of a closed cycle system. Still another object is to provide simple ways and means for interposing the necessary resistance to the passing of the working substance from the high side to the lower side of the system, as from the condenser to the evaporator. Other objects of the invention will be apparent from the detailed description which follows.

Instead of a valve or variable orifice the invention involves the use in a particular location of a fixed orifice having a critical relation to the capacity of the pump or compressor. By providing interchangeable members each having an orifice of a different size the operating characteristics of the system can be varied widely and the same may be caused to run either on the conventional cycle or on the vapor gas principle. By preference the orifice is formed in a disk shaped member or diaphragm which may serve the additional purpose of a sealing gasket in a detachable fitting provided in the connection between the condenser and the evaporator.

In order to illustrate the invention concrete embodiments thereof are shown in the accompanying drawings in which Figs. 1 and 2 are diagrammatic views illustrating different arrangements of parts in closed cycle systems of the condenser-compressor-evaporator type, the feeding device in each view being shown in section; Fig. 3 is a vertical sectional view on a greatly enlarged scale of the feeding or control device shown in Figs. 1 and 2, the device being in the position shown in Fig. 2. Figs. 4 and 5 are plan views of diaphragms having orifices of different sizes.

The heat transforming system illustrated in Figs. 1 and 2 comprises a pump or compressor 6 connected to an evaporator 7 and discharging the fluid drawn from the evaporator 7 at a higher pressure and temperature into a condenser 8 from which the condensed refrigerant is fed back into evaporator 7 through the feeding device or control member 9. Control device 9, to which the invention particularly relates, is shown in full detail in Fig. 3 and in its preferred form comprises a simple fitting or union having a part 10 secured to the condenser connection and a part 11 secured to the evaporator connection, these parts having clamping faces 10^a and 11^a which are forced together by a nut 12 rotatively mounted on part 10 and having screw threaded engagement with part 11. By unscrewing nut 12 the fitting is easily disconnected and the connection is as quickly restored in an obvious manner. To provide a tight seal removable and interchangeable gasket members 13 in the form of circular disks or diaphragms of thin sheet material such as metal are clamped between the engaging faces 10^a and 11^a, which faces are so shaped as to force member 11 into a slightly dished shape. Each gasket member or diaphragm 13 has a fixed orifice 14 which provides the necessary resistance to the passage

of fluid from condenser 8 to evaporator 7 to mark the line of division between the high and low sides of the system.

Figs. 4 and 5 show in plan typical disk members or diaphragms 13 with orifices 14 of different sizes. The disk members or diaphragms 13 shown in Figs. 2, 3 and 4 have an orifice of sufficient size to pass at the same time both the liquid and the gaseous products of the condenser 8 so that the system may operate upon the vapor gas principle referred to above. The diaphragm member 13 shown in Fig. 5 has a smaller orifice 14 which so restricts the passage of fluid from the condenser to the evaporator that a body of liquid will gather at the left of feeding device 9 in Fig. 1 or above the feeding device 9 in Fig. 2 so that the system will operate on the conventional cycle. The proper size of the orifice to cause the system to operate on the desired cycle is determined to some extent by the density, viscosity, and other characteristics of the selected working substance and to a far greater extent by the capacity or displacement of the pump which is used. In any event the size of the orifice bears a critical relation to the pump capacity with a given displacement and given working substance. The size of the orifice for securing the desired operating characteristics of the system may be easily determined empirically, and once determined may be standardized for the range of conditions commercially encountered.

For example, in the case of a refrigerating outfit for domestic use where the variation in the refrigeration required (caused only by variation in room temperature) is obtained by operating the apparatus for longer or shorter periods at a practically constant speed and within a few degrees temperature scale, the orifice should be small enough so that toward the close of the running period and with the refrigerator temperature approaching the minimum desired, there will still be ample liquid to seal off and cover the orifice in the diaphragm, if it is desired to employ the conventional or reversed Rankine cycle. On the contrary when a vapor gas principle is to be employed, the orifice must be large enough to prevent the accumulation of liquid for more than a short period directly after starting the machine with the refrigerator at the upper end of its operating temperature range. With an orifice of proper size it will be found, of course, that on the initial running of the apparatus with the refrigerator at room temperature there will be a temporary loading up of liquid at the orifice but this lasts only a short time and is an advantage rather than a disadvantage as it tends toward the self-limiting of the load imposed on the compressor.

The upper size limit for a feed orifice in a given system is reached when the low side or evaporator pressure begins to rise on successive increases in the orifice area. In experimenting with diaphragm members having orifices of gradually increasing size the following phenomena are noted:

With a closed cycle system containing a quantity of liquid having a volatile component and the remainder of the system filled with a gas such as air and starting with a feeding device having an orifice so small as to pass only liquid and then gradually enlarging the orifice until it begins to pass the gaseous component of the working substance in greater and greater quantity, the temperature of the evaporator close to the orifice will gradually fall while the total or gauge pressure also falls until a point is reached where more orifice area causes the low side pressure to rise abruptly and the temperature near the orifice then also rises to a point even above that of the remoter parts of the evaporator. This turning point is sharply marked and no difficulty will be experienced in avoiding too large an orifice in any given combination.

