

July 23, 1935.

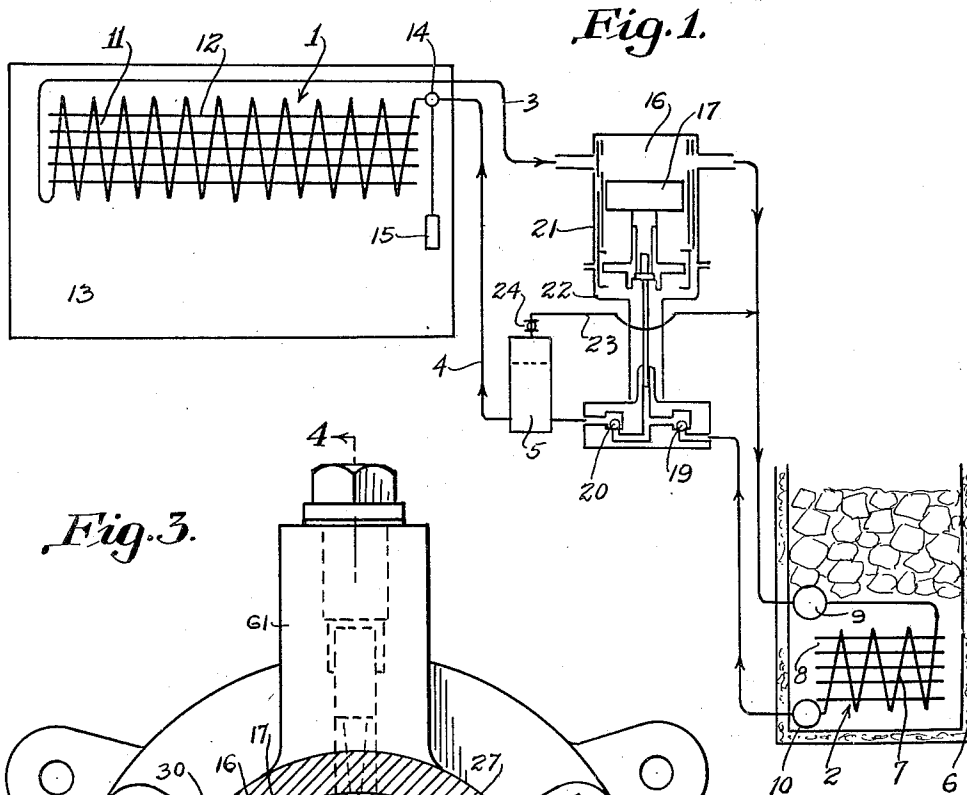
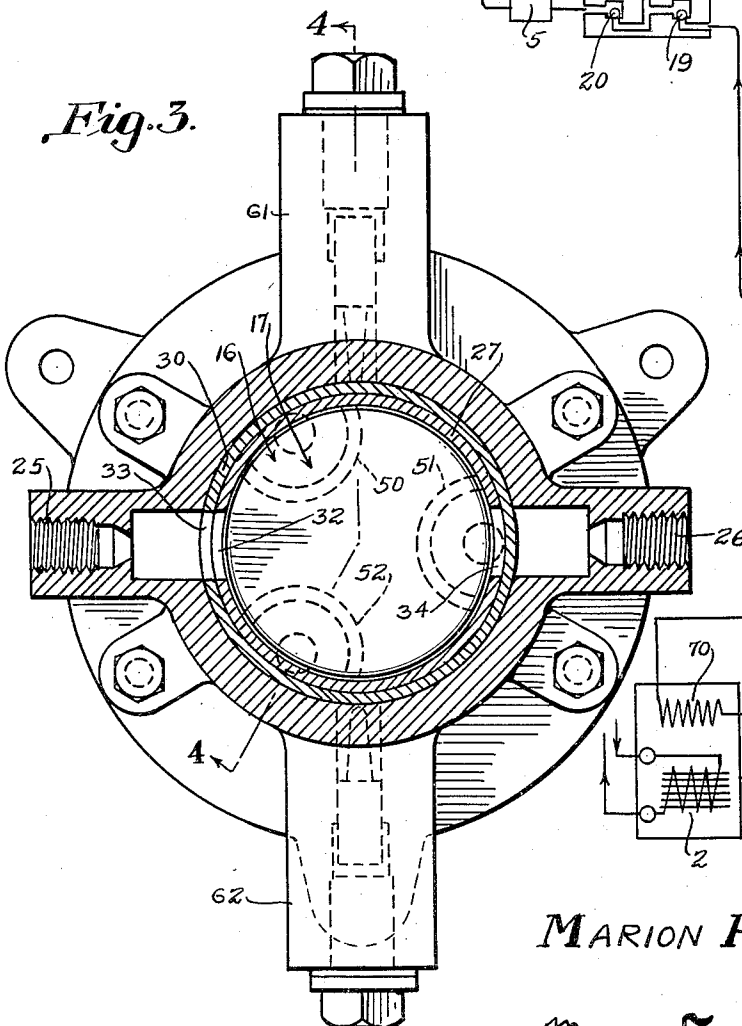
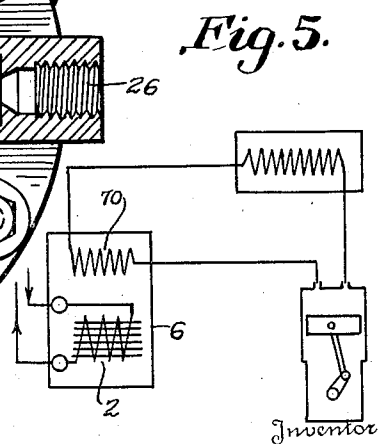
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2,009,372

