Feb. 22, 1938. W. W. WARREN 2,109,002

REFRIGERATOR

Filed July 3, 1936 2 Sheets-Sheet 1

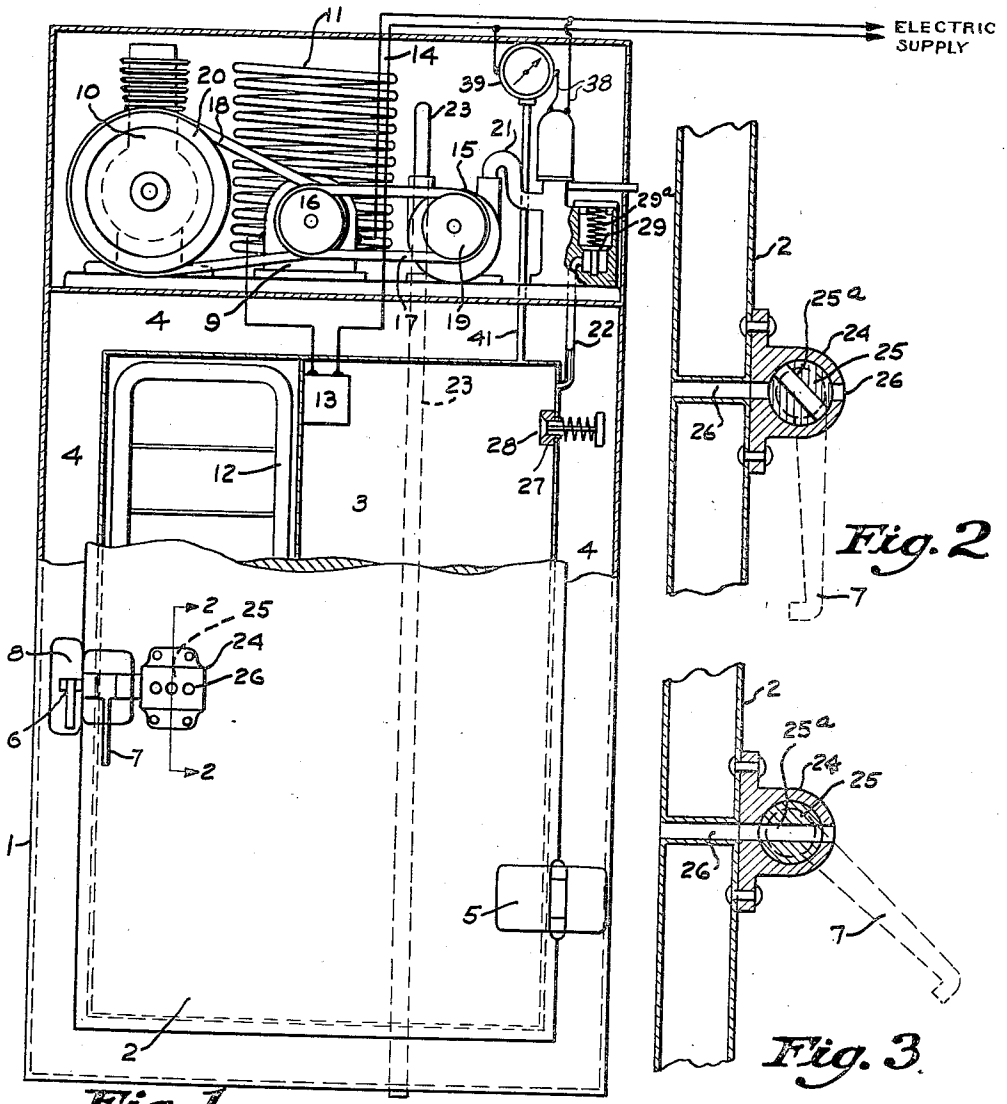


Fig. 1

Fig. 2

Fig. 3

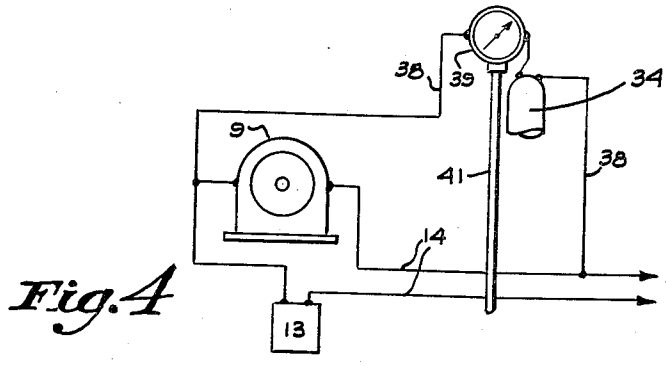


Fig. 4

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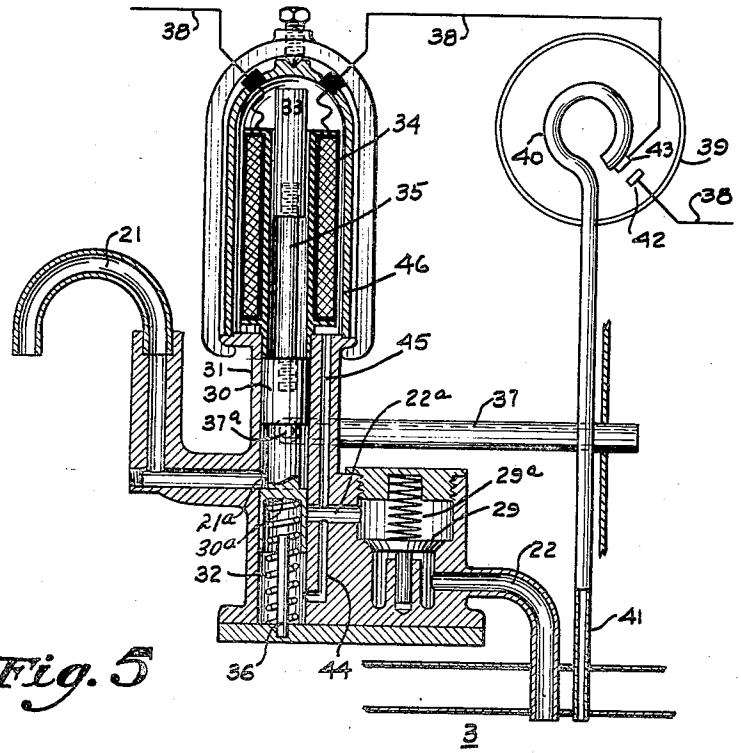


Fig. 5

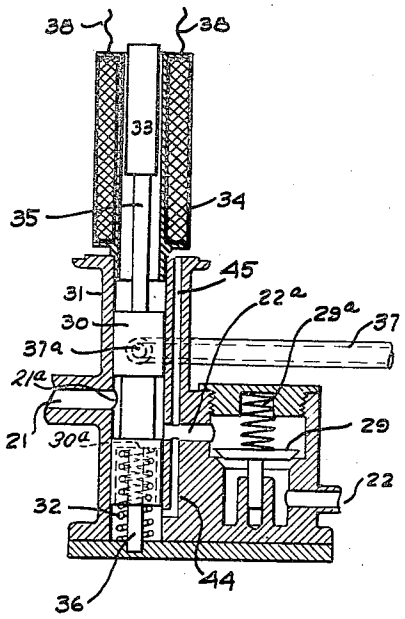


Fig. 6

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Patented Feb. 22, 1938

2,109,002

UNITED STATES PATENT OFFICE

2,109,002

REFRIGERATOR

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Application July 3, 1936, Serial No. 88,792

11 Claims. (Cl. 62—89)

My invention relates to the preservation of foodstuffs and other perishables, and consists in a refrigerator in which a condition of subatmospheric pressure is established and maintained. I have discovered that rarefied atmosphere operates in conjunction with subnormal temperature within a refrigerator, to improve the preservation of certain perishables. The invention is particularly directed to improvements in mechanical refrigerators, as distinguished from refrigerators cooled by ice.

