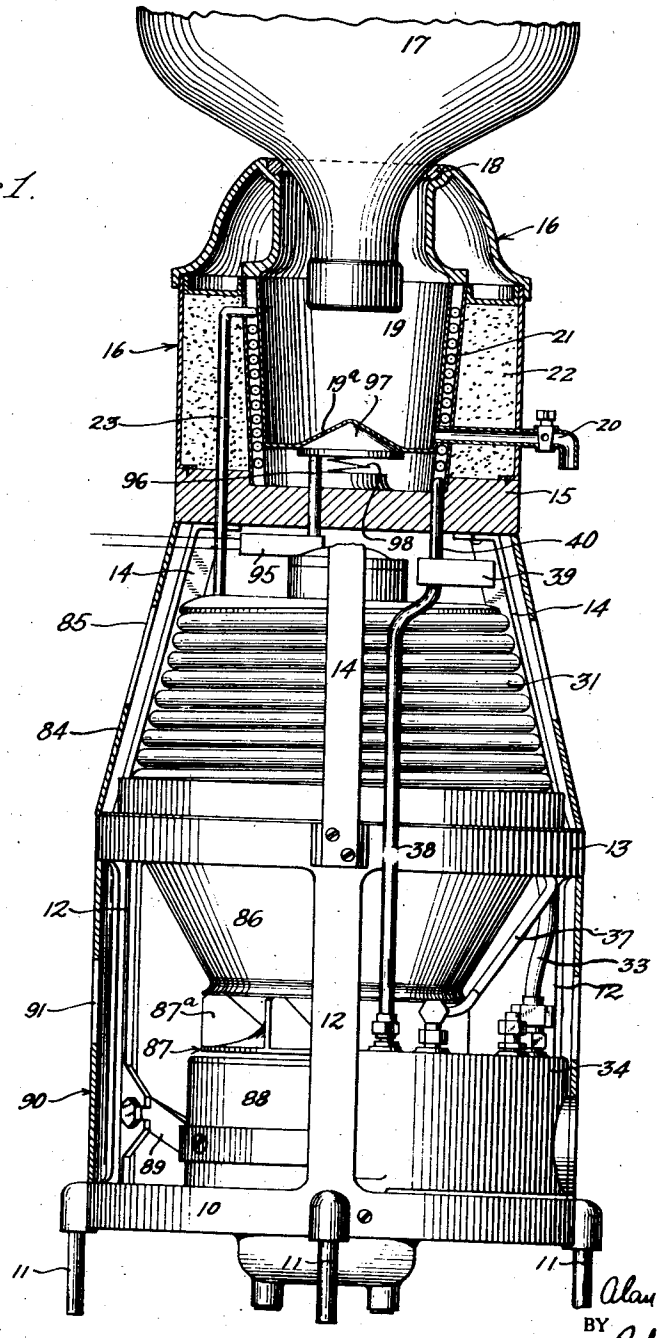
June 23, 1931. A. V. LIVINGSTON 1,811,090

REFRIGERATION

Filed March 7, 1925 4 Sheets-Sheet 1

Fig. 1.



