

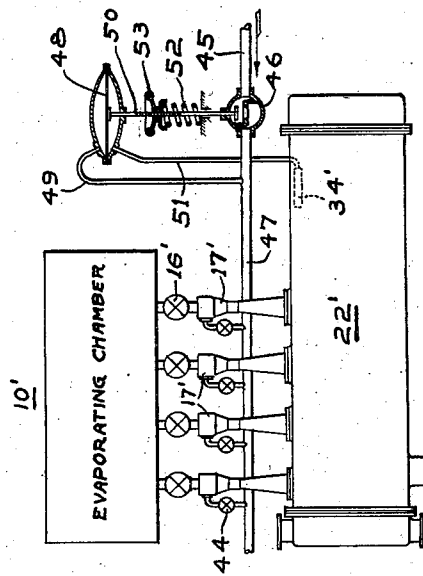
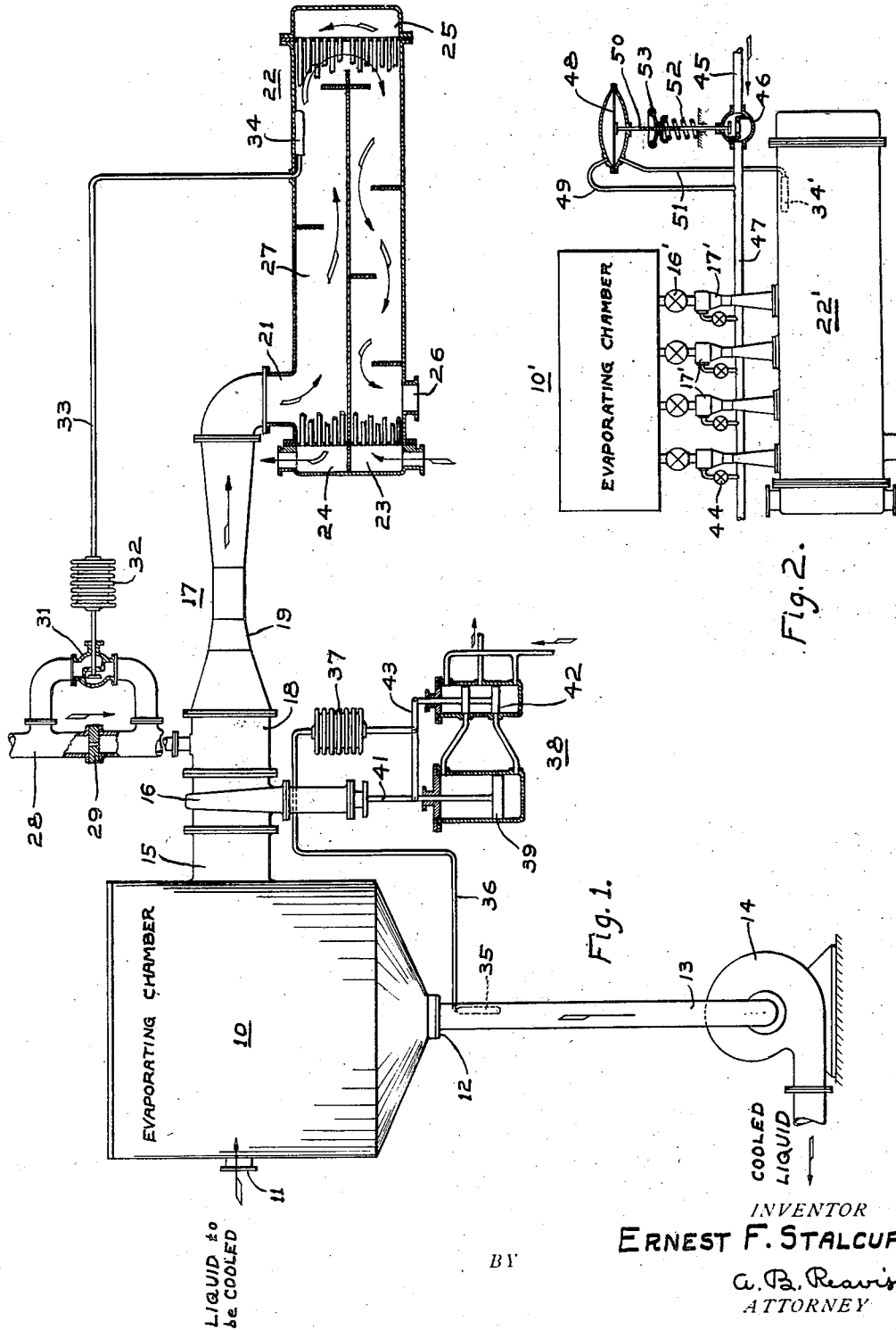
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STEAM JET REFRIGERATION APPARATUS