In the accompanying drawings the invention, by way of illustration and not limitation, is illustrated in embodiment in a domestic refrigerator. Fig. 1 is a view of the refrigerator, partly in front elevation and partly in vertical section; Fig. 2 is a fragmentary view, taken on the plane 2—2 of Fig. 1, and showing to larger scale and in vertical section a particular valve which is organized with the usual door-latch of the refrigerator; and Fig. 3 is a view comparable with Fig. 2, illustrating the valve in alternate position; Fig. 4 is a diagram, illustrating a modification in the electrical wiring of the apparatus shown in Fig. 1; Fig. 5 is a fragmentary view, illustrating to larger scale and in vertical section a particular valve mechanism embodied in the mechanical apparatus of the refrigerator; and Fig. 6 is a view comparable with Fig. 5, illustrating particular parts of the valve mechanism in alternate positions of service.

Referring to Fig. 1, a conventional refrigerator cabinet 1 is illustrated, and in usual way a thermally insulated door 2 affords access to the chamber 3 within the cabinet, in which perishables are stored. The walls of the cabinet are hollow, providing a chamber-enveloping space 4 for a packing of rock-wool, cork, or other heat-insulating material. Alternately, the space between the walls may be evacuated of air, to provide the desired insulation against heat transfer from the outer atmosphere to the chamber 3. The door 2 is mounted on hinges 5 (one only appears), and a latch-bolt 6, mounted on the door and responsive to the turning of a handle 7, is movable into and from engagement with a catch-element 8, mounted on the wall of the cabinet.

In usual way mechanical refrigerating apparatus is arranged to maintain the temperature within the chamber 3 at substantially the desired subnormal value. Such apparatus in this case is installed above the chamber 3. The particular make of refrigerating apparatus is not of prime concern; any of the known types may be employed, and the general principles of operation are already understood by those skilled in the art. Suffice it briefly to say that the refrigerating apparatus includes an electric motor 9, a compressor 10, a condenser 11, expansion coils (not shown) enveloping a tray compartment 12 within chamber 3, and a thermostat 13 connected in the electric supply lines 14 of the motor, for automatically controlling the operation of the motor and compressor in accordance with temperature conditions within the chamber 3.

In accordance with my invention, I rarefy the air within chamber 3, and, advantageously, I provide a rotary exhausting pump 15 which is connected in common with the compressor 10 to the drive shaft of motor 9—a double-grooved pulley 16, belts 17 and 18, and pulleys 19 and 20 providing such common driving connections. The intake port of the pump communicates by way of a duct 21 and pipe 22 with the chamber 3, and in operation the pump draws air from such chamber and discharges it through an exhaust line 23 into the open atmosphere. Subject to automatic controlling means presently to be described, the pump establishes the desired atmospheric rarefication, or degree of vacuum, in the storage chamber 3, while in usual way the mechanical refrigerating apparatus establishes and maintains subnormal temperature of predetermined degree. Under such conditions certain perishables are more effectively preserved.

In order to permit the door 2 readily to open against the normally preponderant pressure of the outer atmosphere, I provide means for breaking the vacuum within the chamber 3. Such means consist in a cylindrical valve-chest 24 including a ported valve 25. The valve chest 24 is mounted on the door 2 of the refrigerator in axial alignment with the latch-bolt 6, and the valve 25 is integrated with, or comprises a continuation of, the latch-bolt. Passages 26 extend from the valve-chest 24 through the insulated body of door 2, and in the normal door-latching position of latch-bolt 6, the handle 7 extends in the dotted line position indicated in Fig. 2, and the valve 25 closes the passages 26, whereby the desired vacuum may be maintained in chamber 3—it being understood that the door 2 carries the usual peripheral gasket (not shown) that seals the doorway of chamber 3 when the door is secured in closed position. Upon swinging the handle 7 upward, to disengage the latch-bolt 6 from catch-element 8 (cf. dotted line position of the handle in Fig. 3), the valve 25 is rotated, and its ports 25a are moved into registry with passages 26. Thus, the chamber 3 is vented to the open atmosphere, and the pressure within the

chamber is so far balanced with the pressure without that the door 2 may be readily swung open.

Before proceeding with a more minute consideration of the evacuating mechanism, it may be remarked that the entire chamber within the cabinet 1 need not be evacuated. That is to say, a compartment, constructed with hermetic, heat-conducting walls, may be provided within chamber 3, and such compartment may have an individual door, provided with an air-venting latch, such as the one carried by the door 2. In such case, the suction tube 22 of the pump 15 communicates with the internal chamber of the compartment, whereby the desired conditions of refrigeration and atmospheric rarefication are maintained within the compartment, while without such compartment, but within chamber 3, refrigeration alone is effective. Accordingly, a compartment is provided for those particular perishables which are best preserved in chilled and rarefied atmosphere. The foodstuff requiring less specialized treatment is stored in the chamber 3 without such compartment.