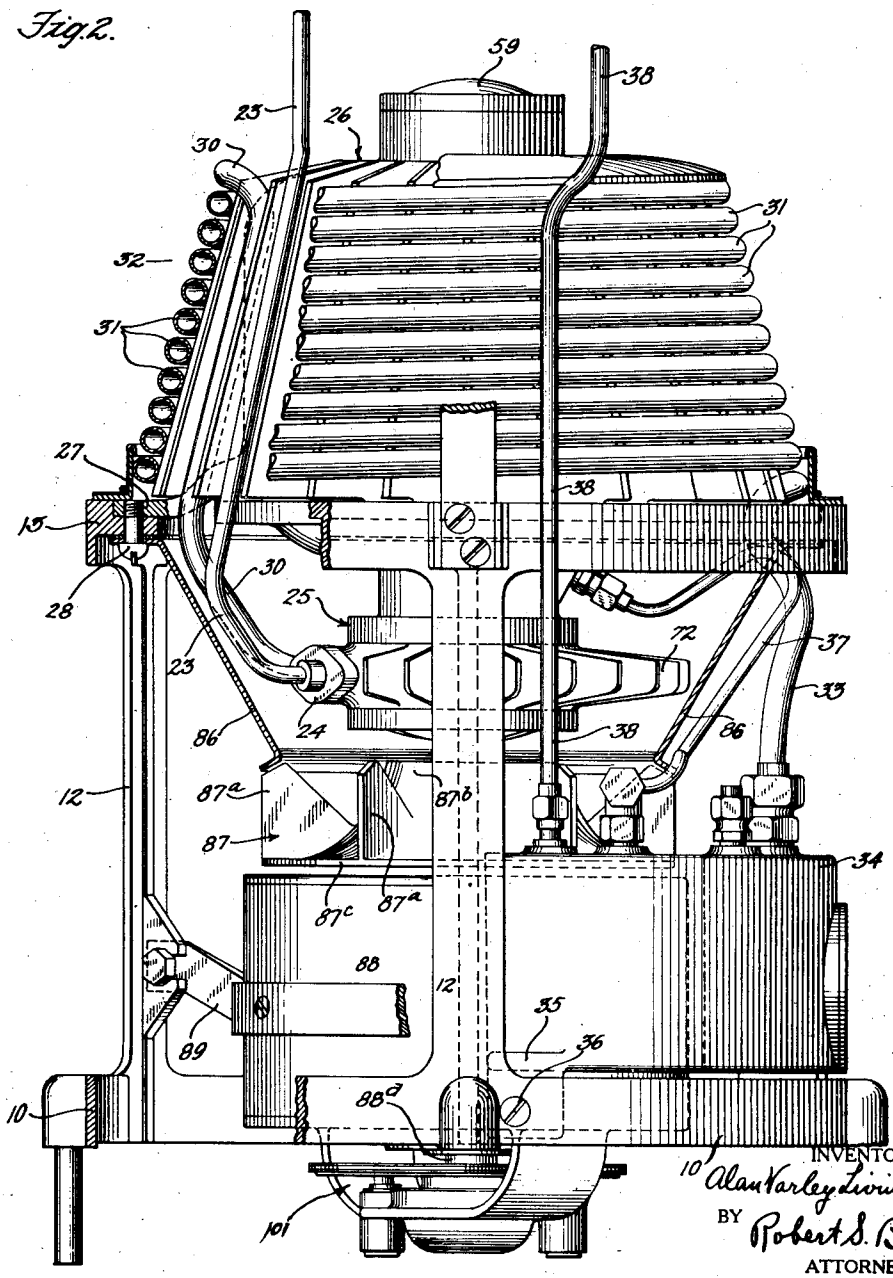
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Fig. 2.



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REFRIGERATION

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Fig. 3.

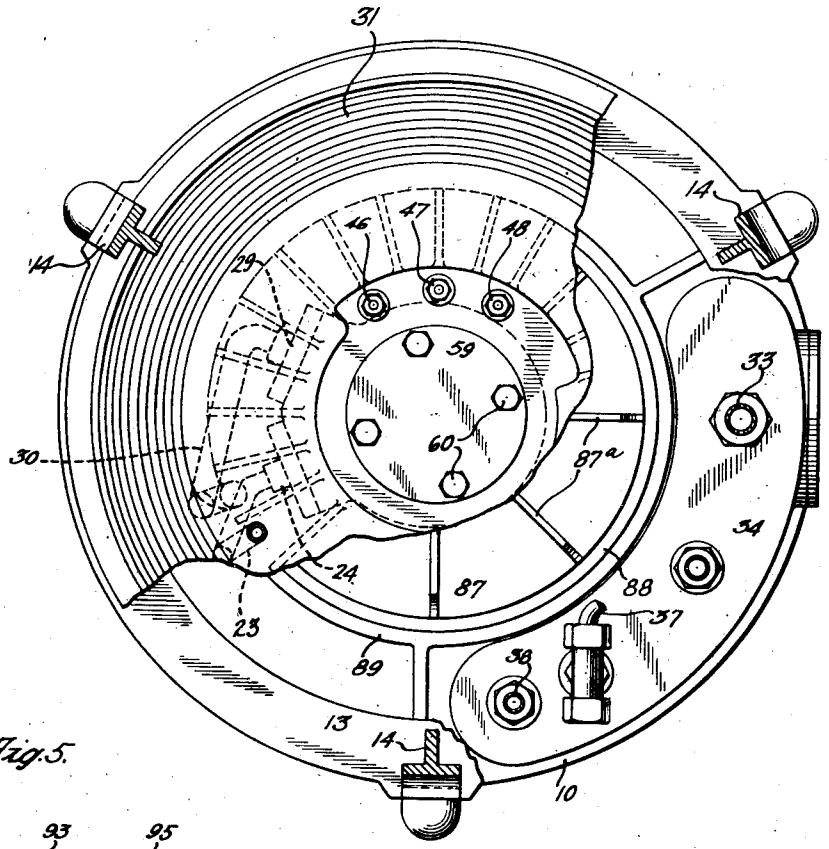
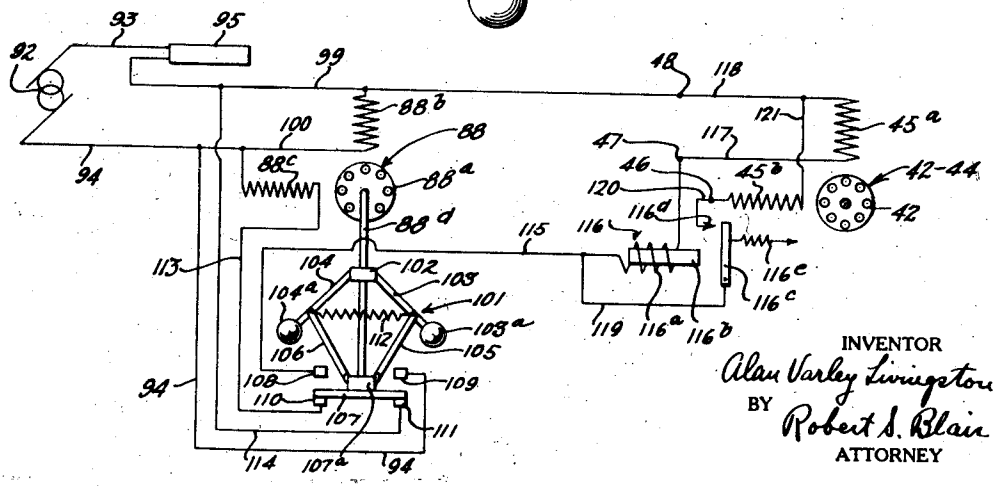