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STEAM JET REFRIGERATION APPARATUS

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My invention relates to refrigeration apparatus of the type known as steam jet refrigeration apparatus, and it has for its object to improve the economy of operation thereof.

5 A further object is to provide novel and improved means for controlling the amount of refrigerating action of steam jet refrigeration apparatus.

10 In refrigeration apparatus of the steam jet type, cooling of liquid is effected in a closed chamber by withdrawing vapor therefrom, which is effected by an ejector motivated by steam or other condensible vapor. The vapor exhausted from the ejector is condensed in a condenser in
15 which it is brought into heat exchange relation with a cooling fluid, usually water. The temperature of the available cooling fluid usually varies throughout the year, particularly with the different seasons. The pressure and the tem-
20 perature of the vapor in the condensing space of the condenser vary with the temperature of the cooling fluid, which means that a lower pressure, or a higher vacuum, may be obtained at certain times than at other times.

25 In accordance with my invention, I vary the admission of motivating fluid to the ejector with variation in the absolute pressure in the condensing space of the condenser, the admission being decreased as the pressure decreases; the
30 ejector being operative with a smaller quantity, or lower pressure, of motivating fluid as the pressure against which it discharges is reduced. The admission of the motivating fluid to the ejector is controlled in response to any operating condi-
35 tion which varies with the pressure in the condensing space, which variable condition may be, for example, said pressure itself, the temperature in the condensing space, or the temperature of the cooling water. The apparatus must be de-
40 signed for admission of the quantity of motivating fluid required for operation with maximum temperature of cooling fluid, and by decreasing said admission as said temperature decreases, I
45 make a substantial saving in the quantity of motivating fluid admitted, the saving varying with the decrease in temperature of the cooling fluid.

50 In accordance with another feature of my invention, I provide valve means between the evaporating chamber and the suction inlet of the ejector, and I control the same to regulate the temperature which the cooling action maintains
at a low value, such as the temperature of the water or other liquid circulated and cooled in the evaporating chamber.

55 The above and other objects are effected by my invention, as will be apparent from the following description and claims, taken in connection with the accompanying drawing, forming a part of this application in which:

Fig. 1 is a diagrammatic view of one embodiment of my invention; and,

Fig. 2 is a diagrammatic view of a second embodiment.

Referring now to the drawing more in detail, I show, in Fig. 1, an evaporating chamber 10 having an inlet 11 for the admission of liquid to be cooled and an outlet 12 for liquid which has been cooled. The latter is connected to a conduit 13, provided with a pump 14, for conveying
1 the cooled liquid to the point of use. The chamber 10 is also provided with a vapor connection 15 connected through a gate valve 16 to the suction inlet of a steam ejector 17, the latter comprising a nozzle chamber 18 and a converging-
diverging conduit portion 19.

The exhaust end of the ejector is connected to the vapor inlet 21 of a condenser 22. As shown in this case, the condenser 22 is of the two-pass type, having an inlet water box 23, an outlet wa-
2 ter box 24, and a reversing chamber 25, and it is also provided with an air outlet 26. Preferably and as shown, the ejector 17 is connected to the condenser adjacent the warm end of the tubes, and the condensing space 27 is so arranged that
2 the vapor flows over successively cooler portions of the tubes, as indicated by the arrows on the drawing; this arrangement being known as a counterflow arrangement and well-known in the art.

