Feb. 10, 1931. F. J. KLEINHANS ET AL 1,791,964

REFRIGERATING APPARATUS

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Fig. 1.

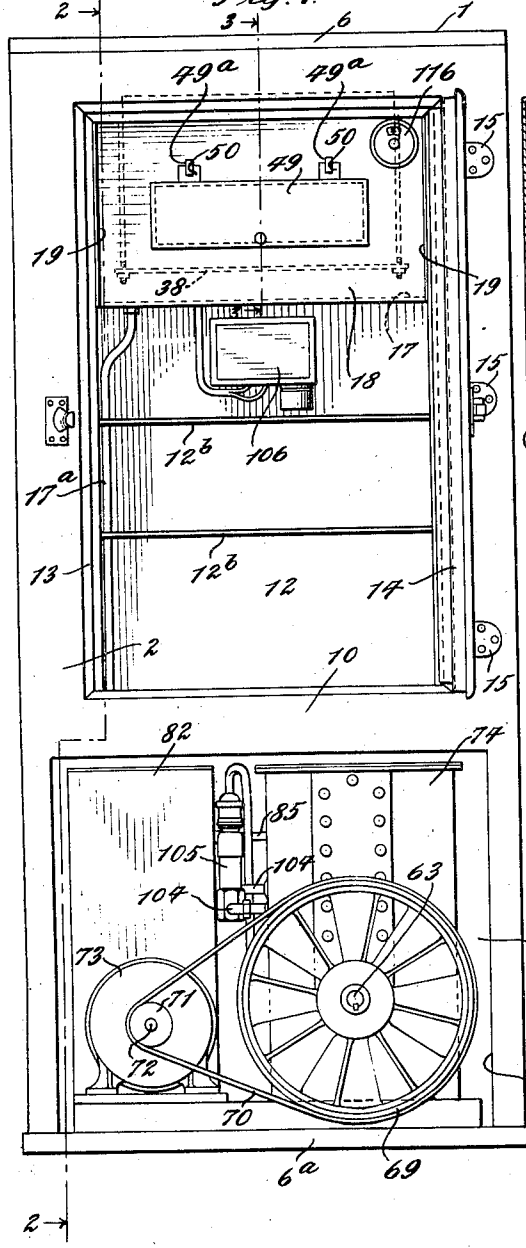
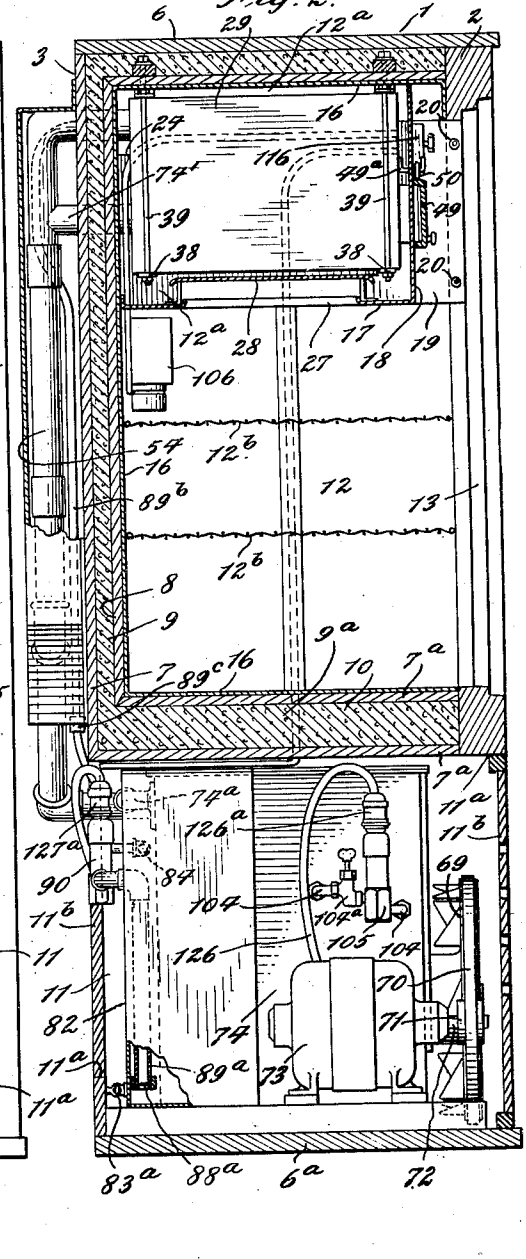


Fig. 2.



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Fig. 3.

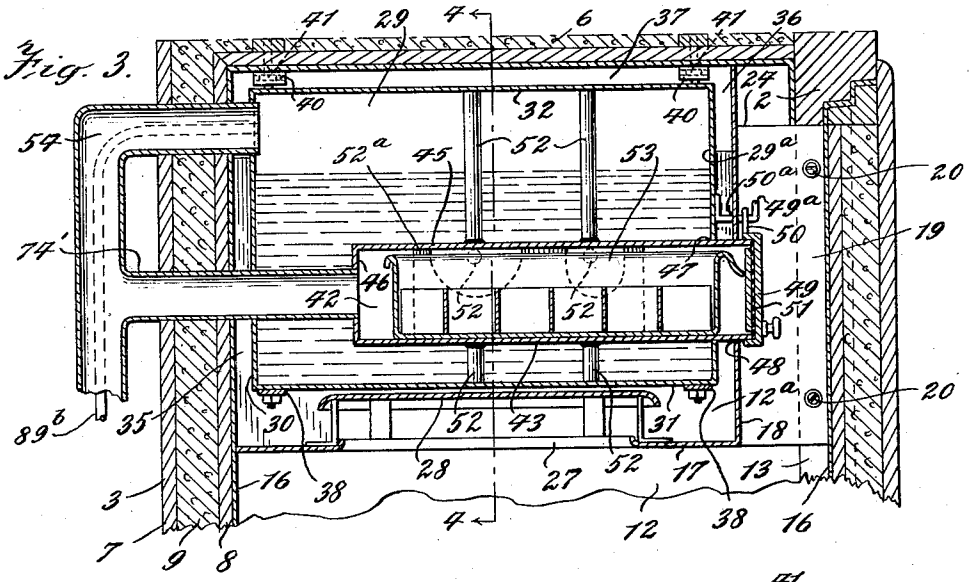
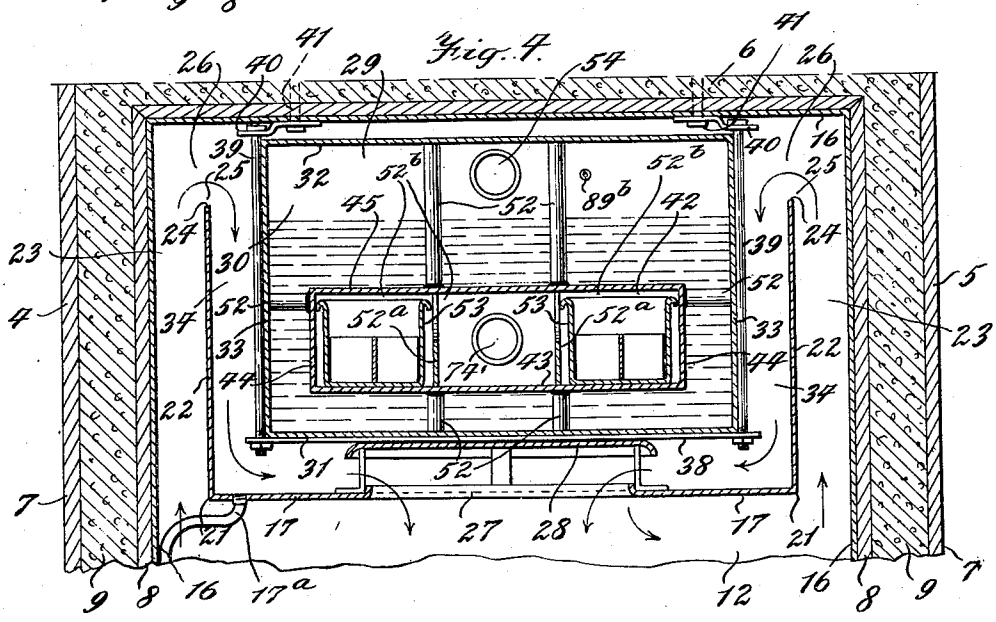


Fig. 4.

