

June 1, 1937.

J. KIRGAN

2,082,009

CONTROLLING APPARATUS

Filed April 30, 1936

2 Sheets-Sheet 1

FIG.-1.

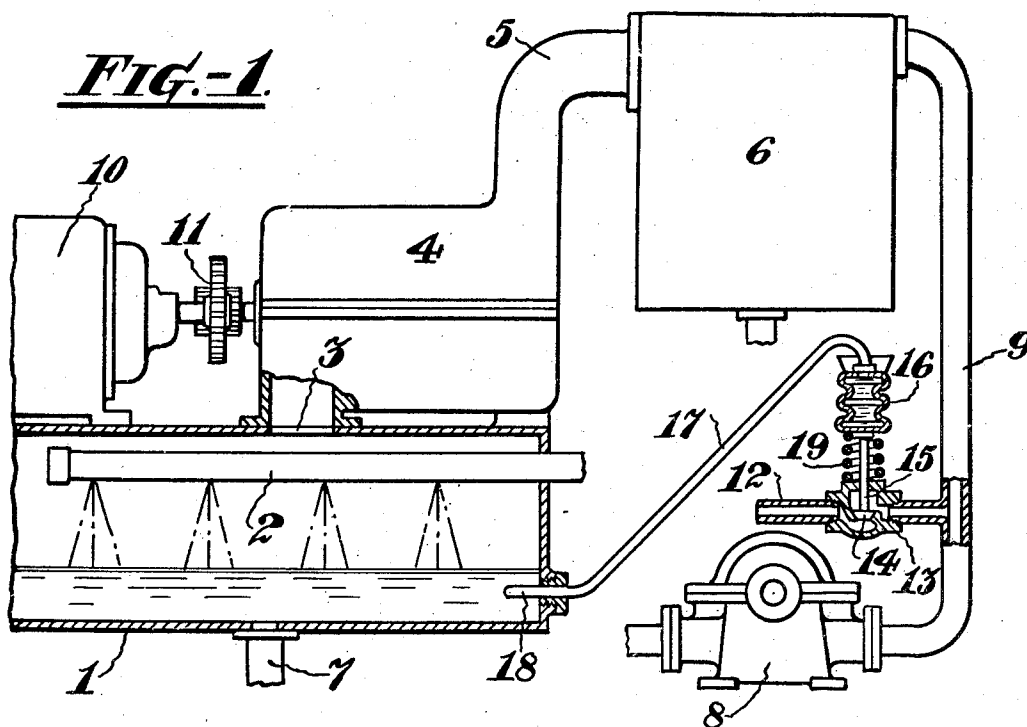
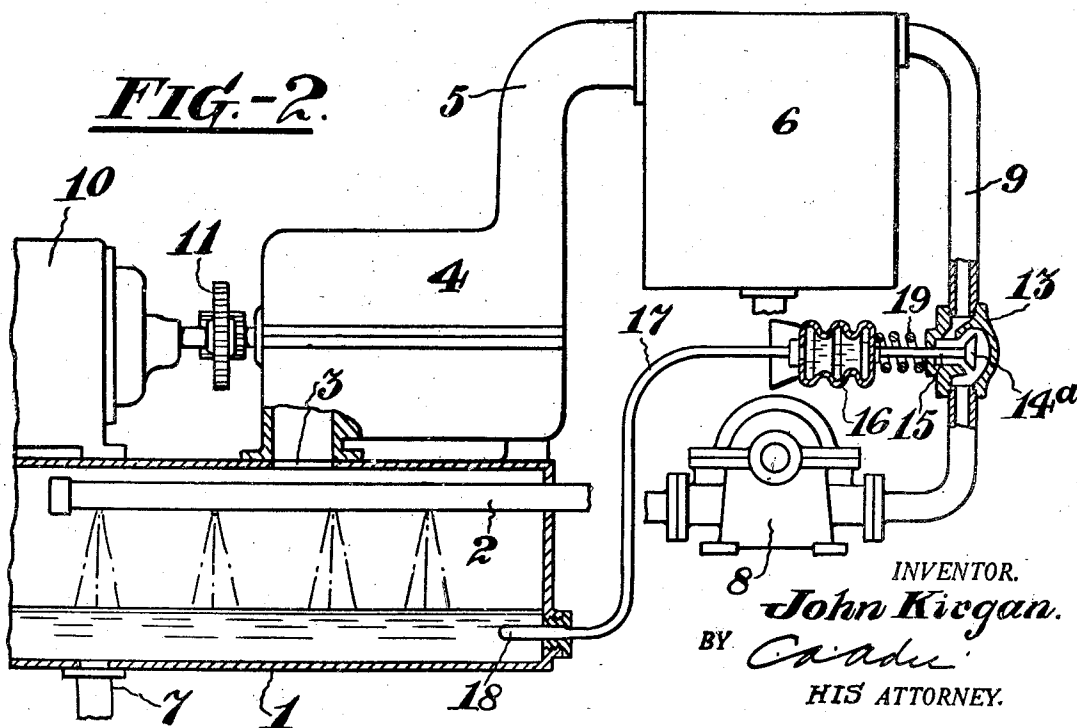


FIG.-2.