Fig. 5.



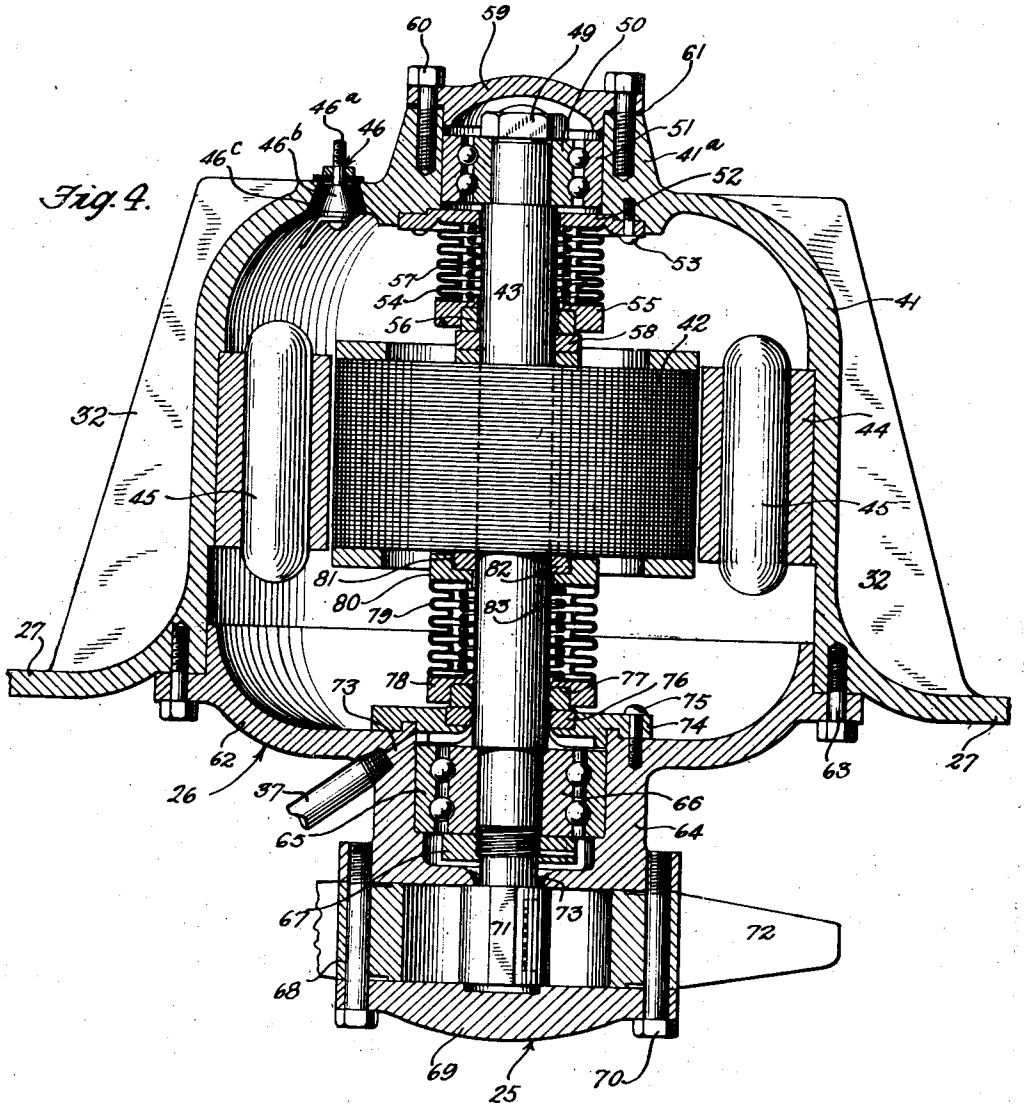
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REFRIGERATION