The art is familiar with the general idea of enveloping a refrigerator chamber with hollow, evacuated walls, in order to obtain the desired insulation against heat transfer. My invention embraces a particularly effective refinement of this concept. The space 4 between the double, hermetic walls of the cabinet 1 communicates by way of a passage 27 (Fig. 1) with the chamber 3 (or with a compartment within) which is subject to evacuation by pump 15. The passage 27 is normally closed by a spring-backed check-valve 28, and, in normal operation of the pump, the check valve is drawn open, whereby both the chamber 3 and the chamber-enveloping space 4 are exhausted. And when the vacuum (the sub-atmospheric pressure) in envelope 4 approaches that in chamber 3, the spring-backed valve 28 automatically closes, so that the door 2 may be opened and closed at will, without destroying the heat-insulating vacuum in the envelope. As will presently appear, the vacuum pump 15 operates automatically to restore the vacuum which is destroyed by opening the door 2 of chamber 3. That is to say, the pump operates automatically to maintain in chamber 3 a vacuum of predetermined degree, and, of course, the refrigerating apparatus operates in known way to maintain subnormal temperature in such chamber. If the established vacuum in the heat-insulating envelope is destroyed, as may happen over a long period of service (due to slow leakage and infiltration of air from the outer atmosphere), the valve 28 opens in response to the suction of the pump, and the desired vacuum in the envelope is automatically reestablished. By virtue of such structure, the hitherto proposed use of hollow, evacuated walls becomes feasible in domestic and commercial refrigerators.

Turning to a more detailed consideration of the evacuating mechanism, it will be noted that the inlet passage 21, 22 of the vacuum pump 15 includes a check valve 29 normally urged to its seat by a spring 29*a*. A plunger valve 30 is vertically reciprocable in a cylinder 31, and such valve is normally held in the upper of its alternate positions (Fig. 5), by means of a spring 32. The armature 33 of an electromagnet 34 is by a non-magnetic rod, say a rod 35 of brass, secured to the valve 30, and, upon the energizing of the electromagnet, the armature moves downward, forcing the valve 30 into its lower position, in which position the portion 30*a* of the plunger abuts against the upper end of a stop 36. The inlet duct 21 of the pump opens into the bore of cylinder 31 at the point 21*a*, while the pipe 22 communicates with the bore of the cylinder by way of a passage 22*a*. A tube 37, opening at one end into the outer atmosphere, communicates at its opposite end (37*a*) with said bore of the cylinder 31. The energizing circuit 38 of the electromagnet 34 is connected to the same electric supply as energizes the motor 9, and in Fig. 1 the electromagnet circuit 38 is shown connected in parallel with the motor circuit 14. I provide a pressure regulator, or, more accurately, a vacuum regulator 39, which consists in a Bourdon tube 40 (Fig. 5) communicating by means of a conduit 41 with the atmosphere within chamber 3. Two electric contacts, 42 and 43, are included in the electromagnet circuit 38; contact 42 is mounted on the housing of regulator 39, and contact 43 is mounted on the movable end of the Bourdon tube. When normal atmospheric pressure exists in chamber 3, the Bourdon tube is so spirally dilated or radially expanded that the two contacts 42 and 43 engage, and close the circuit 38 with the electric supply. Thus, the electromagnet is energized, and the armature 33 is drawn to and held in its lower position, as shown in Fig. 6. In such position the valve 30 closes the inner end of tube 37, and establishes communication between passage 22*a* and inlet duct 21. It will be understood that the motor 9 of the refrigerating apparatus, subject to the control of thermostat 13, operates approximately one third of the time, in maintaining the desired temperature within the chamber 3. Accordingly, when in such usual operation the thermostat 13 closes the circuit 14 and sets the refrigerating apparatus in motion, the vacuum pump 15 is driven. Suction is produced in duct 21; the valve 29 (Fig. 6) rises in response to such suction, and, by way of passage 22, air is removed from chamber 3 and discharged into outlet pipe 23 (Fig. 1). When the atmospheric pressure within chamber 3 falls to desired value—that is, when vacuum of desired degree is established in chamber 3—the Bourdon tube 40 radially contracts in known way, and separates the contacts 42 and 43. Thereupon, the energizing circuit 38 of the electromagnet is opened, and the spring 32 shifts the valve 30 into its upper position (Fig. 5). As the valve 30 moves into such position, the check valve 29 closes, the passage 22*a* is blanked by portion 30*a* of the plunger valve, and the inner end 37*a* of tube 37 is uncovered, permitting communication of tube 37 with the inlet duct 21 of the vacuum pump. Thus, after the desired vacuum is established in chamber 3, the pump 15, continuing in operation so long as the thermostat holds the refrigerating apparatus in active service, merely circulates air at normal atmospheric pressure from the tube 37 to the outlet pipe 23. It will, of course, be manifest that, as an alternative of this specific operation, the pump may be run with exhausting effect upon the chamber 3 after the desired vacuum has been established therein, but such operation manifestly requires an expenditure of electrical energy which is avoided or minimized by idly circulating air at atmospheric pressure in the manner mentioned. So long as the desired vacuum exists in chamber 3, my refrigerator will operate with only a nominal increase in power consumption over ordinary mechanical refrigerators.