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2 Sheets-Sheet 2

FIG.-3.

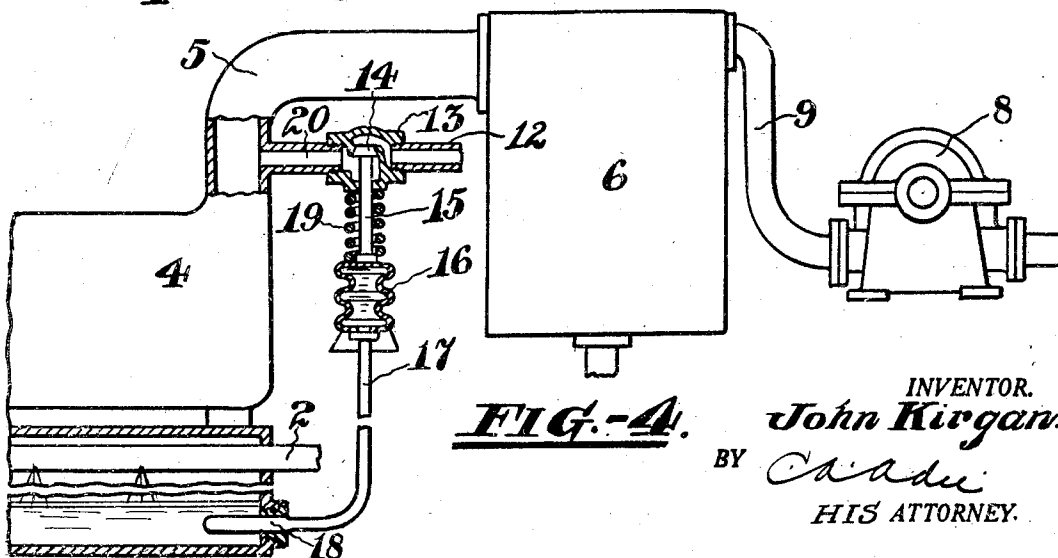
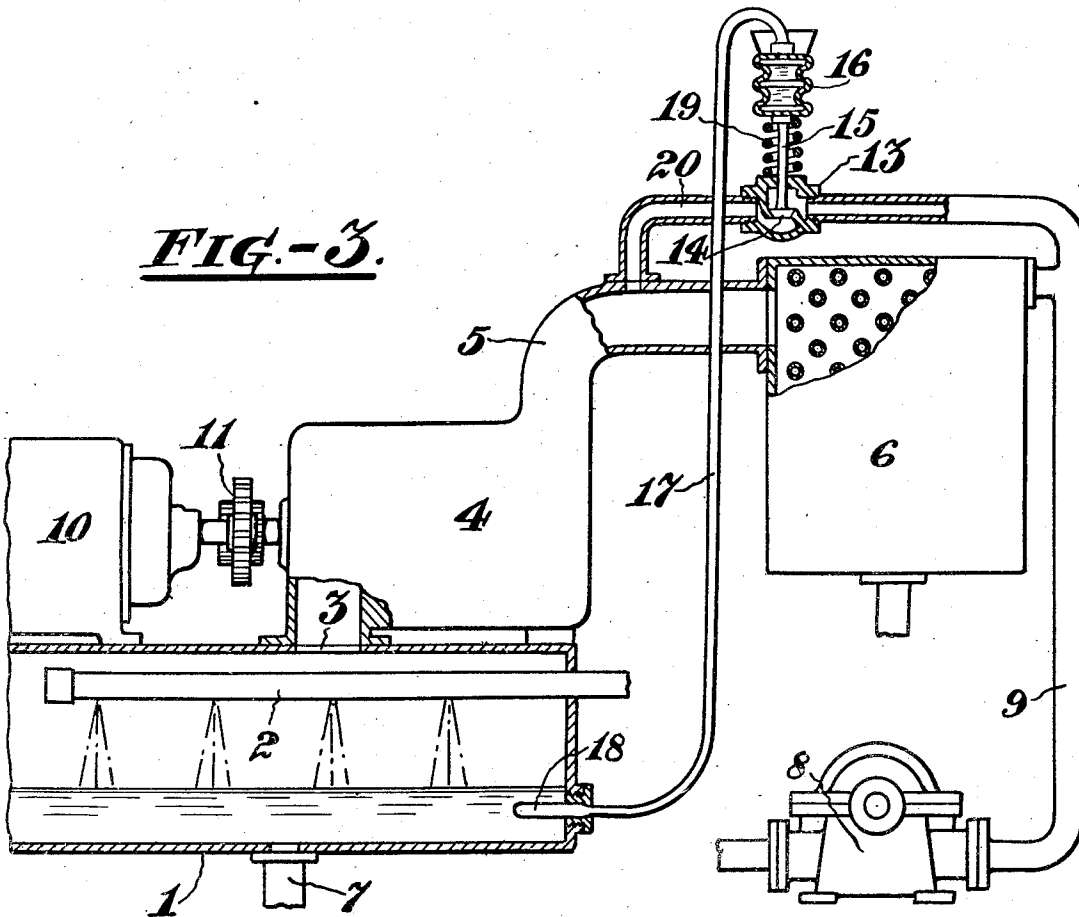


