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COOLING APPARATUS

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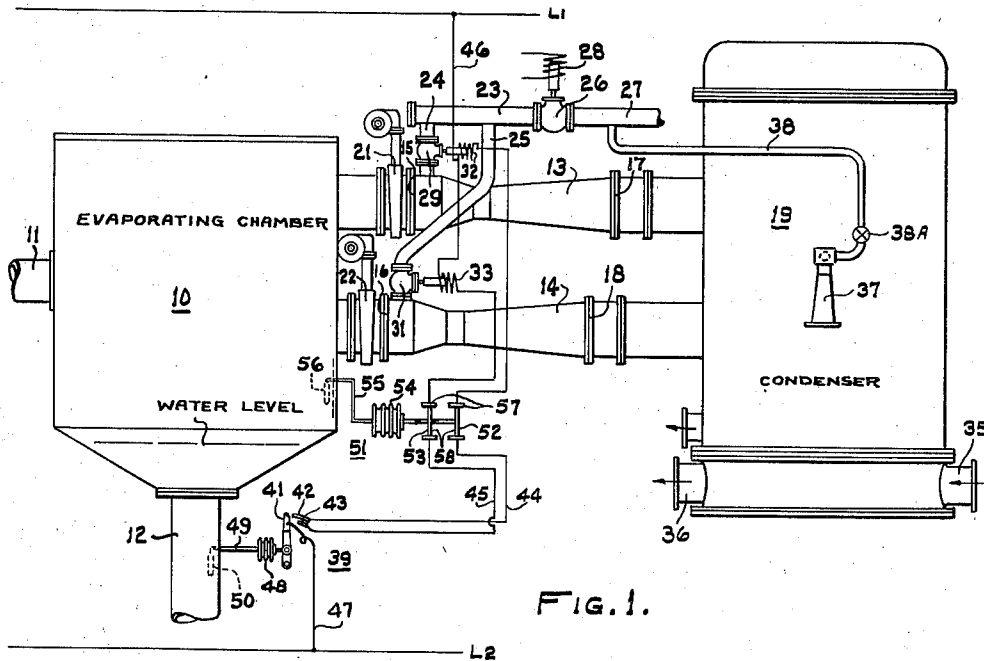


FIG. 1.

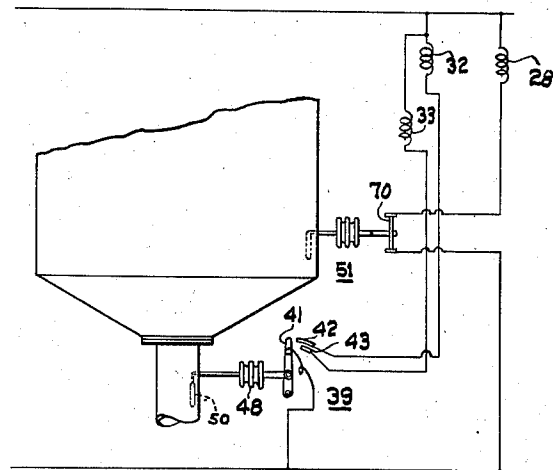


FIG. 2.

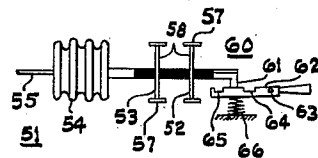


FIG. 3.

WITNESSES:

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COOLING APPARATUS

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Pennsylvania

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11 Claims. (Cl. 62—152)

My invention relates to cooling apparatus of the type known as thermal compressor, or vapor jet refrigerating apparatus and it has for an object to provide an improved control therefor.

A further object of this invention is to terminate operation of a vapor jet refrigerating machine in response to abnormal operating conditions.