AUTOMATIC LOW TEMPERATURE ICE SYSTEM

Filed June 2, 1933

2 Sheets-Sheet 1



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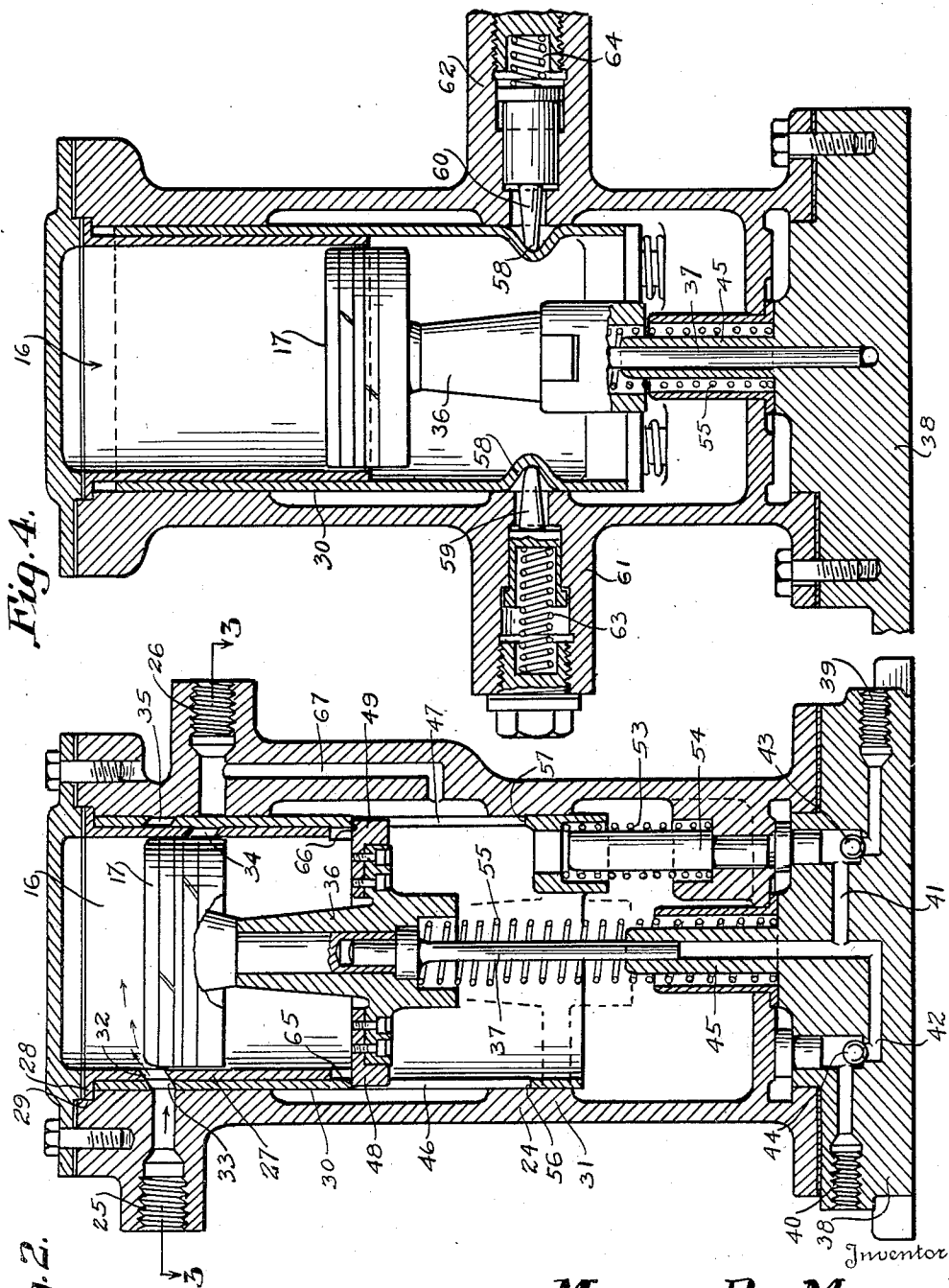


Fig. 2.

Fig. 4.

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UNITED STATES PATENT OFFICE

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AUTOMATIC LOW TEMPERATURE ICE
SYSTEM

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11 Claims. (Cl. 62—125)

This invention relates to a refrigeration system. In has for its general object the provision of a system in which a mixture of ice and salt, or equivalent solid refrigerant, or brine, plays the role of the liquefying agent in a compressorless circulating system of volatile liquid refrigerant operating through a cycle which involves change of state in a hermetically sealed conduit.

individually adjusted so as to compensate for differences in static pressure in the system at the different levels.

Other objects of the invention will appear as the following description of a preferred and practical embodiment thereof proceeds.

In the drawings which accompany and form a part of the following specification and throughout the several figures of which the same characters of reference have been employed to denote identical parts:

Figure 1 is a diagrammatic representation of a refrigeration system embodying the principles of my invention.

Figures 2, 3 and 4 illustrate the preferred construction of the motor pump; Figure 2 being a longitudinal diametrical section through the motor pump; Figure 3 being a cross section taken along the line 3—3 of Figure 2; and Figure 4 being a longitudinal section taken along the line 4—4 of Figure 3; and

Figure 5 is a diagrammatic view showing my compressorless refrigeration system in interlocked relation to a mechanical system of the compressor type.

Referring now in detail to the several figures and adverting to the general layout of the system as shown in Fig. 1, the numeral 1 represents in general an evaporator included in a hermetically sealed system with the condenser 2 and connected to said condenser by the conduits 3 and 4. The high side of said system may include the receiver 5 for containing a reserve body of the liquid refrigerant.

The difference between this system and those common in mechanical refrigerators is found in the high side in which the compressor is absent and the condenser is so modified in structure and function as to take the place both of the compressor and condenser in ordinary practice in reversing the gaseous refrigerant back to its liquid state.