FIG.-4.

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CONTROLLING APPARATUS

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12 Claims. (Cl. 62—115)

This invention relates to controlling apparatus, and particularly to means for controlling the heat-absorbing medium of a refrigerating system.

The invention is particularly adapted for systems in which a liquid refrigerant is treated to lower its temperature and has for its object to provide means whereby the reduced temperature of the chilled refrigerant is maintained at a substantially constant level above the freezing point thereof.

A further object of the invention is to provide a refrigerating system in which a liquid refrigerant is cooled by vaporizing part thereof and removing the vapor to a condenser, with means for so regulating the evacuation of the condenser that cooling of the refrigerant below a predetermined minimum temperature is effectually prevented.

An additional object of the invention is to provide in a system of this type having a condenser in which vapor of a refrigerant is liquefied, evacuator means having connections influenced according to the temperature of the refrigerant for maintaining the pressure within the condenser at such a level that, when a selected low temperature of the refrigerant is reached, the pressure in the condenser can go no lower and the corresponding pressure at the place where vaporization is effected is held at such a point that no further drop in the temperature of the refrigerant can ensue.

The drawings show several embodiments of the invention and the novel features thereof are defined in the claims, but the disclosure is of course illustrative only and many alterations in structure may be adopted without departure from the principle of the invention, or exceeding the spirit, scope and meaning of the terms in which the claims are expressed.

On the drawings, Figure 1 shows a side view, partly in section, of a construction according to this invention.

Figures 2 and 3 are similar views of modifications, and

Figure 4 is a fragmentary view presenting another modification.

On the drawings the same numerals identify the same parts throughout.

Referring first to Figure 1, I show at 1 a closed vessel called an evaporator into which a liquid refrigerant is sprayed through jet openings in an inlet header 2. Within the evaporator the pressure is maintained at such a low point that the incoming liquid, which may be water, is partly vaporized and the vapor is extracted through an outlet opening 3 by means of an evacuator in the

form of a centrifugal compressor within a housing 4. The suction of this unit maintains the vacuum in the evaporator 1 at the desired degree, and the formation of the vapor removes heat from the body of the refrigerant and thus cools it. The vapor is compressed in the housing 4 and discharged through an outlet flue 5 into a condenser 6, while the cooled refrigerant is delivered to a pipe 7 and conducted away to the place where a refrigerating effect is desired. After absorbing heat it is returned to the header 2 for further cooling. The pressure in the condenser is lowered by means of a pump 8 connected to the condenser by an exhaust pipe 9. The compressor in the housing 4 can be driven by a suitable power machine, such as an electric motor 10 connected to the compressor by means of gearing 11.

In practice a system of this sort having a centrifugal compressor to evacuate the vapor acts in such a manner that when the load drops, that is to say, when there is less heat absorbed by the refrigerant before it returns to the evaporator 1, the inlet temperature of the refrigerant when it reaches the evaporator is lower than when the system operates at full load. Under such conditions the outlet temperature of the refrigerant, as it is delivered to the pipe 7, is lower and at very light loads there is danger that the refrigerant may be cooled to such a point that freezing might occur. The pressure at which the vapor is delivered to the condenser 6 from the housing 4 is highest at full load and as the load drops this pressure falls.