Vapor jet refrigerating apparatus usually includes one or more ejectors motivated by a fluid, for example, steam, for maintaining a high vacuum in a chamber containing water, or other medium to be cooled. The water is admitted to the chamber, usually by spraying, and a portion of the water is vaporized at relatively low temperatures due to the low pressure maintained in the chamber. The latent heat of vaporization of the portion which is vaporized is abstracted from the remaining portion, thereby cooling the same. The water vapor is entrained by the ejectors, compressed, and discharged into a condenser. The cooled water in the cooling chamber may be circulated to a point of use for refrigerating purposes.

Faulty operation of the apparatus, such as inadequate vacuum in the condenser, may result in back flow of the relatively high temperature motive fluid from the ejectors into the evaporating chamber and heating of the water or other liquid which is to be cooled. In accordance with my invention, I automatically terminate operation of the ejectors when back flow of motive fluid into the evaporating chamber occurs, in accordance with a predetermined maximum temperature within the evaporating chamber. Undue heating of the water is thereby prevented. The operation of the ejectors may also be terminated in response to a predetermined minimum temperature to prevent freezing of the water.

These 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 a vapor jet refrigerating system arranged in accordance with my invention;

Fig. 2 is a wiring diagram of a modification of the system shown in Fig. 1; and

Fig. 3 is a view of a modified control instrument used in Fig. 1.

Referring now to Fig. 1, the numeral 10 indicates a structure forming an evaporating chamber and having conduits 11 and 12 connected thereto. The conduit 11 conveys liquid, for example,

water, to the chamber for cooling and the cooled water is conveyed from the chamber 10 to a point of use by the conduit 12. Ejectors 13 and 14 are employed for withdrawing vapor from the chamber 10 so as to maintain the pressure therein at the desired value. The ejectors 13 and 14 include vapor inlet portions 15 and 16, respectively, which communicate with the chamber 10. Vapor discharge portions 17 and 18 of the respective ejectors connect with a condenser 19. Vapor valves 21 and 22 may be connected between the ejectors 13 and 14 and the evaporating chamber 10 to prevent reverse flow of vapor from the condenser 19 to the chamber 10, when their respective ejectors are shut down.

Motivating fluid, for example, steam, is supplied to the nozzles (not shown) of the ejectors 13 and 14 from a header 23 through branch conduits 24 and 25, respectively. A main steam valve 26 is arranged between the header 23 and a steam supply pipe 27 for controlling the flow of steam from the latter to the former. Valve 26 may be operated in any convenient manner as by a solenoid 28. Flow of motivating steam through the conduits 24 and 25 is controlled, respectively, by valves 29 and 31 which are preferably electrically operated. Electrical operating mechanisms, such as, for example, solenoids 32 and 33 may be employed for actuating the valves 29 and 31. In connection with the operation of the valves 26, 29, and 31, it will be understood that they are open when their respective operating mechanisms or solenoids are energized, and, conversely, are closed when their solenoids are deenergized.

The condenser 19 may be of a conventional water-cooled type having inlet and outlet connections 35 and 36, respectively, for cooling water. An ejector 37 may be employed for maintaining a suitable condensing pressure within the condenser 19. Motivating fluid for the ejector 37 is conveyed thereto by means of a conduit 38 from the steam supply pipe 27 and is preferably controlled by a hand valve 38A.

Energization of the solenoids 32 and 33 may be controlled by means of a switch 39 having a movable contact 41 and stationary contacts 42 and 43, the latter contacts being so arranged that engagement thereof by the movable contact 41 is effected in sequence. Contacts 42 and 43 are connected to their respective solenoids 32 and 33 by conductors 44 and 45. The solenoids 32 and 33 are connected to one conductor L1 of a source of power by means of a conductor 46 and the opposite conductor L2 of the power source is con-

nected by a conductor 47 to the movable contact 41.

Engagement of the contacts 42 and 41 energizes the solenoid 32 through a circuit including line conductor L2, contacts 41 and 42, conductor 44, solenoid 32, conductor 46, and line conductor L1. The solenoid 33 is energized when contacts 41 and 43 are engaged through a circuit similar to the one traced, but including conductor 45. It will be apparent that, when the switch 39 is so adjusted, contacts 41 and 42 are engaged, the ejector 13 operates. Further adjustment of switch 39 to a position where contacts 41 and 43 engage effects operation of both ejectors 13 and 14.