The condenser preferably includes an insulated tank 6 containing a coil 7 having the convolutions thereof preferably crossed by fins 8. The tubes are connected to a header or surge drum 9 located above the level of said tubes and which serves to prevent the tubes from becoming gas bound and maintains a reasonable constant pressure within the condenser. Gas enters at the top of said tubes, condenses and falls into a liquid sump 10 at the bottom. The liquid exit is located at the bottom to insure the delivery of liquid refrigerant only. All of the condenser structure including the surge drum and liquid sump are

This system permits the use of ice, and at the same time secures for the user the advantages of temperatures below that of melting ice, in market coolers, display cases, etc., and also permits the thermostatic control of the refrigerator temperature, a function not hitherto possible with natural ice or ice and salt refrigerators. The absence of a compressor and water cooled condenser eliminates all wiring and plumbing, one or the other of which and sometimes both are inherent in mechanical refrigerators, while the capability of producing very low temperatures to take care of occasional peak loads by simply increasing the proportion of salt, averts the necessity for carrying extra machine capacity, which extra capacity reduces the efficiency of operation for ordinary loads.

A more specific object of the invention is to provide a system as described in which the condenser is submerged in a body of cracked ice and salt and the hermetic conduit between the evaporator and condenser is bridged by a motor pump for circulating the liquid refrigerant in a direction toward the evaporator, having the moving elements sealed within the hermetic conduit and having the pump element in the high side and the motor element in the low side, the latter being actuated by the gaseous pressure in said low side.

Still another object of the invention is to provide an expansion valve anterior to the evaporator, thermostatically responsive to the temperature of the refrigerated chamber, and through its control of the amount of refrigerant admitted to the evaporator and the amount of gaseous pressure developed therein, it becomes also the controlling means for the operation of the pump motor.

A further object of the invention is the provision of a by-pass around the pump with an adjustable relief valve, whereby the pressure of the liquid refrigerant in the expansion valve may be regulated and controlled so that in a vertical series of evaporators supplied from a single condenser and motor pump, such as may be adapted for apartment house refrigeration, the relief valves of the several units of the series may be

submerged in a mixture of ice and salt, or brine, contained in the insulated tank 6. The desired temperature in the condenser is controlled by the proportion of salt placed in the insulated tank
5 along with the cracked ice. The amount of ice required is determined by the duty of the system and the number of times per day or week that the tank is iced.

The evaporator may be of conventional construction including a tubular coil 11, the convolutions of which are in thermal contact with fins 12. The evaporator, as shown, is in the refrigerated chamber 13. An expansion valve 14 controls the admission of refrigerant to the coil in response to the thermostat 15 located in the refrigerated chamber. So much of the system as has been described constitutes a complete and operative refrigerant circulating system in which the conduit 4 from the sump 10 to the expansion valve 14 is filled with liquid refrigerant, while the conduit 3 from the exit side of the evaporator back to the condenser is occupied by gaseous refrigerant under more or less pressure.

On account of the absence of a compressor conditions in this system would probably be static. Consequently in order to provide for a positive feeding of the liquid refrigerant to the evaporator I have devised a motor pump actuated by the pressure of the gaseous fluid in the low side and acting upon the liquid in the high side of the system. Inasmuch as the motive fluid for this motor pump arises from within the system itself, it becomes possible to hermetically seal the moving parts of the motor pump and absolutely to prevent leakage either of the refrigerant into the atmosphere or vice versa.

Briefly describing the action of the motor pump from the diagrammatic representation shown in Figure 1, it will be understood that the expanded gaseous fluid from the evaporator enters an expansion chamber 16 of the motor pump, acts against a piston 17 which operates a differentially smaller piston 37 in the liquid conduit 4, drawing liquid refrigerant from the condenser sump 10 past a check valve 19 and forcing it past a check valve 20 into the receiver 5 and through the conduit 4 to the expansion valve 14.