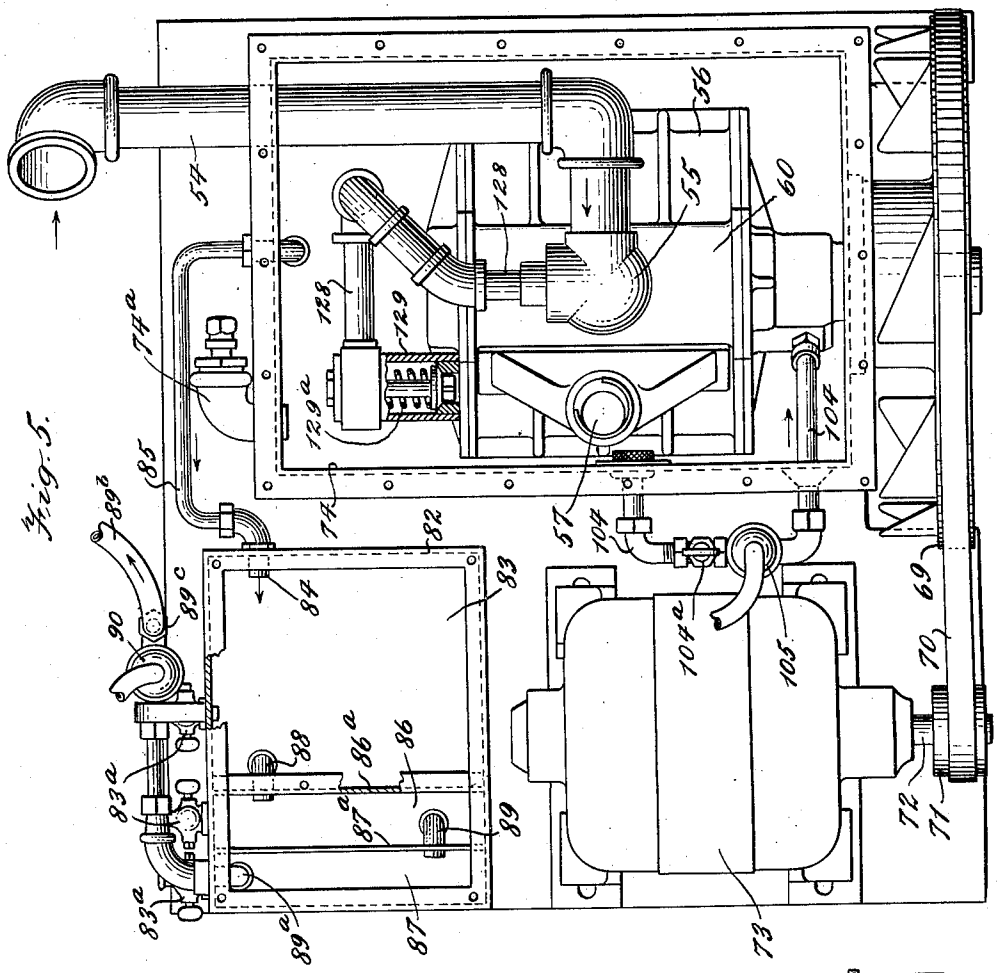


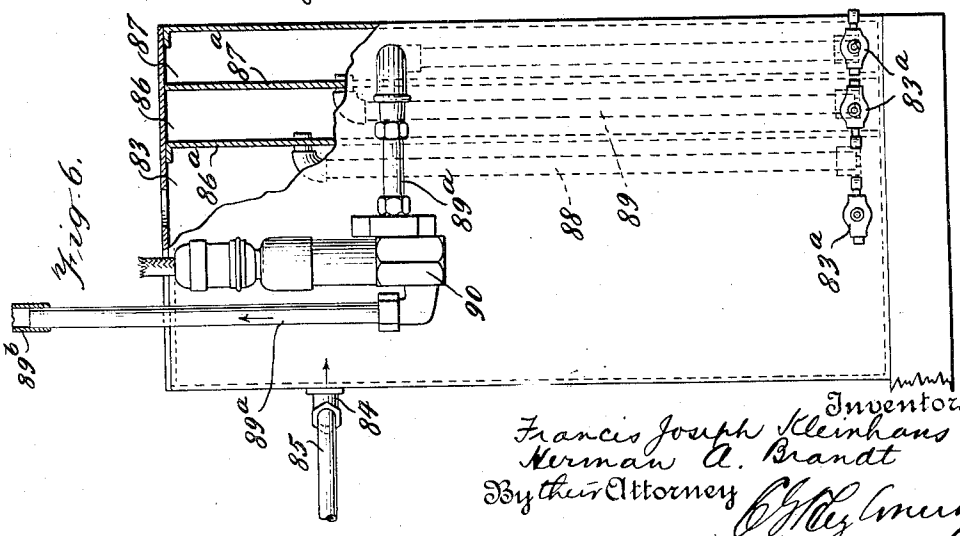
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REFRIGERATING APPARATUS

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REFRIGERATING APPARATUS

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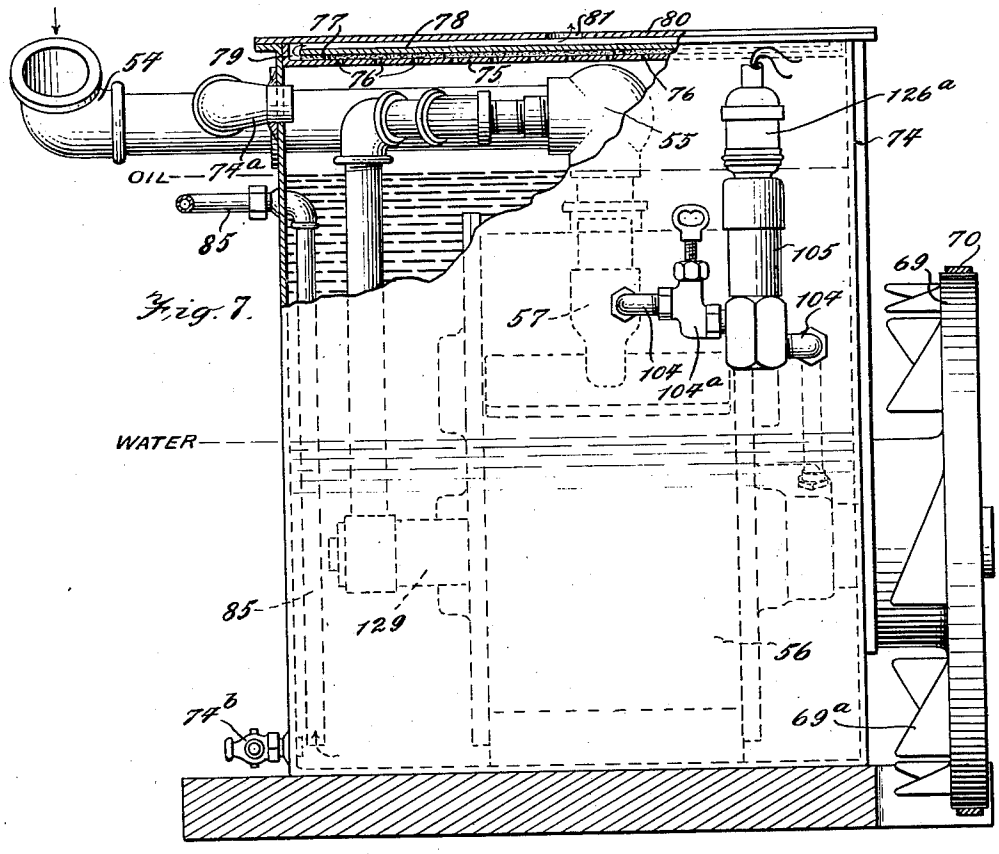


Fig. 7.

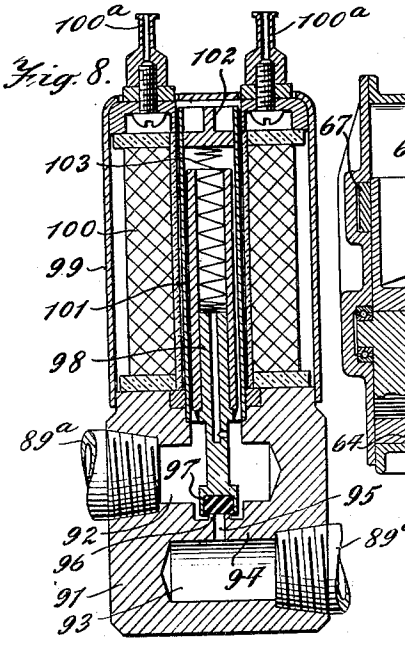


Fig. 8.