Similarly the pressure in the evaporator 1 is greatest at full load and it also drops as the load falls, but at a greater rate than the pressure in the condenser. The pressure in the evaporator 1 is so related to the pressure in the condenser 6 that the ratio between the condenser pressure and evaporator pressure passes through a predetermined range from full load down to part load, but is greatest when the load is least. To prevent the pressure in the evaporator at light loads from dropping to a point where the evaporation would cool the refrigerant too much and perhaps cause freezing, the condenser pressure can be prevented from dropping below a predetermined minimum; and the system can be so controlled in response to the temperature of the chilled refrigerant itself that a pressure below this minimum in the condenser 6 is never attained. I therefore provide the pipe 9 in Figure 1 with a tap or branch 12, which can be open to the atmosphere, this pipe 12 containing a casing 13 having a valve 14 therein. The stem 15 of this valve

projects to the outside of the casing 13 and abuts against the movable end of a siphon or expandible chamber 16. The other end of this chamber is fixed and is connected through a piece of tubing 17 to a bulb 18 in the evaporator 1 disposed so that it will always be below the level of the chilled refrigerant therein. A spring 19 surrounds the stem 15 of the valve and so engages the casing 13 and chamber 16 that it tends to open this valve. So long as the temperature of the chilled water in the evaporator is not too low, an expandible fluid in the pipe 17 causes the chamber 16 to press upon the stem 15 of the valve and keep it shut. When, however, the temperature drops to the selected point the fluid contracts and the spring 19 can force the valve open. Then air can enter the exhaust line 9 between the condenser 6 and the pump 8, and the pump is prevented from lowering the pressure in the condenser 6 too much. The admission of air into the exhaust pipe 9 through the pipe 12 acts to increase the load on the pump 8 thus decreasing its effectiveness for exhausting the condenser 6 and inevitably causing an increase in the pressure in the condenser 6 and the back pressure on the compressor 4. This increased pressure reduces both the capacity of the condenser to receive and liquefy vapor from the evaporator and the capacity of the compressor 4 to remove vapor from the evaporator. The reduced rate of vapor removal from the evaporator causes the pressure therein to remain above a predetermined minimum and can never drop enough to entail freezing of the refrigerant. Thus the lowest possible temperature for the refrigerant in the evaporator can be definitely predetermined.

In the apparatus of Figure 2 the same result is reached by means of a throttle valve 14^a. Here the air pipe 12 is dispensed with and the casing 13 is inserted in the line of the exhaust pipe 9 between the condenser 6 and the pump 8. This valve is normally held open by the action of the cooled refrigerant on the bulb 18, but when the refrigerant becomes too cool the fluid in the chamber 16 and tube 17 contracts and the spring 19 causes the valve to move so as to throttle the exhaust from the condenser, with the same result as before.

In Figure 3 the construction is such that the exhaust pipe 9 has a branch 20 extending from this pipe at a point near its junction with the condenser to a point in the flue 5 connecting the compressor housing 4 to the condenser. This pipe 20 has a valve casing 13 in the line thereof and this valve is actuated by a chamber 16 and spring 19 in the same way to control the pressure in the condenser 6. So long as the temperature of the refrigerant does not drop too much the valve 14 is closed and the full effect of the pump 8 is exerted on the condenser 6. When, however, the refrigerant becomes too cool, the contraction of the fluid in the bulb 18 and tube 17 permits the spring 19 to open this valve more or less. Part of the compressed vapor delivered to the flue 5 is then by-passed to the exhaust pipe 9 and is not liquefied in the condenser 6. This increases the load on the pump 8 and thus the pressure in the condenser is again prevented from dropping to such a point as to allow a corresponding pressure in the evaporator 1 low enough to create danger of freezing therein.

Figure 4 shows a construction in which the air pipe 12 instead of being joined to the pipe 9 as in Figure 1 is connected to the flue 5 between the condenser 6 and compressor housing 4. This

arrangement acts by admitting air to the inlet of the condenser to keep up the pressure therein, with a similar effect on the pressure in the evaporator 1.

All the features of the invention herein set forth are well adapted to serve the intended purpose. The apparatus employed is quite practical, inexpensive, quickly responsive and certain in operation; and while I have shown preferred constructions having the particular features herein set forth I may obviously resort to many variations in detail without fundamentally altering the essential character of the apparatus.

Although I have herein shown the evacuator 4 as a centrifugal compressor, it is obvious that other types of compressors well known in the art may be used. It is equally obvious that the controlling means 18 may be responsive directly to the pressure within the evaporator and the same results secured. I do not, therefore, wish to be limited by the exact form of the apparatus shown, but desire that the scope of the invention be defined by the hereinafter appended claims.