The ejector 17 is motivated by steam or other suitable vapor which is condensible at the pressure at which it is exhausted from the ejector. The steam is supplied from any suitable source through a steam supply conduit 28. In accord-
3 ance with the present invention, suitable means are provided for regulating the admission of the steam to the ejector in response to an operating condition of the condenser, such regulating means being shown in the present embodiment as com-
4 comprising a restricted orifice plate 29 and a valve 31 arranged in parallel with each other. The opening provided by the orifice plate is fixed, while the valve 31 is controlled by a bellows 32.
5 The latter is connected by means of a tube 33 to a bulb 34 which is arranged at a suitable point in the condensing space of the condenser, for ex-
6 ample, at the position between the inlet and air outlet shown on the drawing at which any super-heat in the exhausted vapor has been removed
7 and at which the fluid is still primarily condensible vapor as distinguished from the greater portion of air adjacent the air outlet, so that the temperature is a function of the vacuum or abso-
8 lute pressure against which the ejector exhausts. The bellows 32, the tube 33 and the bulb 34 contain an expansible fluid, so that as the tempera-
9 ture in the condensing space increases, the fluid expands and extends the bellows 32. The latter opens the valve 31 as it is extended.

The operation of the mechanism for controlling the admission of steam to the ejector is as follows: As the temperature of the cooling water in the condenser varies, the temperature at which the vapor is condensed also varies. Since the vapor is at the point of condensation, the temperature of the vapor is a function of the pressure of the vapor. When the pressure of the vapor in the condensing space becomes lower, as when the temperature of the cooling water decreases, it is possible to operate the ejector 17 with lower steam pressure, that is, with a smaller quantity of steam. As the temperature in the condensing space decreases, the expansible fluid in the thermostatic bulb 34 contracts, whereupon the bellows 32 contracts and moves the valve 31 in closing direction. The latter decreases the quantity of steam admitted to the nozzle chamber of the ejector, whereupon the ejector operates with a saving of steam. Due to the greater throttling of the steam, it is admitted to the nozzle chamber at a lower pressure. The ejecting function of the ejector, however, is substantially unaffected by the decrease in the quantity of steam for motivating the ejector.

As the temperature of the cooling water increases, the temperature and pressure of the vapor in the condensing space also increase. The ejector then requires a greater quantity of steam to maintain it in operation. The increase in temperature causes the fluid in the thermostatic bulb 34 to expand, causing the bellows 32 to expand and move the valve 31 in opening direction, thereby supplying the increased steam required by the ejector.

In order to regulate the amount of refrigerating action effected by the apparatus, I provide the valve 16 and operating and control mechanism therefor.

The valve 16 is of any suitable form, for example, a gate valve, and is controlled, in the present embodiment, in response to the temperature of the cooling liquid discharged from the evaporating chamber. For this purpose, I provide a thermostatic bulb 35 disposed in the conduit 13, and containing an expansible fluid and connected to a tube 36 to a bellows 37. Due to the relatively large size of the valve 16, a relay operating mechanism is required. I show a fluid pressure relay 38 comprising a piston 39 connected to the valve by means of a rod 41, a pilot valve 42 for controlling the fluid pressure applied to the piston 39, and a follow-up lever 43 for returning the pilot valve 42 to cut-off position. The bellows 37 is connected to the lever 43 for controlling the operation of the relay.