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Fig. 4.



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UNITED STATES PATENT OFFICE

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REFRIGERATION

Application filed March 7, 1925. Serial No. 13,701.

This invention relates to cooling or refrigerating apparatus, and more particularly to refrigerating apparatus for household use.

One of the objects of this invention is to provide a thoroughly practical and dependable cooling or refrigerating apparatus which will be of reliable and efficient action throughout long continued use. Another object of this invention is to provide apparatus of the above character which will be of compact construction, capable of ready assembly and well adapted to meet the conditions of hard practical use. Another object is to provide a refrigerating apparatus of automatic action throughout and capable of dependable and efficient action through long periods of time without manual attention. Another object is to provide a combined compressor and power unit therefor of simple construction, thoroughly dependable action and capable of rapid manufacture and easy of assembly, as well as being capable of ready and convenient assembly with and incorporation in the remaining parts of the refrigerating apparatus. Another object is to provide an effective, practical and thoroughly dependable driving arrangement for refrigerating apparatus of the above-mentioned type. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the structure to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings in which is shown one of various possible embodiments of this invention,

Figure 1 is a side elevation of the apparatus in assembled relation, certain parts being shown in section and certain parts being broken away in order to show the construction more clearly.

Figure 2 is a side elevation on a larger scale of the lower portion of the apparatus shown in Figure 1, partly in section, and

Figure 3 is a plan view of the apparatus shown in Figure 2, certain parts being broken away to show certain features of construction and arrangement more clearly.

Figure 4 is a central vertical sectional view of a motor-compressor unit, this view being on a still larger scale.

Figure 5 is a diagrammatic representation of the driving units of the apparatus, of the control apparatuses and of the circuits therefor.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring first to Figure 1, there is shown a skeleton frame work for supporting the various parts of the apparatus; this frame work may comprise a bottom ring-like member 10 provided with suitable legs 11 adapted to rest upon the floor and provided further with a suitable number of vertically extending upright members 12 at the upper end of which is supported another ring-like member 13 to which certain parts of the apparatus may be attached. From this ring-like member 13 there extend upwardly and preferably inclined inwardly a suitable number of supporting members 14 to the upper end of which is secured a plate member 15. This plate member 15 supports a housing generally indicated at 16, open at the top so as to receive in inverted position a water bottle 17. The latter may conveniently rest upon a rubber ring 18 supported in a suitably formed seat therefor in the upper end of the housing 16.

Within the housing 16 is positioned a container 19 into which the neck of the bottle 17 extends. The container 19 may thus be supplied automatically with water from the bottle 17, the latter replenishing the supply of water in the container 19 as the water is withdrawn from a suitable faucet 20 connected to the container 19 adjacent the bottom of the latter. Surrounding the container 19 and in intimate thermal contact therewith is a cooling or expansion coil 21. The capacity of the container 19 is preferably considerably less than the capacity of the bottle 17 so that the cooling

coil 21 and the apparatus associated with the latter need maintain at a low temperature only a relatively small volume of water. The space between the cooling coil 21 and the outer walls of the casing 16 is packed with any suitable heat insulating material generally indicated at 22.

The cooling coil 21 is intended to be supplied with an expanded cooling fluid which may, for example, take the form of sulphur dioxide.