The switch 39 may be manually operated but I prefer that it be automatically operated in response to temperature of the cooled water. A thermostatic element 50 is therefore disposed in heat exchanging relation with the cooled water in conduit 12 adjacent the chamber 10. The element 50 is connected to an expansible bellows 48 by a tube 49. The element 50, tube 49, and bellows 48 define a closed chamber in which an expansible or volatile fluid is enclosed. Thermostats of this type are well known in the art, and no further description of the same is deemed necessary. The thermostat functions to maintain a predetermined mean temperature within the chamber 10. When the temperature within the chamber is at a predetermined value, for example, 42°, the bellows 48 is contracted and movable contact 41 is out of engagement with contacts 42 and 43. Accordingly, the ejector valves 39 and 31 are both closed. As the temperature within the chamber 10 increases to 43°, the contact 41 engages contact 42 thereby starting ejector 13 and further increase in temperature effects closure of contacts 41 and 43 for initiating operation of ejector 14.

It will be understood that the vapor valves 21 and 22 are opened when their respective ejectors 13 and 14 are started and are closed as their associated ejectors are stopped. These valves 21 and 22 are preferably operated sequentially with respect to the steam valves associated with their ejectors. For example, as operation of the ejector 13 is initiated, the steam valve 29 is first opened, and, after a time interval has elapsed, the valve 21 opens. In terminating operation of the ejector 13, the vapor valve 21 is closed first and the steam valve 29 last. The mechanism for effecting the sequential operation of the steam and vapor valves forms no part of my invention and has not been disclosed. A mechanism for this purpose is disclosed and claimed in the copending application of D. W. R. Morgan, Serial No. 694,510, filed October 20, 1933 and assigned to the Westinghouse Electric & Manufacturing Company.

During normal operation, the ejectors 13 and 14 are rendered active and inactive by the thermostatically operated switch 39 in accordance with predetermined temperatures to be maintained within the chamber 10. Abnormal conditions may develop during which the temperature may increase beyond or decrease below the desired temperatures to be maintained. These abnormal conditions may be due to defective operation of one or more of the various elements of the cooling system. For example, the steam jet in an ejector may "break" due to low steam pressure or high condenser pressure, so that hot steam backs up into the chamber 10 and increases the temperature therein above a desired

value. Defective operation of the thermostat or the switch 39 may cause prolonged operation of the ejectors and decrease the temperature within the chamber 10 to an undesirable, and possibly freezing value.

In order to preclude these undesirable abnormal temperatures, I provide a thermostatic device 51 responsive to predetermined high and low temperatures within the chamber 10 for terminating operation of the ejectors 13 and 14. Preferably, the device 51 operates switches 52 and 53 connected in the conductors 44 and 45. The operation of the thermostatic device 51 is such, that the switches 52 and 53 are closed during normal operation of the apparatus but are opened when the temperature within the chamber exceeds a predetermined high value, for example 60°, or a predetermined low value, for example 35°.

The thermostatic device 51 may include an expansible bellows 54 connected by a tube 55 to a bulb 56 disposed, preferably, in the vapor space within the chamber 10. The switches 52 and 53 have elongated stationary contacts 57 over which bridging members 58 slide, the arrangement being such that the bridging members 58 engage their respective stationary contacts when the temperature of the bulb 56 is between 35° and 60°. As the temperature within the chamber 10 rises above 60°, the bellows 54 expands, moving the bridging members 58 to the right as viewed in the drawing, and disengages them from the stationary contacts 57. Decreasing the temperature of the chamber 10 below 35° causes the bellows 54 to contract and move the bridging members 58 to the left and out of engagement with the contacts 57.

