June 5, 1934. H. M. GRAHAM 1,961,212

REFRIGERATING APPARATUS

Filed June 29, 1933 2 Sheets-Sheet 1

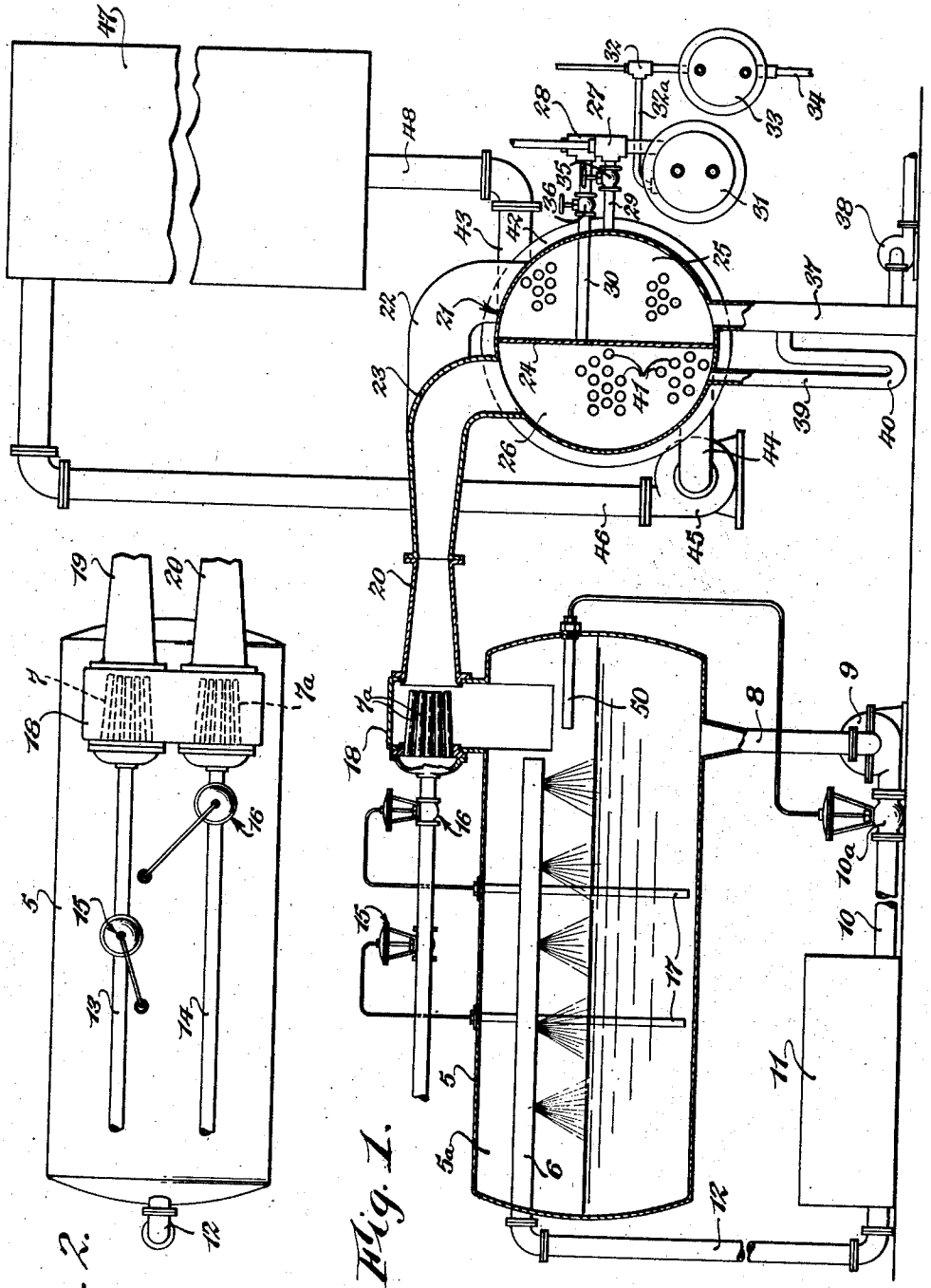

Fig. 1.