The expanded sulphur dioxide after passing through the coil 21 and after withdrawing heat from the contents of the receptacle 19 passes downwardly through the pipe 23 to the intake side 24 of a compressor generally indicated at 25 (see Fig. 2). The compressor is encased in a fluid-tight casing or housing generally indicated at 26 (see also Fig. 4), and is adapted, upon being driven, to compress the refrigerant or sulphur dioxide. This fluid-tight casing 26 in which is included the compressor, is provided with a suitable number of radially extending lugs 27 proportioned so as to rest on the upper ring-like member 13 (see Fig. 2), these parts being secured together as by the screws 28. After the refrigerant is raised in pressure by the compressor 25, it is discharged through the outlet side of the compressor indicated at 29 (see Fig. 3), and thence by way of a pipe 30 enters the upper turn of a condenser coil 31 wound in tapering form so as to rest against and be supported by the radially extending radiating fins 32 of the casing 26 (see Fig. 4) within which the compressor is included. Passing downwardly through the coil 31, the compressed refrigerant is cooled by a current of air drawn downwardly (as viewed in Figs. 1 and 2), past the turns of the coil 31 and also past the radiating fins 21 of the casing 26. The compressed refrigerant, being thus cooled, condenses and in liquefied form passes out of the condenser coil 31 and by way of the pipe 33 into a receiver or enclosed vessel 34 in general of an arcuate shape (see Fig. 3), and supported upon the lower ring-like member 10 of the main frame. The receiver 34 may be provided with suitable lugs 35 to permit securing thereof to the frame member 10, as by the screws 36.

A suitable lubricant such as glycerine if the refrigerant is ethyl-chloride, or a suitable oil if the refrigerant is sulphur-dioxide, for example, is utilized for maintaining the moving parts of the compressor lubricated; such of this lubricant as passes out of the compressor with the refrigerant will also be passed into the receiver 34 wherein a separation of the lubricant from the refrigerant may take place by reason of the difference in their densities of specific gravities. A pipe 37 leads from the region of the lubricant level within the receiver 34 to a suitable point in the compressor structure to return the lubricant to the compressor. The condensed or liquefied refrigerant, collected in the receiver 34, is passed upwardly through a pipe 38 to an expansion device 39 of any suitable construction and from the expansion device 39 the refrigerant is led by way of pipe 40 (see Fig. 1) to the cooling or expansion coil 21 of the heat exchange device. The expansion device 39 relieves the pressure on the liquefied or condensed refrigerant causing the latter to evaporate, and in the course of its evaporation in the cooling coil 31, it obtains its heat of evaporation from the substance to be cooled, namely, from the water within the container 19. The evaporated and relatively warm refrigerant is returned to the compressor by way of pipe 23 to repeat the cycle above briefly outlined.

Considering now the construction and arrangement of the compressor with respect to the prime mover for driving the compressor, reference may now be had to Figure 3 of the drawings; the casing 26 is, as already above noted made fluid-tight and encloses therein the compressor and the prime mover therefor. More specifically, this casing 26 will be seen to comprise a dome-like upper portion 41 upon the exterior walls of which are formed preferably integrally therewith the radially extending fins 32. These radiating fins 32 have their outer ends tapered upwardly, as will be clearly seen from Figure 4, and form a support for the tapered condenser coil 31, as will be clear from Figure 2. Within this upper chamber-forming portion 41 is mounted for operation a prime mover preferably taking the form of an electric motor. This motor, as will be more clearly set forth hereinafter, is preferably in the form of an alternating current motor of the induction type and hence comprises a rotor 42 rigidly secured to a shaft 43 and provided with any suitable form of winding, such as, for example, a squirrel-cage winding. The motor is provided with a stator which may include the magnetic circuit-forming part 44 and the energizing windings generally indicated at 45. Inasmuch as in this preferred embodiment of this invention the motor takes the form of a single phase induction motor, the energizing windings 45 comprise a main winding 45*a* and a starting winding 45*b*, shown diagrammatically in Figure 5. These two windings, as will also be clear from Figure 5, are so connected to provide three terminals which are connected to binding posts 46, 47 and 48 respectively, mounted in the upper end part of the casing 26 (see Fig. 3). In Figure 4 one of these binding posts 46 is shown in section, and it will be seen to comprise a bolt 46*a* with a tapered shank 46*b* fitted into a

suitably tapered opening in the upper end of the casing 26 with a tapered insulating bushing 46c interposed therebetween. With this construction the connection of the windings of the stator of the motor may be brought out through the wall of the casing 26 without disturbing the fluid-tight construction of the latter, it being understood that the other binding posts 47 and 48 are of generally similar construction. It might further at this point be noted that the motor itself is free from any sliding contacts, such as a commutator or slip rings, the advantages of which arrangement will be pointed out hereinafter.