If it should so happen that the refrigerating

apparatus establishes the desired temperature in chamber 3 and ceases operation before the desired vacuum is reached, the Bourdon tube 40 does not operate to open electromagnet circuit 38—the circuit remains closed, and the valve 30 remains in the position illustrated in Fig. 6, until the refrigerating apparatus is again set in motion and the desired vacuum has been established.

In Figs. 5 and 6, it will be perceived that an air passage 44 extends from beneath the valve 30 to the passage 22*a*, and an air passage 45, 46 extends from passage 22*a* to a point above the valve, it being remarked that the armature 33 is so spaced from the internal wall of the electromagnet as to admit of the vertical movement of air. The provision of these passages eliminates any pneumatic resistance to the above-described operation of the valve 30.

In the electric wiring, as above described and as illustrated in Fig. 1, the energizing of the electromagnet 34 is controlled solely by the regulator 39. When the pressure rises to such value that the Bourdon tube closes the contacts 42 and 43, the electromagnet is energized, and shifts the valve 30 into the exhaust position shown in Fig. 6, regardless of whether or no the motor 9 of the refrigerating apparatus is in operation. In some cases it may be advantageous to have the valve 30 open only when the motor 9 is in (or is about to begin) operation, and in Fig. 4 I illustrate a modification to this end. The energizing circuit 38 of the electromagnet 34, including the contacts of regulator 39 in series, is bridged across the terminals of motor 9 in such manner that the thermostat 13 must close before the electromagnet circuit 38 can close. Thus it is that the electromagnet cannot be energized, to move valve 30 into exhaust position (Fig. 6), until the motor 9 is energized, and even then the vacuum in chamber 3 must be so far destroyed or reduced that the contacts 42 and 43 within the regulator stand in circuit-closing engagement. In such manner the valve-shifting electromagnet is energized in synchronism with the motor 9.

It will be understood that, in the usual domestic refrigerator, water is placed in trays within the compartment 12 for the formation of ice cubes. The ice-cube compartment 12, even though provided with a door, is not a hermetically sealed chamber, and it will be understood that, evacuating the chamber 3 in the above-described manner, the compartment 12 is exhausted of air, whereby a quantity of water in the trays is evaporated before ice forms. In accordance with natural laws, this evaporation results in the abstraction of heat both from the atmosphere within chamber 3 and from objects in thermal communication with the water and the atmosphere, and thus it is that the air-exhausting instrumentalities of my refrigerator are effective in aiding the refrigerating mechanism proper in establishing and maintaining the desired low temperature within chamber 3.

The above description discloses my apparatus in exemplary way. It will be manifest to those skilled in the art that many modifications in the means for achieving the ends in view may be made without departing from the essence of the invention claimed.