The hermetic relation of the motor pump to the rest of the circulation conduit may be understood by observing that the cylinder walls 21 and 22 are continued expanded portions of the conduits 3 and 4. Since the pressure in the motor chamber 16 depends upon the rate of expansion of the refrigerant within the evaporator 1, and this, in turn, depends upon the admission of liquid refrigerant to said evaporator by means of the expansion valve 14, the latter may truly be considered as a control monitor for the operation of the motor pump. Since the expansion valve operates in response to the thermostat 15 in the refrigerated chamber, it may also be understood that the motor pump operates strictly in accordance with the needs of the refrigerated chamber.

In order to prevent a situation arising in which there might not be enough liquid refrigerant in the receiver 5 to supply the demands of the evaporator 1, the capacity of the motor pump 18 is such that liquid refrigerant is supplied to the receiver
70 5 at a rate in excess of the demands of the evaporator 1. This necessitates the provision of a by-pass 23 between the receiver and the condenser, around the valves of the pump. This by-pass is controlled by an adjustable relief valve 24 opening outwardly from the receiver 5 and which

determines the pressure at which the liquid refrigerant is supplied to the expansion valve. By adjusting the relief valve towards its closed position, pressure in the receiver and in the conduit 4 may be built up to any desired volume.
5 By adjusting the relief valve away from the receiver the pressure at the expansion valve can be made as small as desired. In apartment house installations in which evaporators are installed in vertical arrangement on the several floors, supplied from a single condenser and motor pump located for example in the basement of an apartment house, the relief valve of each by-pass may be so adjusted as to compensate for the decreasing static pressure at the levels of the several
10 units so that the evaporative efficiency of all of the units may be made the same.

Referring now to the structure in detail of the pump, it comprises in its preferred form a cylinder 24 having threaded inlet and outlet openings 25 and 26 respectively, near its upper end to which the divided ends of the gas conduit 3 are adapted to be connected. The cylinder 24 is provided at its upper portion with a spaced liner 27 preferably suspended by means of a flange 28 at its top and which rests upon a shoulder 29 formed in the cylinder casting. A narrow annular space is defined between the liner 27 and the inner wall of the cylinder 24 which space forms the seat for a sliding sleeve 30, said sleeve extends downwardly through a zone in which it is engaged and guided by an inwardly extending annular band 31 formed as part of the cylinder 24. The inlet opening 25 registers with a port 32 formed in the wall of the liner 27, the sleeve intervening, and the sleeve is provided with a port 33 adapted in reciprocation of said sleeve alternately to open and occlude the passage between the inlet opening 25 and the port 32. The outlet opening 26 is also in substantial registry with a port 34 in said liner, the sleeve being provided with a port 35 adapted to open or occlude the passage between the liner and the outlet opening, in certain positions of the sleeve.

The piston 17, which operates within the cylinder 24, is formed rigid with a piston rod 36 which at its lower end carries the liquid piston 37, the latter being of considerably smaller diameter than that of the piston 17 so as to exert a much greater end pressure than does the piston 17. The lower part of the cylinder 24 rests upon a block 38 having liquid inlet and outlet openings 39 and 40, respectively, and being bored out to form inlet and outlet valve passages 41 and 42, respectively, controlled by the check valves 43 and 44. The block 38 is provided with a hollow cylindrical extension 45 which receives the piston 37. When the latter piston reciprocates downwardly, liquid is forced past the check valve 44 out into the conduit 4 and toward the expansion valve. In the return stroke, the check valve 43 is lifted and liquid is drawn in by way of the inlet opening 39 from the condenser, with which the opening 39 is in communication.