The upper end of the shaft 43 of the motor has rigidly secured thereto, as by the nut 49, the inner race 50 of a ball bearing 50—51, the outer race 51 of which is fitted within an upwardly directed extension 41a of the upper chamber-forming portion 41, this extension 41a being suitably machined to snugly receive the outer race 51. Surrounding the shaft 43, but out of contact therewith, is a circular plate 52 secured to the underside of the extension 41a as by the screws 53, the connection of these two parts being preferably substantially fluid-tight. Surrounding the shaft 43 and secured at its upper end to the plate 52 is a corrugated yieldable or expansible sleeve 54, made of a suitable sheet metal and carrying at its lower end a ring-like member 55. This ring-like member 55, rigidly secured to the lower end of the sleeve 54, is counterbored so as to form a seat within which is received a bearing ring 56 preferably of hardened steel and rigidly held to the ring member 55. This bearing ring 56 is thus supported from the plate member 52 through the interposed expansible sleeve 54 which tends to urge the bearing ring 56 in a downward direction, as viewed in Figure 4. This action of the expansible sleeve 54 may be supplemented to any desired extend by means of a coil spring 57 within the sleeve 54, and interposed between the plate 52 and the ring member 55. The bearing ring 56 is thus urged with a substantial pressure against a bearing ring 58 rigidly fixed to the shaft 43 so that upon rotation of the shaft 43 the bearing ring 58 will be rotated with respect to the bearing ring 56 and while the latter is held in fluid-tight contact with the former.

By this construction the exit of gas under pressure within the upper chamber of the casing 26 and through the upper end bearing of the shaft 43 is effectively prevented; but it will be noted that the upper open end of the extension 41a is closed by a cap 59 secured to the extension 41a by suitable cap screws 60, a suitable washer 61 being interposed therebetween to maintain fluid-tight connection. This arrangement permits the removal of cap 59 to charge the ball bearing 50—51 and adjacent spaces with a suitable lubricant, preferably a heavy oil or grease, the fluid-tight connection between the relatively rotating contact rings 56 and 58 preventing the lubricant from passing into the upper chamber of the casing 26 and preventing gas which may accumulate in this chamber from entering into the upper end bearing of the motor and displacing the grease or lubricant therein. Thus, a single charge of the lubricant may be maintained intact for relatively long periods of time and the upper bearing of the motor may be operated without manual attention for like long periods of time.

The casing 26 may be considered as being divided substantially into an upper chamber (formed by the portion 41) and a lower chamber, with the flange member 62 interposed therebetween. The flange member 62 is so formed at its periphery that the lower end of the upper chamber-forming portion 41 may be seated therein, suitable cap screws 63 holding the parts together and in fluid-tight relation, a suitable packing being interposed therebetween if desired. This flange portion 62 is extended downwardly, as at 64, to form a support first for a ball bearing 65—66, the inner race 66 of which is secured to the shaft 43, as by the nut 67, and the outer race 65 of which is snugly fitted within the extension 64. The further downward extension to form the second chamber of the casing 26 is preferably built up upon this extension 64 and may comprise an outer cylindrical wall-forming part 68 and an end closing wall or cap 69 secured to the extension 64 as by the cap screws 70, thus to form a lower chamber within which the compressor may operate. This compressor is preferably of the rotary form and may comprise a series of impellers generally indicated at 71, the outer cylindrical wall portion 68 being formed to provide an inlet 24 and an outlet 23a (see Figs. 2 and 3) for the refrigerant, these parts being formed to permit ready connection thereto of the pipes 23 and 30 respectively. Furthermore, the outer wall-forming portion 68 is provided with a series of radially extending radiating fins 72 (see also Fig. 2), to permit the ready withdrawal of heat from the compressor generally indicated at 25.

The portion of the extension 64 within which the ball bearing 65—66 is mounted is shaped as at 73 to permit access of lubricant from the regions adjacent the ball bearing 65—66 to the rotating parts of the compressor. The lubricant, taking the form of glycerine or suitable oil depending upon the nature of the lubricant, is supplied from the receiver 34 (see Fig. 2) by way of pipe 37, which is connected to a passage 73 formed in the upper part of the extension 64 and leading to a point above the ball bearing

65—66. The returned lubricant thus first insures the lubrication of the ball bearing and thence passing downwardly, is permitted to lubricate the moving parts of the compressor; such of this lubricant as is passed off with the gas, is, as already above noted, eventually separated from the refrigerant in the receiver 34 and returned through the pipe 37 to the moving parts of the apparatus.