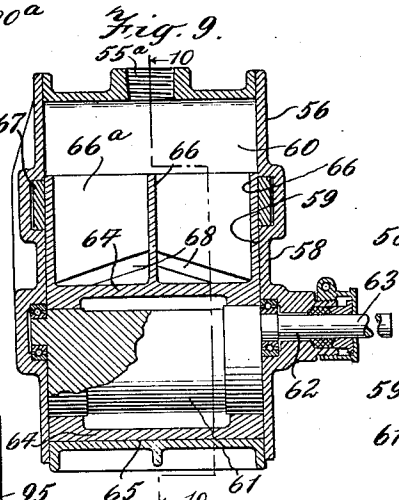


Fig. 9.

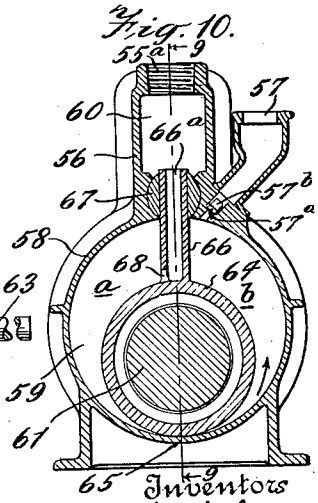


Fig. 10.

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Filed May 24, 1927 5 Sheets-Sheet 5

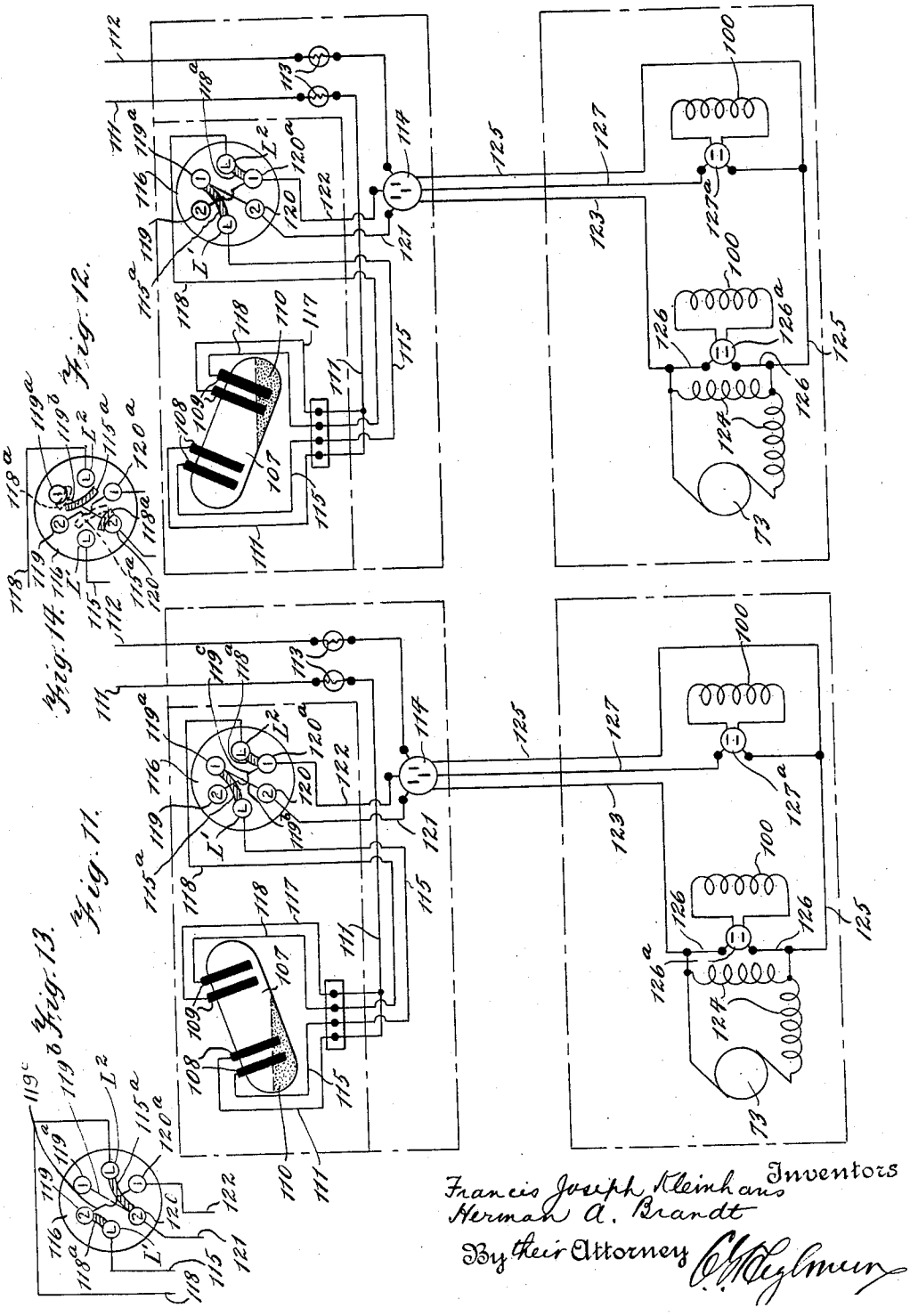


Fig. 11.

Fig. 12.

Fig. 13.

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UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

Application filed May 24, 1927. Serial No. 193,830.

Our invention relates to new and useful improvements in refrigerating apparatus, and while it embodies features which render it useful and applicable for refrigeration generally, it will be found especially applicable and useful in a structure or system for domestic refrigeration, that is, for installation in a refrigerator box or cabinet for domestic use in the refrigeration and preservation of foods. The invention relates particularly to that type of refrigeration in which rapid evaporation of water or an aqueous liquid body is employed as the agency for effecting the production of temperatures low enough to produce a refrigerating effect, and in which the rapid evaporation to produce low temperatures is effected by creating a sufficiently low sub-atmospheric pressure over the body of water or aqueous liquid and withdrawing the water vapors at such rate that the temperature of the liquid body is reduced to a point satisfactory for the desired or determined cooling or refrigerating effect.

An object of this invention is to produce an improved refrigerating apparatus which will operate efficiently to produce the desired low temperature by the efficient use of low sub-atmospheric pressures over a body of water, or, if desired, over a mixture of water and a lower freezing point medium, and thus rendering the apparatus available for efficient and practical use in a system operating on the evaporation principle above stated.

The invention consists in the improvements to be more fully described hereinafter, and the novelty of which will be particularly pointed out and distinctly claimed.

We have fully and clearly illustrated a preferred embodiment of our invention in the accompanying drawings to be taken as a part of this specification and wherein—

Figure 1 is a view in front elevation of our invention as embodied in a refrigerator box or cabinet for domestic refrigeration, the door of the cooling chamber or food compartment and the space for the cooling element being shown open and in edge elevation;

Fig. 2 is a section on the line 2—2 of Fig. 1, with the closure panels for a lower compartment in place;

Fig. 3 is an enlarged sectional view through the cooling element and freezing chamber, taken on the line 3—3 of Fig. 1, with the door of the food chamber closed;

Fig. 4 is a sectional view on the line 4—4 of Fig. 3 with the central freezing pan removed;

Fig. 5 is a top plan view of the exhausting means and driving motor, and means for separating water and lubricant discharged from the exhausting means, parts being broken away, and partly in section;

Fig. 6 is a rear elevation of the water and lubricant separating means shown in Fig. 5, parts being broken away, and partly in section;

Fig. 7 is a view in end elevation, with parts broken away and partly in section of the housing for the exhausting means, and showing in section a separator for air and vapors, and also showing an automatic control means for lubricant;

Fig. 8 is a vertical central section through one form of automatic valve forming one of the elements of our invention, having its cap member removed to show the lead terminals;

Fig. 9 is a section on the line 9—9 of Fig. 10 of one form of pump which may be employed as the exhausting means for the embodiment of our invention herein shown and described;

Fig. 10 is a section on the line 10—10 of Fig. 9;

Fig. 11 is a diagram of a circuit system for supplying and controlling electric current to the several electrically driven and controlled elements, the same being shown in the condition when the system is being operated to perform refrigerating functions;

Fig. 12 is a view of the circuit system shown in Fig. 11, but in the condition when the system is at rest, that is, not operating to create refrigerating conditions or functions;

Fig. 13 is a detail of part of the circuit system showing the control switch when moved to another position controlling operation of the machine, and

Fig. 14 is a diagrammatic view showing in

full lines the switch blades at an intermediate off position when rotated from position shown in Fig. 11 to position of Fig. 13, and showing in dotted lines the blades at a second intermediate off position when rotated from position of Fig. 13 to position of Fig. 11.