Fig. 2.

INVENTOR
Harold M. Graham
BY
Popp and Powers
ATTORNEYS

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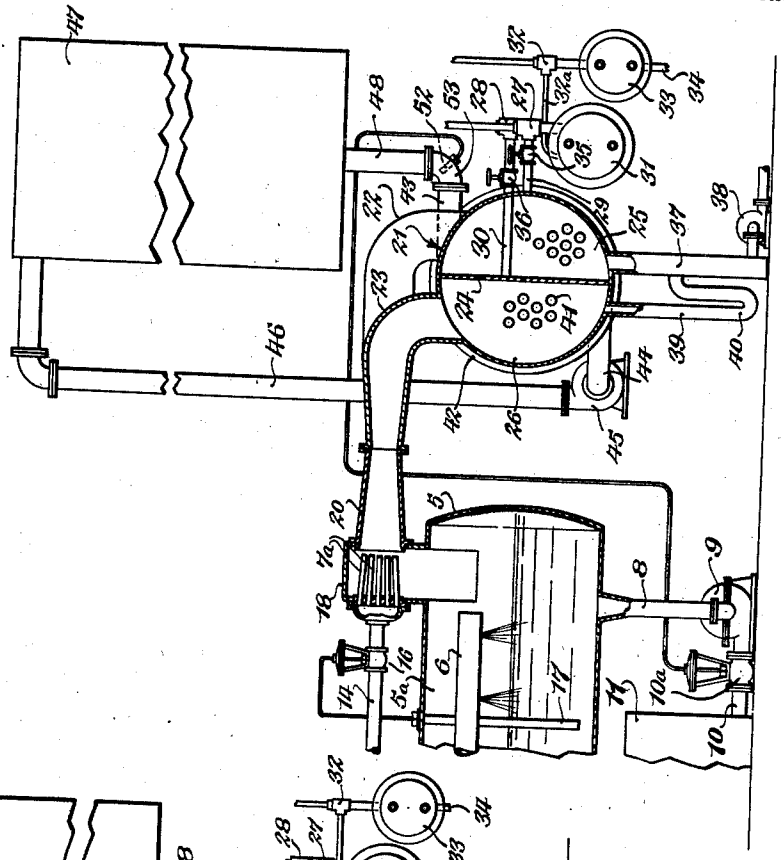

Fig. 4.

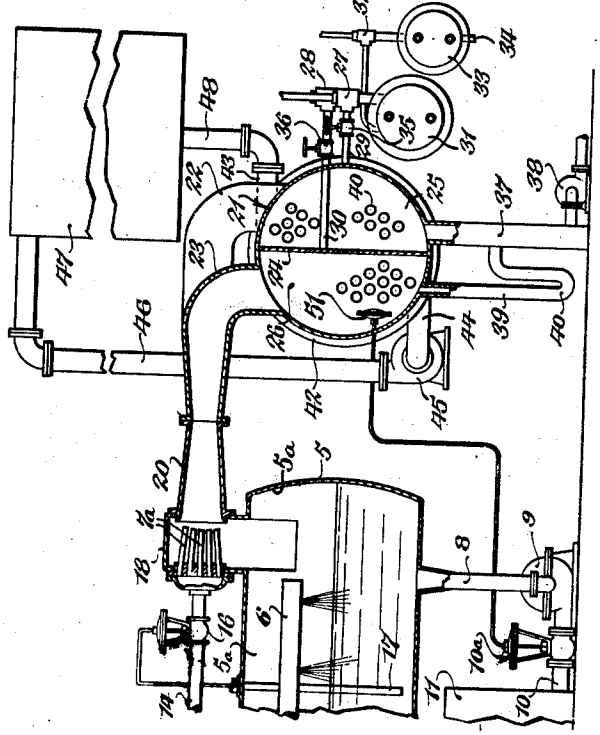

Fig. 3.