Surrounding the lower end of the shaft 43 and secured to the inner face of the flange 62 is a plate member 74 held in place in fluid-tight relation as by the screws 75; this plate 74 is counter-bored to form a seat for a bearing ring 76 of hardened material, also surrounding the shaft 43. The bearing ring may be made of hardened steel, for example, and like the plate member 74 is shaped to permit the free rotation of the shaft 43 with respect thereto. Coacting with the bearing ring 76 is another bearing ring 77, also of hardened steel or like material of good wearing qualities; this bearing ring 77 is held by and seated within a ring-like member 78 extending about the shaft 43 and is secured to the lower end of a corrugated expansible sleeve 79, formed of a suitable sheet material. The upper end of the sleeve 79 is secured to a ring member 80, also surrounding the shaft 43, and threaded as at 81 to a ring 82 which is rigidly fixed, as by shrinking, upon the shaft 43. The sleeve 79 tends to elongate, this action being supplemented, if desired, by a coil spring 83 within the sleeve 79 and interposed between the end ring members 80 and 78, and thus the bearing ring 77, in rotating with the sleeve and associated parts and with the shaft 43 of the motor may be held in good fluid-tight contact with the stationary bearing ring 76.

With this arrangement the lubricant returned to the moving parts of the ball bearing 65—66 and of the compressor is effectively prevented from entering the upper chamber-forming portion 41, and at the same time leakage of gas or refrigerant, raised in pressure by the compressor, is prevented from being effected into the upper chamber-forming portion 41. It may further at this point be noted that the mechanical relation of the various parts shown in Figure 4 is such as to permit ready assembly or ready and convenient disassembly, should access to various parts be necessary. And, as above noted, effective lubrication of the moving parts is insured so that the latter may operate for long intervals of time without attention. But, it is also desired to point out that by reason of certain features of the construction shown in Figure 4 loss of refrigerant or gas is effectively prevented; this advantage is in part achieved by arranging the compressor construction so that only one leak-preventing arrangement between a moving part and a fixed part of the compressor need be provided, and by further arranging the construction so that whatever leakage takes place, as between the bearing rings 76—77 is trapped within the upper chamber-forming portion 41 within which the prime mover or motor is mounted. From this upper chamber egress of gas or refrigerant is impossible, and the chamber being of small volume retains therein but a small amount of gas or refrigerant should any leak into it, it being noted that should such leakage take place into the upper chamber 41, a balance of pressures in the compressor and in the chamber 41 is gradually brought about to prevent further leakage from the compressor system. The prime mover may thus freely operate within the upper chamber 41 irrespective of whether there is contained therein any refrigerant or not, and, as above noted, this prime mover preferably takes the form of an induction motor with the energizing windings (which are to be connected to the source of supply) mounted upon the stator; the motor is thus free from sliding contacts, and there is thus effectively avoided the possibility of sparking within the enclosed upper chamber 41. The elimination of the possibility of sparking precludes in turn the possibility of giving rise to exploding the mixture of initial air in the upper chamber 41 and such gas or refrigerant as may leak into this chamber; moreover, there is thus made possible a wide choice of refrigerant or gas for use in the apparatus, it being hence unnecessary to consider the combustion characteristics of the gas itself or when mixed with air such as may be contained initially in the upper chamber 41.

As already hereinabove set forth, and as will be seen from Figure 2, the upper chamber-forming portion 41 within which is housed the prime mover, is provided with a series of radially extending radiating fins 32 about which is coiled and supported the condenser coil 31; the compressor 25 is in turn provided with a series of radially extending radiating fins 72. About the condenser coil 31 (see Fig. 1) is a casing 84 of sheet metal, for example, and provided with vertically extending openings 85. Supported in depending relation from the ring member 13 (see Fig. 2) as by the screws 28 is a sheet metal guide 86 in the form of a frustum of a cone. This guide encloses the compressor 25 and its radiating fins 72 and extends downwardly so that its lower opening is substantially within the compass of a blower or fan generally indicated at 87. This blower or fan is mounted upon the shaft of a prime mover 88, preferably taking the form of a motor supported as by suitable brackets 89 from the vertically extend-

ing frame members 12, and in such manner that the shaft thereof extends in a general vertical direction. The fan or blower 87 may comprise a series of substantially radially extending blades 87*a* arranged so that upon rotation at a suitable speed these blades will throw the air outwardly by centrifugal action. A lower casing member 90 (see Fig. 1) formed of sheet metal extends about the lower portion of the apparatus, and may be suitably secured to the two spaced ring members 10 and 13 of the main frame; this casing member 90 may be provided with suitable openings 91 to permit egress of air blown outwardly by the blades 87*a* of the fan or blower 87.