Referring to the drawings by characters of reference, 1 designates generally a refrigerator box or cabinet of any design and construction suitable for domestic refrigeration. In the embodiment shown, this box or cabinet may comprise a front wall 2, rear wall 3, side walls 4, 5, a top wall 6, and a bottom or floor 6^a. The walls mentioned preferably consist of outer sheathing or panels 7 and inner walls 8 spaced therefrom to receive suitable intermediate heat insulating packing 9 (see Fig. 2) of any suitable material serving to insulate the interior of the cabinet from the higher external temperature, and maintain the desired low temperature conditions created in the cabinet. The cabinet is divided at a point intermediate its upper and lower portions by means of a horizontal floor or partition 10, into a lower compartment 11 and an upper compartment 12. The compartment 11 constitutes a space or chamber to receive certain apparatus, to be hereinafter described, forming part of our refrigeration system, and the upper compartment 12 forms a space to serve as a food compartment, above which is a space 12^a to receive a cooling element by which the desired cooling effect is produced for cooling the food compartment. The front wall 2 is provided with a suitable door opening 13, through which access may be had to the chamber 12, said opening being controlled by a closure door 14 hinged to the front wall, as at 15, and being of any construction suitable for the purpose for which it is employed. The food chamber 12 may contain suitable shelf grids 12^b to support food or other substances to be preserved or cooled.

The floor 10 is also formed of inner and outer sheathings 7^a with intermediate heat insulating material 9^a in the same manner as described with reference to the outer walls of the cabinet.

The bottom, side, rear and top walls of the upper chamber 12 and the inside of door 14 may be lined with a suitable sheet-metal, as at 16.

The lower compartment 11 is preferably provided at the front and rear of the cabinet with openings 11^a, normally closed by removable perforate panels 11^b which conceal the elements in said compartment, but which may be readily detached for access to the compartment and said elements.

The upper compartment 12 contains a horizontal baffle or partition 17 which divides the interior of the chamber 12 to form the food compartment at the lower portion thereof, and to form the refrigeration space 12^a at the upper portion thereof, in which the cooling element to be hereinafter described is located.

From the front edge portion of the partition 17 rises a vertical front wall 18 which extends upward to the top wall 6, and also extends entirely across the front of the compartment to thereby form the front wall of the space 12^a. The side edges of the wall 18 are provided with forwardly projecting side plates or flanges 19 which are adapted to be secured by suitable fastening devices 20 to the vertical sides of the opening 13, to thereby support said partition 17 and wall 18.

The side edges of the partition 17 do not extend horizontally entirely across the space 12, but terminate short thereof, as shown at 21 in Fig. 4, and from these side edges rise vertical side walls 22 which are spaced from the adjacent side walls of the compartment to form vertical air ducts 23. The upper horizontal edges 24 of the walls 22 terminate, as at 25, at a distance short of the upper wall of the compartment 12^a to provide passages 26, through which air flowing upward through the ducts 23 may pass into the space bounded by partition 17, walls 18, 22, and the top of the compartment 12^a. The space formed in the manner just described is provided to receive the cooling element of the system.

The partition 17 is provided with an opening 27 above which is supported a suitable air deflector plate 28, the arrangement being such that the warmer air which passes from the food compartment 12 up through ducts 23 and passages 26, will be cooled in the space containing the cooling element, and then return through opening 27 into compartment 12 to maintain the same at the desired low temperature. The side edges of the deflector plate 28 overlie or extend laterally beyond the edges of the opening 27, for a purpose to be presently described.

The various walls 17, 18, 19 and 22 are preferably of sheet-metal and may be made integral either by stamping from a single sheet, or may be made separately and welded together to form the structure described.

Within the cooling space above described is located a cooling element 29, in which the desired lower temperature is produced so as to extract the heat from the air currents flowing in contact with the walls thereof. This element in its preferred embodiment consists of a rectangular metal container which is liquid and air tight, except as hereinafter set forth, and includes a vertical front wall 29^a, rear wall 30, bottom wall 31, top wall 32, and side walls 33, all preferably of sheet-metal and formed or united to provide a substantially rectangular hollow or chambered element. This element 29 is of such vertical and transverse dimensions and is so supported that the side walls are spaced from the walls 22 to form vertical side air ducts 34 com-

municating with passages 26, and the bottom wall 31 is spaced above the partition 17. By this arrangement the air from chamber 12 passes up the ducts 23, through passages 26, down through ducts 34 and under the cooling element to the opening 27, and is cooled by contact with side and bottom walls of the element. The cooling element is of such front to rear dimension that the front and rear walls thereof are spaced from the wall 18 and the rear wall of compartment 12^a to form additional air flow ducts 35, 36, and the top wall is spaced from the top wall of the compartment to form an air flow space 37. By the arrangement of the cooling element in the manner described, the warmer air rising from the food compartment is caused to circulate efficiently in contact with the cooling element, be reduced in temperature, and returned by gravity to the food compartment to maintain the desired low temperature therein. The deflector plate 28 is so located beneath the cooling element that any dew formed thereon will be deflected on to the plate 17 and prevented from dropping through the opening 27 into the food compartment. Moisture collected on plate 17 may be drained off through a pipe 17^a to any suitable receptacle (not shown).

The cooling element described is adapted to contain an aqueous body which may be water entirely, or a mixture of water with some other fluid having a lower freezing point than water, for example, glycerine, which freezes at approximately minus 40° F., so as to reduce the freezing point of said body below that of water. Glycerine is particularly advantageous because of its low freezing point, but also because of its high boiling point of approximately 338° F., which insures against evaporation of the glycerine along with the water. The overall dimensions of this cooling element may vary within the scope of our invention, but in one embodiment built according to the disclosure herein, the dimensions are 14″ wide by 14″ long by 9″ high, providing a cooling surface of 6.2 square feet exposed to the air currents circulating as above described in the box.

The cooling element may be supported in the relation described by any suitable means, for example, by underlying transverse supporting bars 38, supported by the lower ends of hanger rods 39, the upper ends of which are headed and held by slotted clips or brackets 40 bolted, as at 41, to the top wall of the cabinet. By this means the element may be readily applied in and detached from operative position.

Within the liquid containing space of the cooling element is located a freezing compartment 42, which is preferably in the form of a horizontally disposed fluid-tight shell composed of a bottom wall 43, side walls 44, top wall 45 and rear wall 46. The front portion of the shell is left open to provide a door opening to the interior thereof, and projects through registering openings 47, 48, respectively, in the walls 29^a and 18, so that access may be had to the freezing compartment from the front of the refrigerator cabinet. The door opening is adapted to be closed by a drop door 49 hinged, as at 50, to keepers 49^a fixed on wall 29^a and extending through slots in wall 18, as at 50^a, the door having a packing facing 51 of rubber or equivalent material adapted to make an air-tight seal with the front projecting edge of the freezing compartment, as will be presently described.

The freezing compartment is supported in the cooling element by suitable vertical spacer bars 52, in such manner that the compartment is spaced from the walls of the element and is surrounded on all sides, except at the front, by the liquid refrigerating medium in the cooling element.

The freezing compartment is divided by apertured partitions 52^a into pigeon holes 52^b, and is adapted to receive suitable removable receptacles, such as trays 53, adapted to contain water or other material to be frozen or cooled, said partitions being shown in full and dotted lines in Fig. 3 and in section in Fig. 4.

We will now proceed to describe the means for producing the desired cooperative effect in the cooling element, and in the freezing compartment to produce refrigeration and cooling or freezing. Connected to the upper rear portion of the cooling element above the liquid level therein is an exhaust or suction conduit 54, which communicates with the interior of the element. The conduit adjacent its point of connection with the cooling element passes through the rear wall of the cabinet and thence downward on the exterior thereof, and is then directed into the chamber 11 where it communicates through a union 55 with the inlet port 55^a of a suitable exhausting or evacuating means 56 capable of producing the required sub-atmospheric pressure in the cooling element to result in the necessary rapid evaporation of the water to lower the temperature thereof to the degree desired. The evacuator should have sufficient volumetric capacity to remove the vapors with sufficient rapidity to facilitate rapid evaporation with consequent efficient lowering of the water temperature. In Figs. 9 and 10 of the drawings, we have illustrated one form of pump or evacuator capable of achieving the results sought, said pump not being of our invention either jointly or severally, the same being shown herein merely by way of example. The exhaust from the exhausting means is discharged through an exhaust port 57.