Assuming the ejectors 13 and 14 are operating to withdraw vapor from the chamber 10 and that one or both of the jets "break" due to a low motivating steam pressure, the hot steam will flow from the ejector through the vapor inlet thereof to the chamber 10. As the thermostatic bulb 56 is arranged in the vapor space in the chamber 10, it immediately reflects the rapid change in temperature, and the bellows 54 operates to open the switches 52 and 53. The valve solenoids 32 and 33 are deenergized so that the valves 29 and 31 close, and flow of steam to the chamber 10 is stopped. The temperature within the chamber 10 may then drop to below 60° due to the cold water therein, and close the switches 52 and 53. Control of the valves 29 and 31 is thereby returned to the thermostatically operated switch 39. If the temperature of the chamber 10 remains above 60°, the operator may start operation of the ejectors by manually energizing the solenoid circuits in any manner, as, by manually holding the switches 52 and 53 closed until the temperature in the chamber 10 drops below 60°.

If the temperature of the chamber 10 is depressed below 35° due, for example, to the failure of switch 39 to open, the bellows 54 contracts and switches 52 and 53 open thereby terminating operation of the ejectors 13 and 14. The latter are again subjected to the controlling action of the thermostatic switch 39 when the temperature of the chamber 10 rises above 35°, at which temperature the switches 52 and 53 close.

It may be desirable to so arrange the control apparatus that manual attention is required before the thermostatic switch 39 is conditioned to control the ejectors 13 and 14. In Fig. 3, I show a latching device 60 for holding the switches 52 and 53 open after they have been actuated

to open position by the bellows 54 in response to abnormal high or low temperatures in the chamber 10. The latch 60 includes a bolt 61, movable with the bridging members 58 and a movable latch 62. The latter is pivoted at 63 to a fixed member and has slots 64 and 65 formed therein. Normally the bolt 61 rides back and forth on the latch 62 between the slots but, when the bellows 54 operates to open the switches 52 and 53, the bolt 61 aligns with one or the other of the slots 64 and 65, and the latch 62 is moved upwardly by a spring 66. This movement locks the bolt 61 in the latch and prevents return movement of the bellows 54 and closure of the switches. Before the system can be conditioned for operation, the operator must depress the latch 62 for releasing the bolt 61. The switches 52 and 53 may then close.

In Fig. 2, I show a modified control system in which the thermostat 51 operates a single switch 70 connected in circuit with the solenoid 28 of the main steam valve 26. The solenoids 32 and 33 of the ejector valves 29 and 31 are controlled by the switch 39 and are not subject to control by the thermostat 51. In this embodiment, flow of motivating steam from the supply pipe 27 to the ejectors 13 and 14 is terminated in response to abnormal temperatures obtaining in the chamber 10, as opening of the switch 70 deenergizes the solenoid 28 of the valve 26. In this embodiment, as in the prior one, the latching device of Fig. 3 may be applied to the thermostat 51 and switch 70.

In both embodiments, flow of motivating steam to the ejector 37 should not be interrupted during periods when the apparatus is operative, as it is desirable to maintain a suitable condensing pressure in the condenser at such times. The conduit 38 is therefore connected directly to the steam line 27 and is not controlled by any of the thermostatically-operated valves 29, 31, or 26.

From the foregoing, it will be apparent that I have devised improved vapor jet refrigerating apparatus which may be manually or automatically controlled to maintain liquid at a substantially constant temperature and which may be rendered inactive when the temperature of the liquid or vapor therein attains predetermined high or low abnormal temperatures. I have disclosed electrically operated controlling mechanisms for actuating various elements of my improved apparatus but my invention is not to be limited thereto as other forms of controlling devices may be employed.

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 cooling apparatus, the combination of an evaporating chamber for receiving liquid to be partially evaporated and cooled, ejecting means for withdrawing vapor from said chamber, and means responsive to a predetermined maximum temperature within said chamber for rendering said ejecting means ineffective to withdraw vapor from the chamber.