INVENTOR
Harold M. Graham
BY
Popp and Powers
ATTORNEYS

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REFRIGERATING APPARATUS

Harold M. Graham, Buffalo, N. Y., assignor to Ross Heater & Mfg. Co. Inc., Buffalo, N. Y., a corporation of New York

Application June 29, 1933, Serial No. 678,203

11 Claims. (Cl. 62—152)

This invention relates to vacuum producing equipment of the kind which utilizes steam ejectors to maintain the required degree of vacuum in the working chamber of the apparatus with which the equipment is associated.

Equipment of the character generally described includes a condenser for condensing the steam discharged from the ejectors, a vacuum of as high a degree as practical being maintained in the condenser in order to facilitate condensation of the steam. The degree of vacuum that can be maintained in the working chamber is dependent, among other factors, upon the degree of vacuum that is maintained in the condenser while the degree of vacuum that can be maintained in the condenser is dependent among other factors, upon the temperature of the cooling water that is circulated through the cooling tubes of the condenser. It will be apparent, therefore, that the degree of vacuum that is maintained in the working chamber, assuming that other factors remain constant, will vary in accordance with the temperature of the water which is circulated through the cooling tubes of the condenser.

In order, therefore, to compensate for variations in the temperature of the cooling water which is circulated through the condenser and in order to compensate for variations in the load upon the equipment, as represented by the work to be performed in the working chamber, for example, the maintenance of the temperature of a refrigerating medium at a predetermined value, it is the practice to provide means, both manually and automatically controlled, for regulating the supply of steam to the ejectors. If, for any reason, for example, failure of the pump which circulates the cooling water through the tubes of the condenser with the attendant increase in the temperature of the cooling water, steam should back up into the working chamber then the refrigerating medium would, unless provision were made to guard against this, be heated instead of cooled. This condition would be aggravated in equipment in which the supply of steam is automatically controlled as the amount of steam delivered to the ejectors would be automatically increased as the degree of vacuum in the working chamber decreased. The circulation of a warm or hot medium through cooling tubes or coils of the apparatus with which the equipment is associated would be highly objectionable, especially if the apparatus were designed for the conditioning of air or the preservation of foods.

The object of the present invention is to provide means for automatically stopping circulation of the refrigerating medium through the apparatus with which the equipment is associated in the event that, as a result of abnormal conditions, the back pressure in the condenser increases, or is likely to increase, to such a value that its capacity will be inadequate for the purpose in view.

The invention is illustrated in connection with air conditioning apparatus. It is to be understood, however, that this is by way of example only as the advantages of the invention may be obtained by its use in connection with various types of apparatus, for example, refrigerating, water cooling and similar systems.

The invention is illustrated in the accompanying drawings, in which:

Figure 1 is a view partially in elevation and partially in section of air conditioning apparatus in which features of the invention are incorporated.

Figure 2 is a top plan view of that part of the apparatus in which the cooling of the refrigerating medium is effected.

Figure 3 is a view similar to Figure 1 of a second embodiment of the invention.

Figure 4 is a similar view of a third embodiment of the invention.

The air condition apparatus, as illustrated, includes a tank 5 which is adapted to provide a cooling chamber 5*a* into which the refrigerating medium is introduced through a pipe 6, a body of the refrigerating medium preferably being maintained in the cooling chamber. The pipe 6 is preferably perforated so that the refrigerating medium is introduced in the form of a spray. Ejectors 7 and 7*a* maintain a vacuum of the required degree in the chamber 5*a*, preferably an absolute pressure of the order of .15 pounds. The temperature of the refrigerating medium in the chamber 5*a* is, therefore, lowered to a temperature which corresponds to such pressure. The refrigerating medium is withdrawn from the chamber 5*a* through an outlet pipe 8 by a pump 9. The latter, which is preferably of a centrifugal type, causes the said medium to flow through a pipe 10 and a valve 10*a* in said pipe to the cooling tubes or coils of the apparatus, the said tubes or coils being sufficiently indicated by a showing of the casing 11 therefor. From the cooling tubes or coils of the apparatus the refrigerating medium is conducted by a pipe 12 to the pipe 6 by which it is reintroduced into the chamber 5*a*.