The pump or exhauster shown comprises in general a casing 58 containing a cylindri-

cal chamber 59 from which projects a hollow boss 60, to which the inlet 55ª opens. In the chamber is a cylindrical member 61 eccentrically mounted on a shaft 62, mounted in suitable bearings in the end walls of the casing, and one end of which projects external of the casing, as at 63. Rotatable on the cylindrical part 61 is a cylindrical piston sleeve 64, the circumference of which at one point closely approaches and rolls on the wall of the chamber 59, as at 65, to make a seal contact. The sleeve 64 carries a rigid, radial abutment 66 which slides in a rocking bearing member 67 between the chamber 59 and the chamber of boss 60, and projects into the latter chamber. The abutment 66 is hollow as at 66ª, and at its base is provided with ports 68, whereby the vapors exhausted from the cooling element entering boss 60 flow through abutment passages 66ª and ports 68 into the inlet side *a* of the pump chamber. Then as the piston rotates in the direction of the arrow the vapor drawn into the pump is forced on the next revolution to the exhaust side *b* and is discharged through the exhaust 57. In the discharge duct 57 is arranged an inwardly closing check valve 57ª, of any suitable construction, which opens to permit expulsion from the exhaust side of the piston, but which is urged to closed position by a bow-spring 57*b* to prevent any liquid in the housing being drawn into the pump chamber. Fixed on the projecting end 63 of the piston shaft, is a belt pulley 69, which is driven by a power belt 70, in turn driven by a pulley 71 on the shaft 72 of a suitable prime mover, preferably in the form of an electric motor 73, mounted on the same base as the pump. The pulley 69 may be equipped with fan blades 69ª to cool the working elements.

In operating this system, we have found that a pump of the character illustrated having a chamber, the internal dimensions of which are 7″ by 7″, and in which the rotor or piston is of such diameter that the greatest radial distance between its circumference and the wall of the chamber is 2½″, and, therefore, having a displacement or volumetric capacity of 158 cubic inches per revolution, will act to produce satisfactory cooling and freezing when driven at the rate of 305 revolutions per minute. When a pump of the capacity stated is driven at this speed, it will produce temperatures corresponding to the freezing point of water, and in so doing will produce a low sub-atmospheric pressure of about .1806 inches mercury absolute, and will also produce temperatures below the freezing point of water with correspondingly lower sub-atmospheric pressures. It will be understood, however, by those skilled in the art, that the area of the surface of the liquid in the cooling element may be properly proportioned relative to the pump capacity to produce the desired rate of evaporation, and, consequently, the desired refrigeration effect.

It will also be understood that the volumetric capacity of the pump in operation is directly related to the temperature of the vapor evolved and to the refrigerating effect desired. It is known that at 32° F. a pound of water vapor occupies 3296 cu. ft. and the evaporation of a pound of water is equivalent to 1073 B. t. u.'s, while at 20° F. one pound of water vapor occupies 5650 cu. ft. and the evaporation of a pound of water at this temperature is equivalent to 1223 B. t. u.'s, from which it will be seen that if a refrigerating effect of 500 B. t. u.'s per hour is desired, so as not to produce a temperature below 32° F., a pump capable of displacing 28 cu. ft. per minute or 1600 cu. ft. per hour, would be sufficient For lower degrees of temperature, pumps of greater capacity would be required. From this it will be apparent that the greater the volumetric capacity of the pump the greater will be the refrigerating effect produced per hour at the same R. P. M. The motor is supplied with electric current from any suitable source, but we prefer to employ a control circuit to be described hereinafter.

The freezing conditions in the freezing compartment are preferably achieved by connecting the interior thereof by an exhaust connection 74′ with the pipe 54, so that in the embodiment shown, the exhausting means or pump will simultaneously create a low sub-atmospheric pressure in the freezing compartment as well as in the cooling element. By this arrangement the food compartment is cooled, and at the same time water may be frozen in the trays in the freezing compartment. This provision also enhances the freezing action because of the external cooling effect of the cold liquid in the cooling element and the direct effect of the low sub-atmospheric pressure in the freezing chamber. It will be noted that the low pressure or approximate vacuum in the freezing chamber will serve to maintain the door 49 in air-tight, sealed engagement with the front edge of the freezing chamber so long as such low pressure exists.

The pump constituting the exhausting means is arranged in a suitable housing 74, which serves as a receiver for the discharge from the pump and a container for a body of water and oil which submerges the pump to a point above the discharge 57, and seals the pump against any ingress of air thereto which might interfere with its vacuum producing capabilities. The housing 74 is provided with a suitable inlet connection and hand valve 74ª by which the housing may be supplied with an initial quantity of oil and water, preferably equal parts, necessary for operation of the device. The water and oil may also be re-

plenished through the said connection and valve. The housing is also supplied with a drain cock 74[b] (Fig. 7), by which the contents of the housing may be drained, if desired. In this arrangement the discharge from the pump takes place directly into the interior of the housing, and inasmuch as the matter discharged may comprise air, water, water vapor and lubricating oil, we provide means for separating oil and water from the air and discharging the latter from the housing. This means comprises a closure wall for the top of the casing, which includes an inwardly cupped plate 75 having distributing perforations 76, and over which is placed a layer of suitable fibrous packing material 77 covering the perforations 76, through the interstices of which fibrous material air alone may pass. Over the sheet 77 of fibrous material, is arranged a metal plate 78, said plate and the sheet of fibrous material being of such dimensional area as to leave a marginal air passage space 79 about the periphery thereof. Overlying the plate 78 and spaced therefrom, and of such area as to cover the marginal space 79, is a top plate 80 having a central air outlet opening 81. The exhaust from the pump passes through the liquid in the housing and strikes the underside of plate 75, any oil and water carried by the air being thrown back into the housing, and the air passing through perforations 76, fibrous material 77, space 79 and the space between plates 78 and 80 emerging through outlet 81. By this arrangement only air is thrown out of the housing. Any water vapor present condenses and together with oil stratifies in the housing, as indicated by the level lines marked "Oil" and "Water" in Fig. 7 of the drawings. Incidently, this arrangement may to some extent act as a muffler of any noise arising from operation of the pump.

We will now describe means, also of our invention, for separating the water from the body of oil in the housing and returning it to the cooling element so that the supply of water therein necessary to produce the cooling effect will not become prematurely depleted to such an extent as to require too frequent replenishment from an outside source.

82 designates an oil and water separator, preferably in the form of a tank having a primary receiving chamber 83. The receiving chamber has communicating therewith at its upper portion, as at 84, one end of a pipe 85, the other end of which enters the housing 74, and is directed downwardly therein so that the open end of said pipe will be located in the body of water in the housing, preferably close to but just above the bottom of the housing. It will be apparent that due to the weight of the liquid body in the housing, water with some oil from the bottom of the housing will flow through pipe 85 into the primary receiving chamber 83. The separator 82 in addition to the chamber 83, has a plurality of separating chambers, indicated at 86, 87, formed by vertical partitions 86[a], 87[a], segregating the chambers, and these chambers are connected in sequence by flow-pipes 88, 89, the pipe 88 having an inlet end adjacent the bottom of chamber 83, and a discharge end delivering through partition 86[a] into the top portion of chamber 86, while the pipe 89 is arranged similarly in chamber 86 and delivers through partition 87[a] into the top portion of chamber 87. It will be seen that by this arrangement water, together with some oil, will flow from the housing 74 through pipe 85 into the primary separating chamber 83, wherein the water and oil will separate in part and stratify in said chamber, the water being at the bottom of the chamber. The water so separated out will flow successively through pipes 88 and 89 to the chambers 86, 87 where further separation takes place until the final chamber 87 contains water free or substantially free of oil. It will be understood that the separator may contain as many separating chambers as may be required to produce satisfactory separation. We have shown this separator as located on the base and external to the housing, but it may be located within the housing, if desired, without changing its construction or principle of operation.

Each of the pipes 88, 89 may be provided at the inlet ends thereof with any suitable form of straining or filtering device 88[a] to pass water but eliminate oil and dirt particles from the water to be returned to the cooling element.

Each of the chambers 83, 86 and 87 may be provided with a drain cock 83[a], by which the contents of said chambers may be withdrawn when desired. Leading from the chamber 87 to the cooling element, is a water return pipe 89[a], which may also have a filtering device 88[a], and through which water may be returned from said chamber to the cooling element by virtue of the vacuum or low sub-atmospheric pressure existing in the latter. This conduit 89[a] may include a flexible connection 89[b] having a slip or telescoping connection 89[c] with a metallic section, so as to be detachable therefrom for a purpose to be presently set forth. Return flow through the return pipe is controlled by an automatic valve 90, which is constructed and controlled so as to be closed while the exhausting means is operating to create sub-atmospheric pressure in the cooling element, and to be opened to permit water to return to the cooling element when the exhausting means comes to rest. By this arrangement the water return pipe is closed to permit creation of the desired low pressure in the cooling element during operation of the exhausting means. The valve mentioned may take a variety of forms, for example, it

may be a magnet or solenoid operated valve, as shown in Fig. 8. The valve illustrated includes a body 91 having inlet and outlet passages 92, 93, connected in the pipe 89ª and separated by a partition 94 having a port 95 and seat 96. Cooperating with the seat 96 to open and close the port 95, is a valve head 97 carried on the lower end of a vertically movable valve stem or plunger 98.