2. In cooling apparatus, the combination of an evaporating chamber for receiving liquid to be partially evaporated and cooled, ejecting means

for withdrawing vapor from said chamber, and means responsive to predetermined minimum and maximum temperatures within said chamber for rendering the ejecting means ineffective to withdraw vapor from the chamber.

3. In cooling apparatus, the combination of an evaporating chamber for receiving liquid to be partially evaporated and cooled, ejecting means for withdrawing vapor from said chamber, means responsive to predetermined high and low temperatures within the chamber for respectively initiating and terminating operation of said ejecting means, and means responsive to a predetermined temperature, in excess of said predetermined high temperature, within the chamber for terminating operation of the ejecting means.

4. In cooling apparatus, the combination of an evaporating chamber for receiving liquid to be partially evaporated and cooled, ejecting means for withdrawing vapor from said chamber, means responsive to predetermined high and low temperatures within the chamber for respectively initiating and terminating operation of said ejecting means, and means responsive to predetermined temperatures, one of which is higher than said predetermined high temperature and the other of which is lower than said predetermined low temperature, for terminating operation of the ejecting means.

5. In cooling apparatus, the combination of a chamber for receiving liquid to be partially evaporated and cooled, an ejector for withdrawing vapor from said chamber, means for controlling the supply of motivating fluid to the ejector, means responsive to predetermined high and low temperatures within said chamber for actuating said last-named means, and means responsive to predetermined temperatures, one of which is higher than said predetermined high temperature and one of which is lower than said predetermined low temperature, for actuating the motivating fluid controlling means to terminate operation of the ejector.

6. In cooling apparatus, the combination of an evaporating chamber for the reception of liquid to be partially evaporated and cooled, a plurality of ejectors for withdrawing vapor from said chamber, means for selectively controlling the operation of the ejectors, and means responsive to a predetermined high temperature within said chamber for terminating the operation of all of the ejectors.

7. In cooling apparatus, the combination of an evaporating chamber for the reception of liquid to be partially evaporated and cooled, a plurality of ejectors for withdrawing vapor from said chamber, means responsive to predetermined temperatures within said chamber, for controlling the operation of at least one of the ejectors, and means responsive to a predetermined low temperature within said chamber for terminating operation of all of the ejectors.

8. In cooling apparatus, the combination of an evaporating chamber for the reception of liquid to be partially evaporated and cooled, a plurality of ejectors for withdrawing vapor from said chamber, means responsive to predetermined temperatures within said chamber, for selectively controlling the operation of the ejectors, and means responsive to abnormal high and low temperatures within said chamber for terminating the operation of all of the ejectors.

9. In cooling apparatus, the combination of an evaporating chamber for the reception of liquid to be partially evaporated and cooled, a plural-

- ity of ejectors for withdrawing vapor from said chamber, a source of motivating fluid for the ejectors, means associated with each of the ejectors for controlling the flow of motivating fluid thereto, and means responsive to a temperature within said chamber which is a function of an abnormal condition for terminating the flow of motivating fluid to the ejectors independently of the last-named means.
- 10 10. In cooling apparatus, the combination of an evaporating chamber for the reception of liquid to be partially evaporated and cooled, a plurality of ejectors for withdrawing vapor from said chamber, a source of motivating fluid for the ejectors, a header, means for controlling the flow of motivating fluid from said source to said header, a plurality of valves connected, respectively, between said header and the ejectors, means responsive to normal temperature conditions within said chamber for controlling at least one of said valves, and means responsive to abnormal temperature conditions within said chamber for actuating the first-named means to terminate flow of motivating fluid to the header. 5
11. In cooling apparatus, the combination of an evaporating chamber adapted to contain liquid, an ejector for withdrawing vapor from said chamber to effect cooling by evaporation of liquid, means for controlling the admission of motive fluid to said ejector in accordance with the cooling demand on the cooling apparatus, and means operable in response to an operating condition of the cooling apparatus substantially concurrent with and indicating back-flow of motive fluid from said ejector into said chamber for shutting off the admission of motive fluid to said ejector. 10 15

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