The gaseous pressure within the chamber 13 is more or less constant over substantial periods of time, and consequently means other than fluctuations of gaseous pressure have been devised for operating the motor pump. These means include structural elements incorporated in said motor pump and as follows. The sleeve 27 is provided on opposite sides with slots 46 and 47. The piston rod 36 is provided with strikers 48 and 49 extending into said slots. The lower end of the sleeve is provided at a plurality of points, three in this instance and designated by the reference charac-
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ters 50, 51 and 52 in Figure 3, with a plurality of sockets each forming the seat for a spring 53. The lower end of the cylinder 24 is provided with guides 54 in axial alignment with the springs 53 and being surrounded by said springs acting as a guide therefor. A spring 55 reacts between the piston rod 36 and an abutment formed by the block 38.

With the parts in the position depicted in Figure 2, the sleeve 30 is in its uppermost position, having been returned to this position by the expansion of the springs 53. The opening 25 and the ports 33 in the sleeve and 32 in the liner are in registry. On the opposite side, the exhaust passage is closed by the interposition of an imperforate part of the sleeve between the liner port 34 and the exhaust opening 26. Gaseous refrigerant under pressure is being admitted into the expansion chamber 16. This causes the piston 17 together with the piston rod and strikers 48 and 49 to descend against the pressure of the spring 55, the sleeve meanwhile remaining stationary. Finally the piston reaches a point in its descent at which the strikers 48 and 49 operating in the slots 46 and 47 engage the lower ends 56 and 57 of said slots, pulling the sleeve down against the compression of the three springs 53. Figure 4 shows that the sleeve 30 is formed on opposite sides with depressions 58 having upper and lower inclined walls acting as cams and engaged by the ends of plungers 59 and 60 slidable in suitable housings 61 and 62 and pressed against said sleeve by springs 63 and 64.

Normally, that is to say, up to the time the strikers collided with the lower ends of the slots 46 and 47, the plungers 59 and 60 abut against the cylindrical surface of said sleeve. Just after the strikers have pulled the sleeve downward against the springs 53, for a short distance, the plungers begin to fall into the depressions 58, and said plungers camming against the lower inclined walls of said depressions pull the sleeve downward with a quick motion, suddenly closing the inlet port and at the same time opening the exhaust port by bringing the sleeve port 35 into registry with the exhaust port in the liner and the exhaust opening 26 in the cylinder casting.

The piston immediately starts its return under the bias of the expanding spring 55. When the piston has almost reached the top of its stroke the strikers collide with the upper end walls 65 and 66 of the slots 46 and 47, pulling the sleeve upward causing the plungers 59 and 60 to be pushed outwardly by the camming action of the lower walls of the depressions 58. Just as soon as the plungers 59 and 60 have been pushed out of the way, the sleeve is given a quick movement upwardly through the release of the three springs 53, thus suddenly closing the exhaust port and opening the inlet.

It will be understood that the cylinder casting 24 forms a hermetic connection between the low side of the refrigeration system represented by the gas inlet and gas exhaust openings 25 and 26, respectively, and the high side of said system represented by the liquid inlet and exhaust openings 39 and 40. There can be no leakage whatsoever outside of the system. It is not of very great moment that there should be some leakage either past the gas piston 17 or the liquid piston 37. Nevertheless, a pressure equalizing duct 67 is provided which allows any leakage to return to the condenser through the exhaust opening 26.

The ratio of the area of the gas piston to the

liquid piston in the preferred assembly herein illustrated is 140 to 1, although it is, of course, to be understood that there is nothing critical as to the ratio of the areas of these pistons. The speed of operation of the motor pump is determined by the rate of evaporation of the liquid refrigerant in the evaporator. In the event that an excess amount of liquid should be pumped into the liquid receiver the safety valve 24 referred to in connection with the description of the flow diagram allows excess liquid to return to the condenser.

The efficiency of the motor pump is determined not only by the gaseous pressure developed in the evaporator but also by the reduction of vapor pressure in the condenser through the use of the low temperature condensing medium, there being always a differential pressure between the gas inlet and outlet sides of the motor element of the pump to assure an operating capacity amply sufficient to supply the necessary amount of liquid refrigerant to the expansion valve.