Mounted on the valve body 91 is a casing 99 enclosing a hollow magnet or solenoid winding 100, in the hollow portion of which is arranged a sleeve 101 in which is housed the upper end of the valve stem 98. The upper end of the tube 101 is closed by a head 102 between which and the top of the stem is arranged a spring 103 which normally exerts its force to move the valve stem and the valve head 98 so that the latter will be seated on the seat 96 to close the port 95. The arrangement is such that when the magnet or solenoid is energized, it will raise the valve stem or plunger to lift the valve from its seat and permit flow through the port 95, but when the magnet is deenergized the spring 103 will move the valve to closed position. The magnet or solenoid winding is arranged in a circuit system to be hereinafter described, which in the embodiment shown may be so controlled that the magnet will be deenergized for closing the valve whenever current is supplied to the motor 73 to drive the exhausting means, but will be energized to move the valve to open position when current to the motor 73 is discontinued. Lead terminals for the winding are shown at 100ª.

We will now proceed to describe means for supplying lubricating oil to the pump or exhausting means 56, and for maintaining the supply of lubricant thereto for proper lubrication and sealing thereof. As heretofore stated, the housing 74 contains a body of liquid, consisting of a lower stratum of water and an upper stratum of oil. Leading from the housing at a point high enough so as to always be in position to receive oil from the oil stratum, is the inlet end of an oil feed pipe 104, which is led through the wall of the housing to a point external thereof, and is then returned within the housing and connected to one of the bearings for the pump shaft 62, which bearing communicates with the interior of the pump chamber. The arrangement is such that when flow is permitted through the pipe 104, the suction or low sub-atmospheric pressure in the pump chamber will operate to draw lubricant from the stratum of oil in the housing and deliver such oil through the shaft bearing into the pump cylinder in such quantity as to properly lubricate and seal the bearing and supply enough oil to the pump cylinder to lubricate the piston sleeve 64 and act as an oil seal between the circumference of the sleeve and the inner surface of the piston chamber. In the pipe 104 is arranged a valve 105 adapted to establish flow of lubricant through the pipe 104 while the pump is in operation and requires lubrication and sealing, and to cut off supply of lubricant when the pump is at rest. This valve 105 is preferably electrically and automatically operated so as to open when ever current is supplied to the motor to drive the pump, and to close to cut off supply of lubricant when current to the motor is discontinued. The valve may take a number of forms available for the purpose, without departing from the spirit and scope of our invention, and may be of the form illustrated in Fig. 8 and heretofore described. In the pipe 104 may be arranged a manually controlled valve 104ª which may be of any suitable type permitting manual adjustment to regulate the rate of flow of lubricant passed from the housing and through the automatic valve to the pump bearing and piston or rotor chamber.

We will now describe an electric circuit system for controlling supply of current to the motor 73 and the valves 90 and 105, in order to accomplish the refrigerating action and the operation of said valves, as heretofore described, reference being particularly had to Figs. 11 and 12 of the drawing. Located at any suitable point in the system where best subject to variations in temperature which may be employed as the agent to control the system, is a thermostat 106, the same being preferably located in the food compartment 12, and for the purposes of this application being shown as of the type including a double pole mercury switch 107, embodying a tube or vessel, which is adapted to be tilted by thermostatically responsive means, not shown, to shift the mercury to establish the circuit at one pair of poles, and break the circuit at the other pair of poles. The switch 107 contains at each of its opposite ends a pair of contacts 108, 109, respectively, and also contains a body of mercury 110 adapted to immerse either pair of contacts to establish current therethrough according to the direction in which the switch tube is tilted. Such switches are readily available on the market, and, therefore, a specific description of the structure thereof need not be set forth herein, except in so far as may be necessary for a disclosure and understanding of the manner of controlling the circuit system.

The source of current may be from any suitable point, for example, a commercial line circuit, and is indicated by the leads 111, 112, which connect to protective fuses 113. The lead 111 is connected to the innermost of the pair of contacts 108, and the lead 112 connects to one of the contacts of a three-pole cord connector or socket 114, which may be of any of the well known commercial types. The other or outer contact 108 is connected by a lead 115 with a contact L′ of a

rotary hand switch, of a type known on the market as a Perkins double-pole, double-throw snap switch, the same being indicated at 116. The innermost of the other pair of switch contacts 109 is connected by a lead 117 to the lead 111. The outermost contact 109 is connected by a lead 118 with the other point L^2 on the switch 116. Intermediate the switch points L', L^2, are contacts 119, 119^a and 120, 120^a, and the switch includes a pair of rotary contacts or blades 115^a, 118^a, shown diagrammatically in Figs. 11 to 14, by which the circuit may be completed from the points L', L^2 to said contacts and bridge across from contact 119 to 120^a, or from 119^a to 120, added jumper leads 119^b, 119^c, as indicated, connecting these contacts. Contact 120 is connected by a lead 121 to a second of the contacts of the connector 114, and contact 120^a is connected to the third contact of connector 114 by a lead 122. The contact to which lead 121 is connected in the connector 114 is connected by a lead 123 to the motor circuit or windings 124 of the motor 73, the return lead of the motor being shown at 125 and connecting to the connector 114 at the point to make circuit with the line lead 112. The winding or core 100 for the control valve 105 heretofore described, is bridged across the leads 123 and 125 through suitable connections 126 and a two-pole plug connection 126^a, if desired. To the third contact of the connector 114 is electrically connected a circuit lead 127, which is in circuit through the lead 122 with the contact 120^a. This lead 127 connects to one end of the wire for the coil 100, which operates the water valve 90, the other end of said coil winding being connected to the lead 125. The coil for the water valve may be connected into the lead 127 by a two pole plug 127^a. It will be seen that with the parts in the position shown in Fig. 11, with the contacts 108 in the switch tube immersed in the mercury and the hand switch 116 operated to cause the blade 115^a thereof to connect the switch points L', 119^a and 120, the motor circuit will be energized to drive the exhauster pump, and simultaneously therewith the winding 100 of the magnet for operating the oil control valve 105 will be energized to cause the valve to open to permit flow of oil from the pump housing 74 to the pump bearing and the piston chamber of the pump. The conditions just described are those which exist when the thermostat has been affected by higher temperatures to throw the mercury switch to immerse the contacts 108 in the mercury. This condition continues so long as the temperature is high enough to cause the thermostat to tilt the mercury switch to the position described.

When the temperature produced and controlling the thermostat falls low enough to actuate the thermostat to throw the mercury switch to the position shown in Fig. 12, the mercury flows out of contact with the contacts 108, breaking the circuit at that point and establishing the circuit at the contacts 109. This breaks the circuit to the motor and the coil 100 of the oil control valve, causing the motor to come to rest and the pump to stop, and at the same time releasing the oil valve to permit the same to seat and cut off the supply of oil from the housing to the pump bearing and cylinder. Simultaneously with the operation just described, the circuit system is changed to operate as follows: from the lead 111 the current flows to the innermost of the tube contacts 109, through the mercury to the outermost contact and through the lead 118 to the contact L^2 at the right of the double pole switch 116, thence through blade 118^a to the contact 120^a, and by way of the lead 122 and lead 127 through the winding 100 of the water valve to lead 125. By way of lead 125 the current passes through the connector 114 to the line lead 112. In this condition of the circuit it will be seen that the water valve is opened to permit flow of water from the separator to the cooling element whenever the motor and pump are at rest, and thereby adds an increment of water to the body in the cooling element to maintain the desired quantity therein. It will be seen that when the circuit is in the condition shown in Fig. 11, current to the lead 127 and the coil for the water valve, will be cut off so that the valve plunger will be released from the magnet and the spring 103 will seat the valve and thereby prevent flow of water from the separator to the cooling element.