I am aware that it has previously been proposed to use a fixed orifice in a closed cycle system as in the patent to A. T. Marshall No. 1,436,815 of Nov. 28, 1922. Such proposed use, however, is for an entirely different purpose from my invention since the orifice is provided on the low or suction side of the system and for a distinctly different purpose, namely, to prevent liquid from being drawn into the pump or compressor.

In practice it has been found to be highly desirable, if not essential, that the condenser 8 be disposed at a higher level than the feeding device 9. At least the connection from the condenser to the feeding device 9 should be so disposed that the condensate shall drain by gravity to the latter. In general the preferred arrangements of parts are shown diagrammatically in Figs. 1 and 2. While the system will operate efficiently on the vapor gas cycle with either of the arrangements shown in Fig. 2 the particular disposition of the feeding device which is preferable is shown in Figs. 2 and 3 wherein disk 13 is disposed horizontally and is slightly dished upwardly so that the condensate intercepted by the diaphragm drains toward the orifice and is blown or carried through the orifice by the gaseous component of the working substance.

While my invention has been herein disclosed in what is now considered to be its preferred form or forms, it is to be understood that the invention is not limited to the specific details thereto but covers all changes, modifications and adaptations within the scope of the appended claims.

I claim as my invention:

1. Apparatus for producing heat transforming effects comprising an evaporator, a

pump, and a condenser connected together to form a closed cycle system, and a feeding device mounted in the connection between said condenser and said evaporator and having a feeding element, said device being demountable and arranged for interchangeable association with different feeding elements, thereby to vary the operating characteristics of the system.

2. Apparatus for producing heat transforming effects comprising an evaporator, a pump, and a condenser connected together to form a closed cycle system, and a feeding device mounted in the connection between said condenser and said evaporator and having a perforated disk for passing condensate from said condenser to said evaporator, said device being demountable and arranged for interchangeable association with a second disk having a perforation of a different size, thereby to determine whether the system shall operate on the conventional cycle or on the vapor-gas principle.

3. Apparatus for producing heat transforming effects comprising an evaporator, a pump, and a condenser connected together to form a closed cycle system, a detachable fitting in the connection between said condenser and said evaporator, and having a removable feeding element, said fitting being arranged for interchangeable association with another feeding element for varying the operating characteristics of said system.

4. Apparatus for producing heat transforming effects comprising an evaporator, a pump, and a condenser connected together to form a closed cycle system, a detachable fitting in the connection between said condenser and said evaporator, and having a perforated disk as a feeding element arranged to assist in the sealing of said fitting, the latter being arranged for interchangeable association with disks having perforations of different sizes for determining the operating characteristics of said system.

5. Apparatus for producing heat transforming effects comprising an evaporator, a pump, and a condenser connected together to form a closed cycle system, a detachable fitting in the connection between said condenser and said evaporator, and a diaphragm forming a gasket for said fitting and having an opening for controlling the feeding of fluid to said evaporator.

6. Refrigerating apparatus comprising an evaporator, a pump, and a condenser, connections between said parts to form a closed cycle system, and a horizontally disposed member extending transversely of the connection between said condenser and said evaporator, said member having an opening therethrough bearing a critical relation to the capacity of said pump and arranged to pass the liquid products of the condenser around the periphery of the opening and the gaseous products through the center of the opening.

7. Refrigerating apparatus comprising an evaporator, a pump, and a condenser, connections between said parts to form a closed cycle system, and a horizontally disposed member extending transversely of the connection between said condenser and said evaporator, said member having an opening therethrough bearing a critical relation to the capacity of said pump, said condenser being disposed above said member and arranged to drain by gravity directly thereto so that the liquid products of the condenser may pass through the opening in said member adjacent the periphery thereof while the gaseous products blow through the center of said opening.

8. Refrigerating apparatus comprising an evaporator, a pump, and a condenser, connections between said parts to form a closed cycle system, a detachable fitting in a substantially vertical portion of the connection between said condenser and said evaporator, and an upwardly dished diaphragm in said fitting having an opening therethrough bearing a critical relation to the capacity of said pump for controlling the feeding of fluid from the condenser to the evaporator.

9. Refrigerating apparatus comprising an evaporator, a pump, and a condenser, connections between said parts to form a closed cycle system, a detachable fitting in a substantially vertical portion of the connection between said condenser and said evaporator, and an upwardly dished diaphragm in said fitting having an opening therethrough bearing a critical relation to the capacity of said pump for controlling the feeding of fluid from the condenser to the evaporator, said diaphragm also serving as a sealing gasket for said fitting.

Signed by me at Detroit, in the county of Wayne, and State of Michigan, this 24th day of February, 1927.

RANSOM W. DAVENPORT.