The system operates as follows: The condenser 2 is charged with the required amount of refrigerant, the type of refrigerant being not vital to the invention, then the insulated tank 6 is filled with cracked ice and the proper amount of salt. The expansion valve 14 is opened, or all of the expansion valves are opened in the event that a series of evaporators are employed. The liquid refrigerant thereupon vaporizes increasing its volume greatly. This vapor flows through the pressure conduit 3 to the inlet opening 25 of the motor pump. The pressure of the incoming gas is always sufficient to operate the pump. The gas having done its work in the motor pump is exhausted through the exhaust opening 26 and flows to the condenser 2 where the low temperature of the ice and salt, or brine medium, reduces it again to liquid form. From the condenser it is drawn into the liquid inlet opening 39 of the pump and forced by the piston 37 by way of the outlet opening 40 through the receiver 5 and to the expansion valve 14, thus completing the cycle. The thermostat 15 located in the refrigerated chamber controls the opening of the expansion valve. The thermostat may be set to obtain any desired refrigerator temperature within the range of the equipment and may be changed at will. The receiver 5 functions as a reservoir to hold and supply to the expansion valve 14 at all times a volume of liquid refrigerant equal to the demands of the evaporator.

The system of the present invention can be used in conjunction with any type of mechanical refrigeration system which is capable of producing the low temperature necessary to condense the refrigerant gas in the condenser. It may also be used with brine and mechanical refrigeration in such manner as to utilize the storage capacity of the brine to produce a continuous refrigerating effect in the evaporator 1 during periods when the refrigerating machine to which it is adjunctive may be inoperative. For example, a refrigerator car may be equipped with an ordinary compressor refrigeration system operated through the axle, while the car is in motion and storing its cold in a volume of brine. The condenser of the refrigeration system of the present invention may be submerged in the brine so that when the car stops and the compressor system is inactive, the system of the present invention will take up the work of refrigeration through the heat interchange between the brine and the condenser 2.

The interlocking of the compressorless her-

metic system with a compressor system as above indicated, in which the evaporator 70 of the latter system, see Figure 5, effects change of state of the refrigerant in the condenser of the former system through a heat exchange medium such as brine, is not limited to the refrigeration of carriers, but to stationary installations where the demands exceed the capacity of ice and salt, or for other reasons.

While I have in the above description described what I believe to be a preferred and practical embodiment of my invention, it is to be understood that the details of construction as illustrated and described are merely by way of example, and not to be construed as limiting the scope of the invention.

What I claim is:

1. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a change of state, and including an evaporator, a condenser, and a pump having its motor element in the gas phase of said cycle and actuated by gas pressure, and having its pump element in the liquid phase of said cycle for circulating the refrigerant, said pump having its moving parts hermetically sealed within said conduit and actuated by pressure of the refrigerant in the gas phase of said cycle.

2. Refrigeration system as claimed in Claim 1 characterized by the absence of a compressor, the condenser including a coil for the refrigerant and a tank in which said coil is positioned, adapted to contain a brine refrigerant capable of absorbing sufficient heat to bring the refrigerant in said coil to liquid state.

3. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a change of state, and including an evaporator, a condenser, and a pump having its moving parts hermetically sealed within said conduit including a pumping element in the liquid phase of said cycle and a motor element in the gas phase of said cycle.

4. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a change of state, and including an evaporator, a condenser, a pump in the liquid phase of said cycle for circulating the refrigerant, said pump having its moving parts hermetically sealed within said conduit and being actuated by pressure of the refrigerant in the gas phase of said cycle, an expansion valve in said conduit between said evaporator and the suction side of said pump, a bypass between said suction and induction sides of said pump communicating with the liquid column of said conduit in advance of said expansion valve, and a relief valve controlling said bypass.

5. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a change of state, characterized by the absence of a compressor, including a condenser and an evaporator in said conduit, and means actuated by pressure in the gas limb of said system for circulating liquid refrigerant from said condenser to said evaporator.