While the circuit is in the condition shown in Fig. 11, if for any reason it should be desired to stop the motor and pump, the double pole switch 116 may be moved to the position shown in Fig. 13 to make contact at L', blade 118^a, 119, jumper lead 119^c and contact 120^a, thereby cutting off the current to the motor and establishing the current to the coil for operating the water valve. This arrangement provides for a manual control independently of the thermostatic automatic control. The flow of current when the parts are in this condition is from lead 111 through the contacts 108, lead 115, switch point L', contact 119, contact 120^a, to lead 122, and thence through the water valve magnet, as heretofore described. If for any reason it should be desired to start operation of the pump when the same is at rest, and independently of the thermostatic control, and when the mercury switch is in the position shown in Fig. 12, the switch 116 is operated to cause blade 115^a to bridge the contacts L^2, 120, under which conditions the current flow is as follows: from lead 111 through the lead 117 to the innermost contact 109, thence to the outermost contact 109 and lead 118 to the switch contact L^2, thence to contact 120, and

by leads 121, 123 to the motor and oil-valve coil. Under these conditions the water valve magnet is cut out of the circuit system and the water valve closed.

The parts being constructed and arranged as above set forth, the operation of a preferred embodiment of our invention is as follows: The cooling element 29 is supplied with either a body of water, or a mixture comprising a liquid body of glycerine and water, preferably in the proportions by weight of about seventy (70) per cent. of water to thirty (30) per cent. of glycerine, the total quantity of liquid being such that the level thereof will be below the inlet to the suction duct 54, so that an air or vapor space will be left above the liquid, and the latter will not be drawn as liquid through the suction duct. In a system of given capacity the liquid may amount to three and one-half (3½) gallons, and the proportions of the element 29 being such that with the liquid quantity mentioned there will be about 1.36 square feet of evaporative surface. The trays or other receptacles in the freezing chamber may be supplied with water or other ingredients to be frozen or cooled. The cooling element 29 may be charged with the water or aqueous mixture by disconnecting the flexible pipe connection 89^b from the section 89^a and connecting said connection to a vessel (not shown) containing the desired quantity of water or aqueous mixture, and then operating the hand switch 116 to cause the exhauster to create a low enough sub-atmospheric pressure in the cooling element 29 to draw the charge from the vessel into the element 29. When charging, the amount of water or aqueous mixture placed in the vessel may substantially approximate that desired to form the charge in the cooling element. The housing 74 will also be supplied with a quantity of water and suitable lubricating oil, as indicated in Fig. 7 of the drawings. For initial starting, the motor and pump will be at rest, the oil valve closed and the water valve open, the circuit being in the condition shown in Fig. 11, due to the fact that the food compartment is relatively warm and the thermostat has assumed a position to hold the mercury switch in the position shown in Fig. 11. The switch 116 is then operated to throw the current on to the system, whereby the motor 73 is energized and the oil valve magnet also energized to open the oil supply connection 104. At the same time the circuit to the magnet of the water valve is interrupted and the water valve moves to closed position. The motor when energized drives the pump, and the latter operates to evacuate or exhaust the space above the liquid level in the cooling element, resulting in rapid evaporation of the liquid which causes the temperature of the liquid to be lowered at a rate depending upon the degree of sub-atmospheric pressure created in said space. When the liquid evaporates, the vapors liberated therefrom are carried out by the pump suction, and passing through the duct 54 enter the pump and are discharged therefrom through the discharge 57. In view of the great affinity of glycerine for water, these two elements are intimately mixed in the cooling element, but in view of the difference in boiling points, the water alone will evaporate and be carried over as vapor through the suction line. The glycerine remains in the cooling element. With a pump of sufficient volumetric capacity to cause a substantial vacuum over the surface of the liquid in the cooling element, the evaporation will take place so rapidly that the temperature of the liquid, and consequently that of the cooling element, will be rapidly reduced toward the freezing point of the water, or lower, depending upon the degree of vacuum produced. By employing a mixture of water which freezes at approximately 32° F., and glycerine, which freezes at a lower temperature, approximately −40° F., the temperature of the liquid in the cooling element may be carried to a point below that of the freezing point of water, so that low temperatures may be produced, if desired, and sufficiently low to create efficient freezing conditions around the freezing chamber without freezing the mixture in the cooling element. Simultaneous with the suction created in the cooling element, the vacuum or low sub-atmospheric pressure is also produced in the freezing chamber, so that water or other substance therein will be frozen, cooled or congealed, according to the degree of vacuum produced and the characteristics of the material placed in the freezing chamber.

During this operation of the exhausting means or pump, the oil valve 105 will be open and the suction created in the pump chamber will draw in small quantities of oil, but sufficient to properly lubricate the bearings and form a seal between the surface of the pump piston or rotor sleeve and the cylinder wall. The air and water vapor withdrawn by the pump from the cooling element and the freezing chamber, are expelled from the discharge 57 of the pump into and through the body of liquid in the housing, and together therewith will pass small quantities of oil, some of the water vapor not condensed during compression by the pump being condensed by contact with the liquid in the housing. The air carrying any water vapor not condensed, or oil particles not separated out, will pass upward from the liquid body and against the oil and air separator made up of the elements 75, 77 and 78, the water vapor and oil being separated out and falling back into the housing, while the air is expelled from the port 81. The oil and water separated out remain in the housing and a portion of the water with some oil will pass from the housing through

pipe 85 to the primary chamber 83 of the oil and water separator, wherein the oil and water will stratify and be separated as described, substantially oil-free water finally reaching the chamber 87. This flow of water will take place whenever there is a greater level of liquid in the housing than in the oil separator, and is assisted in part by any pressure which may exist over the surface of the liquid in the housing. This operation continues so long as the thermostat acts to maintain the switch 107 in the position shown in Fig. 11.

When the system has operated long enough to create the desired or determined low temperature condition in the food compartment, or other point of control, the thermostat operates to move the switch 107 to the position shown in Fig. 12, under which conditions the circuit to the motor will be discontinued and the pump brought to rest. Simultaneously with stopping of the pump, the current to the oil valve coil will be discontinued and further flow of oil from the housing 74 to the pump and its bearings will be stopped, even though a sub-atmospheric pressure exists within the pump when brought to rest, although the suction may draw in the small amount of lubricant between the valve 105 and the pump. The system being air and fluid-tight, the pump piston being oil-sealed, and the discharge therefrom being provided with an inwardly closing check valve, the low sub-atmospheric pressures created will be maintained for a considerable time after the pump has come to rest. It will thus be seen that the oil flow to the pump will be established whenever the pump is operating to draw a sub-atmospheric pressure, and will cease whenever the pump is stopped. Simultaneously with the stopping of the pump and the closing of the oil valve, the current will be thrown upon the coil for the water valve 90, and the latter will be immediately opened, so that the suction existing by reason of the low sub-atmospheric pressure in the cooling element will serve to draw back a certain quantity of water from tank 87 into the cooling element to make up for any water loss which may have resulted, due to evaporation, while the pump was running. By this provision water loss is minimized and replenishment of water in the cooling element from a source outside the system will not be required as often as would be the case if this automatic water return were not provided. The parts remain in this condition until the temperature rises to a point sufficient to actuate the thermostat to again shift the tube 107 to the position shown in Fig. 11, whereupon the operation above described is repeated until the temperature drops low enough to cause the thermostat to throw the switch 107 back to the position shown in Fig. 12.

In order to relieve any excessive starting load on the pump and motor, which might exist when the pump is started from a position of rest, and due to air which may be pocketed in the pump chamber on the exhaust side of the pump piston, said exhaust side is connected by a by-pass pipe 128 with the hollow boss 60 of the pump, and in this by-pass pipe is arranged a pressure relief valve 129 of any suitable type, which is spring seated by an adjustable spring 129^a, but opens outwardly under predetermined pressure when the pump starts. This arrangement will cause the resistance of such air to be reduced by relieving the pressure through the by-pass into the inlet side of the pump when the latter starts. It will be understood that during normal operation of the pump, the relief valve is seated and held shut, and that it opens to relieve the pressure only at starting.

It will be noted that the pump when running operates to evacuate the interior of the cooling element and simultaneously therewith the interior of the freezing chamber. By this operation not only is the freezing chamber evacuated at a rate to produce rapid freezing conditions therein, but the liquid in the cooling element is cooled down to a point which will rapidly lower the temperature of the wall of the freezing chamber and thereby facilitate freezing in the freezing chamber. This is true whether the liquid in the cooling element be water or an aqueous mixture, such, for example, as water and glycerine, as described. It will be understood that by employing a mixture of water and glycerine (which freezes at a temperature much lower than water), the mixture will have a lower freezing point than that of water, and therefore higher vacuums may be employed with resulting lower temperatures than is possible with the use of water alone. This permits low temperature (below the freezing point of water, if desired) of the liquid in the cooling element, and also facilitates freezing in the freezing chamber, the walls of which are in contact with the low temperature liquid.