The ejectors 7 and 7*a* include steam supply pipes 13 and 14 respectively. A valve 15 is located in the pipe 13 while a similar valve 16 is

located in the pipe 14. The valves 15 and 16 are controlled by temperature responsive elements 17 which are preferably immersed in the body of refrigerating medium in the chamber 5*a*. While the equipment shown includes two ejectors, it is to be understood that this is for purposes of illustration only as the number of ejectors in each case will be determined in accordance with the requirements of the particular installation. Under normal operating conditions one or more of the ejectors will, in the average installation, be inoperative, such ejector or ejectors being utilized only when the apparatus is operating under a maximum load. In the embodiment illustrated, the temperature responsive elements 17 are independently operative to regulate the valves 15 and 16 to maintain the refrigerating medium at the temperature desired. For example, the element associated with the valve 15 may be conditioned to hold the said valve open so long as the temperature of the refrigerating medium is maintained at a temperature of the order of 45° F. or higher while the element associated with the valve 16 may be conditioned to open the latter when the temperature of the refrigerating medium raises to a value of the order of 50° F. or higher.

The ejectors 7 and 7*a* are arranged in a header 18 which is carried by the tank 5. The steam and the entrained vapors are discharged through the diffuser throats 19 and 20 of the ejectors into a condenser 21, the latter being provided with conduits 22 and 23 with which the diffuser throats 19 and 20 respectively, communicate. The condenser 21 is divided by a partition 24 into chambers 25 and 26, the ejector 7 discharging through the conduit 22 into the former and the ejector 7*a* discharging through the conduit 23 into the latter. A relatively high vacuum is maintained in the chambers 25 and 26. To this end ejectors 27 and 28 are employed. The former communicates with the chamber 25 through a pipe connection 29 while the latter communicates with the chamber 26 through a pipe connection 30.

The ejectors 27 and 28 discharge into an auxiliary condenser 31, a vacuum being maintained in the said condenser by an ejector 32. The ejector 32 is connected to the condenser 31 by a pipe 32*a* and it discharges into a condenser 33 which is in communication with the atmosphere through a vent 34. In order to cut off communication between the condensing chambers 25 and 26 through the auxiliary condenser 31 when either of the ejectors 7 or 7*a* is inoperative, the pipe connections 29 and 30 are preferably provided with valves 35 and 36, respectively.

The condensate from the condensing chambers 25 and 26 is withdrawn from a common hot-well 37 by a pump 38. The condensate which accumulates in the chamber 26 is conducted to the hot-well 37 by a pipe 39, the latter being formed or provided with a U-shaped section or trap 40 through which the condensate must flow in its passage to the hot-well. The condensate in the trap 40 is adapted to prevent a back-flow between the chambers 25 and 26 through the pipe 39 when, as a result of the ejector 7*a* being inoperative, the absolute pressure in the cooling chamber 5*a*, and hence the absolute pressure in the condensing chamber 26, is higher than the absolute pressure in the condensing chamber 25. The legs of the trap are so formed that the differential in pressures between the chambers 25 and 26 will not be high enough, when the ejector 7*a* is inoperative, to force the liquid which provides the seal out of the trap.

The cooling tubes 41 of the condensing chambers 25 and 26 are serially connected by suitable headers, one of which is shown at 42. The cooling water is introduced into the inlet chamber of the header 42 through a pipe 43. It flows through the tubes in the chamber 25 and returns through the tubes in the chamber 26 to the outlet chamber of the header 42. From the outlet chamber it is discharged through a pipe 44. The said pipe is connected to the inlet of a pump 45, the outlet of the pump being connected by a pipe 46 to the top of a cooling tower 47 of conventional construction. The water which cools as it passes downwardly through the tower is discharged through an outlet pipe 48. The latter is connected to the pipe 43 through which the cooling water is introduced into the inlet chamber of the header 42.