The operation of the mechanism for operating the valve 16 is as follows: As the temperature of the liquid discharged from the evaporating chamber decreases, indicating that there should be less evaporation and cooling within the chamber, the valve 16 is to be moved in closing direction, to decrease the quantity of vapor withdrawn from the evaporating chamber. The decrease in temperature causes contraction of the liquid in the thermostatic bulb 35, thereby causing the bellows 37 to contract and move the right-hand end of the lever 43 upwardly. Fluid pressure is thereupon admitted to the lower side of the piston 39, moving the same upwardly and the valve 16 in closing direction. The upward movement of the rod 41 tilts the lever 43 clockwise about its pivotal connection with the bellows 37 and returns the pilot valve 42 downwardly to cut-off position. It will be seen that this mechanism

provides a given incremental movement of the valve 16 for a given change in temperature, and operates to provide a valve opening permitting just enough vapor to be withdrawn from the evaporating chamber to maintain the desired temperature of the liquid being cooled. 5

Upon increase in temperature of the liquid in the conduit 13, the mechanism operates in the opposite direction to move the valve 16 in opening direction. The increase in the amount of vapor 10 withdrawn from the chamber 10 effects the increase in refrigeration necessary to maintain the desired temperature of the liquid. It will be apparent that the temperature of the water is maintained within close predetermined limits, a small 15 change in temperature being necessary to effect operation of the valve 16, but for practical purposes the temperature of the cooled water is said to be maintained substantially constant. It is to be understood that the gate valve is controlled to 20 regulate the temperature that is maintained at a low value by the refrigeration apparatus, and that the temperature of the cooled liquid in the conduit 13 is merely one example of such a temperature. 25

In Fig. 2, I show my invention embodied in steam jet refrigeration apparatus embodying a plurality of ejectors 17' operating in parallel, such a plurality of ejectors being provided to vary the refrigerator load or capacity. Each ejector is 30 provided with a valve 44 whereby motivating steam thereto may be shut off, and a valve 16' for cutting off communication with the evaporating chamber 10'. For this form of apparatus, I preferably employ pressure-reducing means for 35 providing steam of predetermined pressure to such ejector or ejectors as are in operation, and I vary the predetermined pressure at which the steam is supplied to the ejector in response to the temperature of the condensing space in the condenser, whereby the quantity of steam supplied to each ejector is automatically controlled in accordance with changes in pressure in the condensing space independently of the number of 40 ejectors in operation. The steam is supplied from any suitable source to a conduit 45, which is connected to a pressure-reducing valve 46. The latter discharges into a reduced-pressure header 47 with which the ejectors 17 are connected through the respective valves 44. The valve 46 is controlled by a pressure responsive element, such as 50 the diaphragm 48. The pressure in the header 47 is applied to the diaphragm 48 in valve-closing direction through a conduit 49. A thermostatic bulb 34' is disposed in the condensing 55 space, similarly to the bulb 34, and contains a volatile fluid whose pressure is communicated through a tube 51 to the other side of the diaphragm 48 to act in valve opening direction. The valve 46 is biased in opening direction by a 60 spring 52 acting through a hand-wheel 53, which is screw-threaded on the stem 50 and which provides for adjustment of the spring setting.

The operation of the embodiment shown in Fig. 2 is as follows: for each temperature in the condensing space of the condenser 22', the pressure 65 reducing valve 46 maintains a predetermined pressure in the header 47. The fluid in the thermostatic bulb 34' provides a given pressure on the under side of the diaphragm 48 for a given temperature, so that a given pressure in the header 70 47, applied to the upper side of the diaphragm 48, is required to balance the pressure on the lower side. If the pressure in the header is less, the diaphragm 48 moves the valve 46 in opening di- 75

rection to admit more steam until the given pressure is attained, and if said pressure is more, the diaphragm 48 moves the valve 46 in closing direction until the pressure in the header 47 is reduced to said given value. For example, if one of the ejectors is shut down, so that less steam is taken out of the header 47, the pressure therein will begin to rise, and the valve 46 will be moved in closing direction, in the manner just described, to maintain the desired given pressure in the header 47.

Upon a decrease in temperature in the condensing space of the condenser, occasioned by decrease in temperature of cooling water providing decreased pressure in the condensing space, the pressure of the fluid action on the underside of the diaphragm 48 decreases, causing the valve 46 to move in closing direction until a lower pressure is established in the header 47, which lower pressure is acting on the upper side of the diaphragm 48, balances the pressure on the under side. The decreased pressure in the header 47 results in decreased admission to each of the ejectors in operation, since the steam supplied to each ejector varies with the pressure at which the steam is supplied. Upon increase in temperature and pressure in the condensing space, occasioned by an increase in temperature of the cooling water, the pressure in the header 47 is increased so as to supply the increased quantity of steam to each ejector which is required to operate the ejector against the increased pressure in the condensing space.