It will be understood that while the pump is running and creating the low sub-atmospheric pressure in the freezing chamber, the door or closure 49 will be held closed to seal the opening to the freezing chamber, due to the preponderance of external atmospheric pressure. However, when it is desired to obtain access to the freezing chamber, it is only necessary to operate the switch 116 to bring the system to rest, whereupon the pressures within and external to the freezing chamber will become balanced sufficiently to permit the door to be readily opened.

What we claim and desire to secure by Letters Patent of the United States is:

1. In an apparatus of the character described, a cooling chamber adapted to contain an aqueous liquid, a freezing chamber within said cooling chamber, and evacuating means

to produce simultaneously a low sub-atmospheric pressure in said chambers.

2. In an apparatus of the character described, a cooling chamber adapted to contain an aqueous liquid, a freezing chamber housed within said cooling chamber and sealed with relation thereto, evacuating means, and connections between said evacuating means and said chambers whereby a low sub-atmospheric pressure may be produced simultaneously in said chambers by said evacuating means.

3. In an apparatus of the character described, a cooling chamber adapted to contain an aqueous liquid, a freezing chamber housed within said cooling element and sealed with respect thereto, evacuating means for simultaneously producing a sub-atmospheric pressure in said chambers, said freezing chamber having an opening through a wall of the cooling chamber, and a sealing closure for said opening.

4. In an apparatus of the character described, a cooling chamber adapted to contain an aqueous liquid, a freezing chamber housed within said cooling chamber and sealed with relation thereto, said freezing chamber being surrounded by the liquid in the cooling chamber, evacuating means, and connections between said evacuating means and said chambers respectively whereby a low sub-atmospheric pressure may be produced simultaneously in said chambers by said evacuating means, whereby the freezing chamber is cooled interiorly by the low pressure produced therein and is cooled externally by the surrounding liquid in the cooling element.

5. In an apparatus of the character described, a cooling chamber adapted to contain an aqueous mixture of water and another liquid of a lower freezing point than water, a freezing chamber housed within said cooling chamber and sealed with relation thereto, and immersed in said liquid mixture, evacuating means, and connections between said evacuating means and said chambers whereby a low sub-atmospheric pressure may be produced in said chambers by said evacuating means.

6. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a receptacle, said evacuating means having a discharge opening into said receptacle, an air outlet from said receptacle, and means between said discharge opening and said air outlet for separating moisture from air before passage from said outlet.

7. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a housing enclosing said evacuating means, said evacuating means having a discharge opening into said housing, an air outlet from the housing, and means between said discharge opening and said air outlet for separating moisture from air before passage of the air from said outlet.

8. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a housing enclosing said evacuating means, said evacuating means having a discharge opening into said housing, an air outlet from the housing, and means between said discharge opening and said air outlet for separating moisture from the air before passage of the air from said outlet, said last-named means including air passages and moisture-eliminating means intercepting said passages.

9. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a housing enclosing said evacuating means, said evacuating means having a discharge opening into said housing, an air outlet from the housing, and means between said discharge opening and said air outlet for separating moisture from the air before passage from said outlet, said last-named means comprising a closure for said housing and including a perforated plate, and fibrous material overlying the perforations of said plate.

10. In an apparatus of the character described a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a housing enclosing said evacuating means, said evacuating means having a discharge opening into said housing, an air outlet from the housing, means between said discharge and air outlets for separating moisture from the air before passage from said outlet, said last-named means comprising a closure for said housing and including a perforated plate, fibrous material overlying the perforations of said plate, and a cover-plate overlying said fibrous material.

11. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a housing receptacle enclosing said evacuating means, means for lubricating said evacuating means, said evacuating means having an exhaust discharge into said housing receptacle which constitutes a separator for oil and aqueous liquid, an oil and water separator connected to said housing receptacle, and means for re-

turning said aqueous liquid from said separator to said cooling element.

12. In an apparatus of the character described, a cooling element adapted to contain an aqueous liquid, means for evacuating the interior of said element to evaporate said liquid to cool the same, a receptacle, means for lubricating said evacuating means, said evacuating means having an exhaust discharge into said receptacle which constitutes a separator for oil and aqueous liquid, an oil and water separator connected to said receptacle, and means for returning aqueous liquid from said separator to said cooling element, said last-named means including provisions whereby the return of aqueous liquid to said cooling element is established when the exhausting means is at rest and cut off when the evacuating means operates.

13. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid and removing vapor of said liquid, lubricating means for the evacuating means, means for receiving the exhaust from said evacuating means and separating aqueous vapor and entrained lubricant from the exhaust, means to receive condensed aqueous vapor and the lubricant, conduit connections for feeding condensed aqueous vapor to the cooling element and feeding lubricant to the evacuating means respectively, a valve controlling each of said conduit connections, and means whereby the valve in the aqueous liquid conduit opens automatically when the evacuating means is at rest and closes when the evacuating means operates, and the valve in the lubricant conduit opens when the evacuating means operates and closes when the evacuating means is at rest.

14. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid and removing vapor of said liquid, means for returning lubricant to said evacuating means and including a receptacle for receiving lubricant from said evacuating means, and means acting automatically to feed lubricant from said receptacle to said evacuating means when the latter is operating, and to stop said feed when the evacuating means is at rest.

15. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid and removing vapor of said liquid, an electric motor for driving said evacuating means, means for furnishing lubricant to said evacuating means and including a receptacle for receiving lubricant from said evacuating means, and having a conduit connection with said evacuating means, an electrically operated valve in said conduit connection, and a circuit system including said motor and valve whereby the valve is energized to open said conduit connection when the motor is running and the valve is deenergized to close said conduit connection when the motor is at rest.

16. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a subatmospheric pressure over said liquid and removing vapor of said liquid, means for receiving the exhaust from said evacuating means and separating from the exhaust the aqueous vapor and entrained lubricant, means to receive condensed aqueous vapor and lubricant, conduit connections for returning condensed aqueous vapor to the cooling element and lubricant to the evacuating means respectively, and automatic means acting when the evacuating means operates to cut off feed of the aqueous liquid to the cooling element and establish flow of lubricant to the evacuating means, and acting when the evacuating means is at rest to establish flow of aqueous liquid to the cooling element to cut off the flow of lubricant to the evacuating means.

17. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid and removing vapor of said liquid, means for receiving the exhaust from said evacuating means and separating from the exhaust the aqueous vapor and entrained lubricant, means to receive condensed aqueous vapor and lubricant, conduit connections for returning condensed aqueous vapor to the cooling element and lubricant to the evacuating means respectively, a valve controlling each of said conduit connections, and means whereby the valve in the aqueous liquid conduit opens automatically when the evacuating means is at rest and closes when the evacuating means operates, and the valve in the lubricant conduit opens when the evacuating means operates and closes when the evacuating means is at rest.

18. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid

and removing vapor of said liquid, means for receiving the exhaust from said evacuating means and separating from the exhaust the aqueous vapor and entrained lubricant, means to receive condensed aqueous vapor and lubricant, conduit connections for returning condensed aqueous vapor to the cooling element and lubricant to the evacuating means respectively, an electrically operated valve for controlling each of said conduit connections and circuit connections for said valves whereby the valve in the aqueous liquid conduit opens automatically when the evacuating means is at rest, and closes when the evacuating means operates, and the valve in the lubricant conduit opens when the evacuating means operates and closes when the evacuating means is at rest.

19. In a apparatus of the character described, a cooling chamber containing a liquid comprising a mixture of water and a liquid having a lower freezing point than water, a freezing chamber within said cooling chamber, and means to produce simultaneously a sub-atmospheric pressure in said chambers.

20. In an apparatus of the character described, a cooling chamber containing a liquid comprising a mixture of water and glycerine, a freezing chamber within said cooling chamber, and means to produce simultaneously a sub-atmospheric pressure in said chambers.

21. In an apparatus of the character described, a cooling chamber containing a liquid comprising a mixture of substantially seventy per cent. water and thirty per cent. glycerine, a freezing chamber within said cooling chamber, and means to produce simultaneously a sub-atmospheric pressure in said chambers.

22. An apparatus of the character described, comprising a hollow cooling element adapted to hold an aqueous liquid, evacuating means communicating with said element above the liquid level therein for creating a sub-atmospheric pressure over said liquid and removing vapor of said liquid, an electric motor for driving said evacuating means, means for furnishing lubricant to said evacuating means and including a receptacle for receiving lubricant from said evacuating means, and having a conduit connection with said evacuating means, and a valve in said conduit connection, said valve acting automatically to open said conduit connection when the motor is running and to close said conduit connection when the motor is at rest.

In testimony whereof we have hereunto signed our names.

FRANCIS JOSEPH KLEINHANS.
HERMAN A. BRANDT.