The amount of steam that is supplied to the ejectors 7 and 7*a* is regulated so that the temperature of the refrigerating medium will be maintained at the required value, the amount of steam being increased as the temperature of the refrigerating medium raises above such value. If, for any reason, therefore, such as, for example, failure of the pump 45 with the attendant increase in temperature of the cooling water in the condenser tubes 41, a portion of the steam is not condensed but backs up in the cooling chamber 5*a* the refrigerating medium will, unless provision is made to guard against this, be heated. In this connection it is understood, of course, that as the temperature of the cooling water in the tubes 41 rises there is a corresponding back pressure built up in the condensing chamber, such back pressure increasing, as the temperature of the cooling water increases, until there is a back flow of the steam into the cooling chamber 5*a*. In the embodiment illustrated the amount of steam which is supplied to the ejectors is automatically increased as the temperature of the refrigerating medium increases beyond the required value. The condition described would, therefore, be aggravated in installations of this kind. The circulation of a heated medium through the cooling tubes or coils of the apparatus with which the equipment is associated is highly objectionable if not involving elements of danger, this being especially true in the case of air conditioning apparatus. In accordance with the invention means is provided whereby in the event that a back pressure builds up in the condensing chambers 25 and 26, for example, as a result of the failure of the pump 45, and as a result of this the capacity of the condenser is rendered inadequate for the purpose in view, circulation of the refrigerating medium is automatically suspended. The said means includes the valve 10*a* which is located in the pipe 10. The valve is connected to a temperature responsive element 50 (Figure 1) which is located in the cooling chamber 5*a* preferably above the level of the body of refrigerating medium. The said element is adapted to automatically close the valve 10*a* when the temperature in the cooling chamber 5*a* increases to a predetermined value, for example, 75° F. Thus, while the pump 45 may continue to operate there will be no circulation of the refrigerating medium through the air conditioning apparatus. Circulation of a heated medium through the cooling tubes or coils of the apparatus will, therefore, be prevented. The element 50 may be so designed that as soon as the temperature in the cooling

chamber 5a is lowered to a predetermined value, for example, 65° F. it will open the valve 10a and again permit circulation of the refrigerating medium through the tubes or coils of the air conditioning apparatus.

From the foregoing it will be apparent that if there is an interruption in the circulation of the cooling medium through the tubes 41 and, as a result of this the capacity of the condenser is so reduced that steam backs up in the cooling chamber, the circulation of the refrigerating medium will be automatically suspended until the temperature of the cooling chamber is again normal.

In the embodiment illustrated in Figure 3 the valve 10a is controlled by a pressure responsive element 51 which is located in the condensing chamber 26, preferably adjacent the bottom thereof. The said element is adapted to close the valve 10a when the back pressure in the chamber 26 increases to such a value that there is, or is a possibility of, a back flow of steam to the cooling chamber 5a. In this connection it is understood, of course, that such an increase in the absolute pressure in the chamber 26 could be caused, among other factors, by a suspension in the circulation of the cooling water through the tubes in the condensing chamber as a result of the failure of the pump 45. The element 51 is operative, when the absolute pressure in the chamber 26 is lowered to such a value that substantially all the steam entering it will be condensed, to open the valve 10a and permit a resumption in the circulation of the refrigerating medium through the tubes or coils of the air conditioning apparatus. It will be apparent, therefore, that in the event of failure of the pump 45 circulation of the refrigerating medium will be suspended until it is repaired.

In the embodiment illustrated in Figure 4 the valve 10a is controlled by a temperature responsive element 52 which is located in a section 53 of the conduit 48. The element 52 is adapted to close the valve 10a when the temperature of the cooling water in the conduit 53, and hence in the tubes 41, is of such a value that, owing to the corresponding value in the absolute pressure in the chamber 26, there is a possibility of a back flow of the steam into the cooling chamber 5a. Thus when the pump 45 fails and circulation of the cooling water through the tower is suspended, with an attendant rise in temperature of the cooling water in the tubes 41, circulation of the refrigerating medium through the air conditioning apparatus will also be suspended. As soon as the circulation of the cooling water through the tower is resumed and the temperature of the water is lowered to the required value, the element 52 is operative to open the valve 10a and permit a resumption in the circulation of the refrigerating medium. In other respects the apparatus illustrated in Figures 3 and 4 is substantially the same as that shown in Figure 1.