The relation of pressure in the header 47 to temperature in the condensing space may be adjusted by turning the hand-wheel 53 to adjust the spring setting.

Valve 16' may be operated in any suitable manner, preferably as disclosed in connection with the first embodiment, as shown in Fig. 1.

It will thus be seen that the embodiment shown in Fig. 2, in controlling the pressure at which the steam is supplied to each of the ejectors, varies the admission of steam to each ejector in accordance with the variations in temperature and pressure in the condensing space, independently of the number of ejectors in operation.

From the above description, it will be seen that I have provided apparatus whereby the required quantity of steam or other motivating fluid is reduced whenever the temperature of the cooling fluid is below its maximum value. It will also be seen that I have provided means whereby the amount of refrigeration may be readily controlled, and the temperature of the cooling action maintained substantially constant.

I have used the expression "steam jet refrigeration apparatus" for the reason that it is well known in the art and readily conveys the idea of the type of apparatus to which the invention relates. As used in the appended claims, the expression includes, not only apparatus using steam, but also apparatus of this type using any other suitable fluid, since it is obvious that the invention may be practiced with numerous other fluids.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art

or as are specifically set forth in the appended claims.

What I claim is:

1. In vapor jet refrigeration apparatus, the combination of an evaporating chamber adapted to contain liquid, a plurality of ejectors having their suction inlets connected in parallel to said evaporating chamber for withdrawing vapor from said chamber to effect cooling by evaporation of liquid therein, condensing means connected to the outlets of said ejectors, means for supplying motivating vapor of predetermined pressure to said ejectors, and means responsive to an operating condition of the condensing means variable with the pressure in the condensing space for varying said predetermined pressure.

2. In vapor jet refrigerating apparatus, the combination of evaporator means adapted to contain liquid, a plurality of ejectors for withdrawing vapor from said evaporator means to effect cooling by evaporation of liquid therein, means for supplying vapor under pressure for motivating said ejectors, pressure reducing means between said supply means and the ejectors for maintaining a predetermined pressure of the motivating vapor supplied to the ejectors, means for condensing the vapor exhausted from the ejectors, and means controlling said pressure reducing means to decrease said predetermined pressure in response to variation in an operating condition occurring with decrease in pressure in the condensing space of the condensing means.

3. In vapor jet refrigerating apparatus, the combination of evaporator means adapted to contain liquid, a plurality of ejectors having their suction inlets connected to said evaporator means for withdrawing vapor from said chamber to effect cooling by evaporation of liquid therein, condensing means connected to the outlets of said ejectors, means for supplying motive vapor of predetermined pressure to said ejectors, means for selectively controlling the admission of motive vapor to one or more of said ejectors, and means responsive to decrease in a temperature condition of the condensing means for decreasing said predetermined pressure and vice versa.

4. In vapor jet refrigerating apparatus, the combination of evaporator means adapted to contain liquid, a plurality of ejectors for withdrawing vapor from said evaporator means to effect cooling by evaporation of liquid therein, means for supplying motive vapor under pressure for motivating said ejectors, a valve for controlling the admission of motive vapor to one ejector whereby the same may be individually rendered operative or inoperative, a condenser for condensing the vapor exhausted from the ejectors, a pressure reducing valve between said motive vapor supply means and said valve for controlling pressure of the motive vapor admitted to the ejectors, and means for regulating said valve comprising means responsive to variation in an operating condition occurring with decrease in pressure in the condensing space of the condenser for decreasing the pressure maintained by said valve and vice versa and means responsive to the pressure of the motive vapor leaving said valve for controlling the latter to maintain a substantially constant pressure for each value of said operating condition independently of the number of ejectors in operation.

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