6. Refrigeration system as claimed in claim 5, including an expansion valve between said evaporator and circulating means, the capacity of the latter being in excess of the demands of said evaporator, and a bypass communicating with said conduit between said expansion valve and

circulating means and with the gas limb of said conduit.

7. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a change of state, and including an evaporator and a condenser, a casing bridging said conduit between the liquid and gas limbs thereof and forming part of said conduit, said casing including cylinders respectively of relatively large and small diameters, pistons in said cylinders operatively connected, the smaller cylinder together with the working face of its piston constituting part of the liquid limb of said conduit and the larger cylinder with the working face of its piston constituting part of the gas limb, intake and exhaust valves for said smaller cylinder constituting it a pump, and means responsive to pressure of the gaseous refrigerant upon said larger piston for reciprocating said pistons.

8. Refrigerating system comprising a conduit forming a closed circulation path for a refrigerant passing through a cycle involving a change of state, including an evaporator, a condenser, a casing bridging said conduit between the liquid and gas limbs thereof and forming a part of said conduit, said casing including cylinders respectively of relatively large and small diameters, pistons in said cylinders, the smaller cylinder and the working face of its piston constituting part of the liquid limb of said conduit, and the larger cylinder together with the working face of its piston constituting part of its gas limb, intake and exhaust valves in said smaller cylinder constituting it a pump, the larger piston being responsive to pressure in the gas limb for reciprocating it in one direction, a spring for returning said piston, a sleeve valve in said larger cylinder controlling gas inlet and exhaust ports in said cylinder, and means movable with said piston and engageable with said sleeve, with lost motion in both directions of reciprocation of said piston for pulling said sleeve down after said piston has made an initial independent downward movement, and a detent for engaging said sleeve when the latter has been pulled by the said piston toward the position in which said inlet ports is closed and said exhaust ports opened, and holding it until said piston has accomplished part of its return stroke.

9. Refrigeration system as claimed in claim 8, including a spring compressed by said sleeve as it travels downward and functioning to return it quickly when released from said detent by said piston near the latter part of its upward stroke, to quickly open said inlet port and close said exhaust port.

10. Refrigeration system comprising a conduit forming a closed circulation path for a refrigerant passing through a cycle involving a change of state, including an evaporator, a condenser, a casing bridging said conduit between the liquid and gas limbs thereof and forming part of said conduit, said casing including cylinders respectively of relatively large and small diameters, pistons in said cylinders, the smaller cylinder and the working face of its piston constituting part of the liquid limb of said conduit, and the larger cylinder with the working face of its piston constituting part of the gas limb, intake and exhaust valves in said smaller cylinder constituting it a pump, said larger piston being responsive to pressure in the gas limb for reciprocating said pistons in one direction, a spring for returning said piston, a sleeve valve in said larger cylinder con-

trolling inlet and exhaust ports in said cylinder, means movable with said piston and engageable with said sleeve with lost motion in both directions of reciprocation of said piston for drawing
5 said sleeve downward during the final part of the downward stroke of said piston, a spring detent engaging a cam on said sleeve when the latter has been pulled by said piston toward the position in which the inlet port is closed and
10 the exhaust port opened, and pulling it quickly to inlet port closing position and exhaust port opening position by the pressure of said detent against said cam, and holding it until said piston has partly accomplished its return stroke, and a
15 spring compressed by said sleeve on its downward travel and functioning to return said sleeve quickly when released from said detent, to the

open position of said inlet and the closed position of said exhaust valve.

11. Refrigeration system comprising a closed conduit including a circulation path for a refrigerant passing through a cycle involving a
5 change of state, characterized by the absence of a compressor, including a condenser in said conduit, an evaporator, an expansion valve between said condenser and evaporator, and means actuated by pressure in the gas limb of said system
10 for circulating liquid refrigerant from said condenser to said evaporator, said expansion valve through its determination of the vapor pressure in said evaporator controlling the actuation of
15 said circulating means.

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