From the foregoing it will be apparent that so long as cooling water of the required temperature is circulated through the tubes of the condensing chambers, the ejectors 27 and 28 will maintain the required absolute pressure in the said chambers and the steam will be condensed as fast as it enters them. Each of the embodiments of the invention contemplates an arrangement whereby the circulation of the refrigerating medium through the apparatus with which the equipment is associated is automatically suspended in the event that the back pressure in the condensing chambers increases to such an extent that a back flow of steam is created. In other words, if, for any reason, the capacity of the condenser becomes inadequate for the purpose in view circulation of the refrigerating medium is suspended until the capacity of the condenser is again normal.

I claim as my invention:

1. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, means for condensing the steam discharged from said ejector and means, operative upon said last named means becoming inoperative to such a degree that a back flow of steam into said chamber is likely to result, for stopping the circulation of the refrigerating medium through said apparatus.

2. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, means for condensing the steam discharged from said ejector and means, operative upon a reduction in the capacity of said means last named to such a degree that it fails to condense said steam, for stopping the circulation of the refrigerating medium through said apparatus.

3. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector is discharged and in which said steam is condensed, means for maintaining a vacuum in said condenser and means, operative upon a reduction in the capacity of said condenser to such a degree that it fails to condense said steam, for stopping the circulation of the refrigerating medium through said apparatus.

4. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector is discharged and means operative upon the backing up of steam in said chamber for stopping the circulation of said refrigerating medium through said apparatus.

5. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it is circulated therethrough, a steam supply line for said ejector, means for automatically supplying steam from said supply line to said

ejector when the temperature of the refrigerating medium in said chamber increases to a predetermined value, a condenser into which the steam from said ejector is discharged and means operative upon the backing up of steam in said chamber for stopping the circulation of said refrigerating medium through said apparatus.

6. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector is discharged, means for maintaining a vacuum in said condenser, means for circulating a cooling medium through said condenser and means operative upon the backing up of steam in said chamber for stopping the circulating of said refrigerating medium through said apparatus.

7. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it is circulated therethrough, a steam supply line for said ejector, means for automatically controlling the supply of steam from said line to said ejector so as to maintain the temperature of the refrigerating medium at a predetermined value, a condenser into which the steam from said ejector discharges, means for maintaining a vacuum in said condenser, means for circulating a cooling medium through said condenser and means operative upon the backing up of steam in said chamber for stopping the circulation of said refrigerating medium through said apparatus.

8. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector is discharged, a valve for controlling the circulation of the refrigerating medium through said apparatus and a temperature responsive element for closing said valve when steam from said ejector backs up in said chamber, said element being located in said chamber above the level of the refrigerating medium.

9. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a steam supply line for said ejector, a valve in said line, a temperature responsive element for controlling said valve, said element being immersed in the refrigerating medium in said chamber and being adapted to open said valve when the temperature of said medium raises to a predetermined value, a condenser into which said ejector discharges, means for maintaining a vacuum in said condenser, a second valve for controlling the circulation of the refrigerating medium through said apparatus and a temperature responsive element for closing said valve to stop the circulation of the refrigerating medium through said apparatus when steam from said ejector backs up in said chamber, said element being located in said chamber above the level of said refrigerating medium.

10. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector discharges, means for maintaining a vacuum in said condenser and means, operative upon the absolute pressure in said condenser increasing to such a value that a back flow of steam into said chamber is likely, for stopping the circulation of said refrigerating medium through said apparatus.

11. The combination with refrigerating apparatus, of equipment for cooling the refrigerating medium which is circulated through said apparatus including a chamber through which said refrigerating medium is circulated, a steam ejector for evacuating said chamber to lower the temperature of the refrigerating medium as it passes therethrough, a condenser into which the steam from said ejector is discharged and in which said steam is condensed, means for maintaining a vacuum in said condenser, means for circulating cooling water through said condenser, said means including a pump, a cooling tower and means connecting the condenser, pump and cooling tower in a circuit, whereby cooling water from said tower is circulated continuously through the condenser and means, operative when the temperature of the cooling water which is introduced into the condenser increases to a value at which the corresponding absolute pressure in the condenser is such that a back flow of the steam is created, for stopping circulation of the refrigerating medium through said apparatus.

HAROLD M. GRAHAM.