I claim as my invention:

1. In a refrigerator including a storage chamber, mechanical refrigerating apparatus, including a motor, for cooling such chamber, and a thermostat responsive to temperature in said chamber for controlling such apparatus, the combination of a pump driven by said motor for establishing a vacuum in said chamber, and means responsive to the pressure of the atmosphere in said chamber for controlling effective operation of said pump.

2. In a refrigerator including a storage chamber and mechanical refrigerating apparatus, including a motor, for cooling such chamber, the combination of a vacuum pump driven by said motor, a passage communicating with the inlet of said pump for removing air from and establishing a vacuum in said chamber, and a by-pass passage for establishing communication between the inlet of said pump and the outer atmosphere.

3. In a refrigerator including a storage chamber and mechanical refrigerating apparatus, including a motor, for cooling such chamber, the combination of a vacuum pump driven by said motor, a passage communicating with the inlet of said pump for removing air from and establishing a vacuum in said chamber, and a by-pass passage for establishing communication between the inlet of said pump and the outer atmosphere, and means for alternately opening and closing said passages.

4. In a refrigerator including a storage chamber and mechanical refrigerating apparatus, including a motor, for cooling such chamber, the combination of a vacuum pump driven by said motor, a passage communicating with the inlet of said pump for removing air from and establishing a vacuum in said chamber, and a by-pass passage for establishing communication between the inlet of said pump and the outer atmosphere, and electromagnetic means for alternately opening and closing said passages.

5. In a refrigerator including a storage chamber and mechanical refrigerating apparatus, including a motor, for cooling such chamber, the combination of a vacuum pump driven by said motor, a passage communicating with the inlet of said pump for removing air from and establishing a vacuum in said chamber, and a by-pass passage for establishing communication between the inlet of said pump and the outer atmosphere, and electromagnetic means for alternately opening and closing said passages, an energizing circuit for said electromagnetic means, together with an electric make-and-break device in said circuit responsive to the pressure of the atmosphere in said chamber.

6. In a refrigerator including a chamber to be cooled, mechanical refrigerating apparatus including an electric motor, an electric circuit for connecting said motor to an electric supply, and a thermostat responsive to temperature in said chamber for controlling said circuit; the combination of a vacuum pump, a passage from said pump to said chamber, a valve for controlling flow in said passage, and electrically operated means connected to said electric supply for controlling operation of said valve.

7. In a refrigerator including a chamber to be cooled, mechanical refrigerating apparatus including an electric motor, an electric circuit for connecting said motor to an electric supply, and a thermostat responsive to temperature in said chamber for controlling said circuit; the combination of a vacuum pump, a passage from said pump to said chamber, electrically operated means for controlling flow in said passage, a circuit for connecting said means to said electric supply, and an electric make-and-break device

responsive to the pressure of the atmosphere in said chamber for controlling said last-mentioned circuit.

8. In a refrigerator including a hollow walled chamber, apparatus for cooling said chamber, and a motor driven pump for exhausting air from said hollow walls, the combination of means for causing said pump idly to circulate air at atmospheric pressure when a vacuum of predetermined degree has been established.

9. In a refrigerator including a hollow walled chamber and apparatus, including an electric motor, for cooling said chamber, the combination of a pump driven by said motor for exhausting air from said chamber and said hollow walls, and means for interrupting the exhausting effect of said pump when a vacuum of predetermined degree has been established in said chamber.

10. In a refrigerator including a storage chamber, mechanical refrigerating apparatus, including a motor, for cooling said chamber, and a thermostat responsive to the temperature in said chamber for controlling said apparatus, the combination of a pump driven by said motor for establishing a vacuum in said chamber, and means responsive to the pressure of the atmosphere in said chamber for controlling the effective operation of said pump, the walls of said chamber being hollow and including an exhausting passage for establishing communication between said pump and the interior of said walls.

11. In a refrigerator including a storage chamber, mechanical refrigerating apparatus for cooling said chamber, an electric motor for operating said refrigerating apparatus, and electrical means responsive to temperature for controlling the energizing of said motor, the combination of a vacuum pump, a passage from the inlet of said pump to said chamber, and means responsive to the pressure of the atmosphere within said chamber for controlling the exhausting effect of said pump upon said chamber, said last-mentioned means including an electrically operated valve for controlling flow in said passage.

WILLIAM W. WARREN.