I claim:

1. The method of refrigeration which consists in vaporizing a part of a liquid refrigerant to chill same, removing and compressing the vapor thus formed into a confined space for liquefaction, evacuating said space, and automatically varying the rate of evacuation of said space in response to the temperature of said chilled refrigerant to maintain the pressure in said space and the temperature of the chilled refrigerant above certain predetermined minimums.

2. The method of refrigeration which consists in subjecting a liquid refrigerant to the action of a vacuum to effect partial vaporization thereof, delivering the vapor thus formed to a confined space, evacuating said space, and automatically varying the rate of evacuation of said space in response to the degree of said vacuum to control the delivery of vapor to the space and thereby prevent said vacuum from exceeding a certain value and the temperature of the refrigerant from falling below a corresponding minimum.

3. A refrigerating system comprising an evaporator, an evacuator therefor, a condenser to which the evacuator delivers, means for evacuating said condenser, and means responsive directly to an operating condition in the evaporator variable with the temperature therein for varying the rate of evacuation of the condenser thereby to control the operation of the condenser and the evaporator.

4. Refrigerating apparatus comprising an evaporator, an evacuator for removing vapor therefrom, a condenser for liquefying said vapor, means for exhausting said condenser, and means acting in accordance with the temperature in the evaporator to vary the load on said exhausting means and thereby control the pressure in said condenser and maintain the temperature in the evaporator above a certain predetermined minimum.

5. Refrigerating apparatus comprising an evaporator, an evacuator for removing vapor therefrom, a condenser to which said vapor is delivered, and means acting at a predetermined low temperature in said evaporator to effect a sudden increase in pressure in the condenser to hinder said vapor removal and thereby prevent the temperature in the evaporator from falling below said predetermined temperature.

6. Refrigerating apparatus comprising an evaporator, an evacuator for removing vapor there-

from, a condenser to which the vapor is delivered, means for exhausting said condenser, and means acting in accordance with the pressure in the evaporator to vary the load on said exhausting means thereby controlling the pressure in the condenser and maintaining the pressure in the evaporator within predetermined limits.

7. Refrigerating apparatus comprising an evaporator, an evacuator therefor, a condenser, an exhaust pump for the condenser, and means acting at predetermined conditions to prevent the pump from lowering the pressure in the condenser below a selected point, said means including a valve to control the action of the exhaust pump on the condenser, and connections for actuating the valve in accordance with the temperature in the evaporator.

8. Refrigerating apparatus comprising an evaporator, an evacuator therefor, a condenser, an exhaust pump for the condenser, and means for varying the load on said pump to control the operation of said condenser and evaporator, said means including a valve acting responsively to the temperature in the evaporator, a spring acting on the valve, and an expansible chamber acting on the valve in opposition to said spring, said chamber having a thermal connection with said evaporator.

9. Refrigerating apparatus comprising an evaporator, an evacuator therefor, a condenser, an exhaust pump having a connection with the condenser, means intermediate the pump and condenser for admitting fluid from an extraneous source to the pump, and means including a valve and connections for actuating the valve in accordance with the temperature in the evaporator whereby the admission of said fluid is regulated to control the pressure in the condenser and maintain the temperature in the evaporator above certain predetermined minimums.

10. Refrigerating apparatus comprising an evaporator, an evacuator therefor, a condenser, an exhaust connection for the condenser, a valve in said connection, and means for actuating the valve in response to the temperature in the evaporator whereby the flow of fluid past the valve is regulated to prevent the pressure in the condenser from reaching a certain minimum and the temperature in the evaporator from falling below a corresponding minimum.

11. Refrigerating apparatus comprising an evaporator, an evacuator for removing vapor therefrom, a condenser to which the vapor is delivered, an exhaust connection for the condenser, a by-pass connection between said evacuator and said exhaust connection, and a valve in said by-pass acting in accordance with the temperature in the evaporator to control the amount of vapor passing around the condenser to said exhaust connection thereby controlling the pressures in the condenser and the evaporator to maintain said pressures above certain predetermined minimums.

12. Refrigerating apparatus comprising an evaporator, an evacuator for removing vapor therefrom, a condenser receiving said vapor, means for admitting fluid from an extraneous source into the discharge of said evacuator to augment the contents of the condenser, a valve normally in closed position preventing the admission of said fluid, and means acting at a predetermined low temperature in the evaporator to open said valve to effect an increase in the pressure of the evacuator discharge and in the condenser thereby to hinder said vapor removal from the evaporator and prevent a temperature in the evaporator lower than said predetermined temperature.

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