The blower 87 being positioned within the lower opening of the guide 86 is thus made effective to cause a rarification in the atmosphere adjacent the compressor 25, the radiating fins 32 and the condenser coil 31, and there is thus produced a downward flow of air in thermal contact with these parts so as to bring about the condensation and liquefication of the compressed refrigerant in the condenser coil 31, and the maintenance of the motor 42—44 and associated parts, as well as of the compressor 25 at the desired operating temperature. This current of cooling medium or air will thus be seen to enter the apparatus through the openings 85 in the upper casing 84 (see Fig. 1) and after being passed in thermal contact with the various parts above-mentioned of the apparatus and guided by the sheet metal guide member 86 is permitted to pass outwardly through the openings 91 in the lower casing member 90. Preferably the blades 87*a* of the blower 87 are formed integrally with the hub portion 87*b* of the blower 87 (see Fig. 2), and also integrally with a lower circular plate portion 87*c* in turn formed integrally with the hub portion 87*b*.

The motor 88, for driving the blower 87 is preferably a motor adapted to be operated from a two-wire source of current supply, and preferably is of the alternating current type. Very conveniently, it is an induction motor of substantially similar general characteristics electrically as the motor 42—44 which drives the compressor (see Fig. 4). The motor 88 hence is provided with an energizing winding and also with a starting winding, inasmuch as, in the preferred embodiment of certain features of this invention, the energy supplied through the two-wire source of supply is alternating and single phase.

From the foregoing certain features of action and operation of the apparatus will be clear; in Figure 5, however, I have diagrammatically shown certain other features of my invention. Turning now to Figure 5, the rotor of the motor 42—44 for driving the compressor 25 (see Fig. 4) is diagrammatically shown at 42; the windings 45 of the stator are shown in Figure 5 as comprising the main energizing winding 45*a* and the starting winding 45*b*. These two windings are so related to one another that upon their energization, a difference in phase of the currents in the two windings will exist, upon their initial energization, so as to effect a starting of the motor 42 initially by reason of this difference in phase, the starting winding 45*b* being thereafter cut out of action, as will be more clearly described hereinafter.

The motor 88 (see Fig. 2) for driving the fan 87 will be seen in Figure 5 to comprise a rotor 88*a*, a main energizing winding 88*b* and a starting winding 88*c*, these two windings being preferably associated with the stator of the motor 88. The starting winding 88*c* is, after the motor 88 has been started cut out of action, as will be made clear hereinafter.

At 92 is diagrammatically indicated a source of single phase alternating current supply, and leading from this source of supply 92 are the two line conductors 93 and 94 from which the motors 42—44 and 88 are to receive their energy. Conductor 93 leads to a thermostatically-controlled switch diagrammatically shown at 95; this switch controls the supply of energy to the two motors, and may be of any suitable construction. Preferably it is of the pressure-controlled type and hence is connected by way of a pipe 96 (see Fig. 1) to a thermostatic vessel 97 preferably of a tapered or conical shape, so as to be fitted and received within a like tapered or conical depression in the bottom 19*a* of the container 19, in which is held the material or water to be cooled. This thermostatic vessel 97 may be supported from the plate member 15 as by a spring 98, the latter acting to urge the vessel 97 upwardly and to hold it in intimate thermal contact with the bottom 19*a*, and hence with the contents of the container 19.

Within the thermostatic vessel 97 may be placed a suitable liquid, such as ethyl chloride, for example, so that upon a rise in temperature thereof the vapor tension will be increased and the resultant pressure becomes effective to operate the switch 95; conversely, should the temperature of the contents of the container 19 be brought down to the desired lower limit, the vapor tension of the ethyl chloride will be decreased and this change in pressure is made effective to cause an opening of the switch 95. Thus, the supply of energy to the motors may be controlled by the switch 95 in accordance with the changes in temperature of the water in the container 19, and thus the temperature of the water or other substance to be cooled may be maintained at the desired value within relatively narrow limits.

Turning again to Figure 5, it will be seen that a conductor 99 extends from the switch 95 to one terminal of the main winding 88*b* of the motor 88, and a conductor 100 connects the other terminal of the main winding 88*b* to the line conductor 94; hence should the switch 95 be closed, the main winding 88*b* will be energized.

The rotor 88*a* of the motor 88 drives through its shaft 88*d* a centrifugal-controlled circuit breaker generally indicated in Figure 2 at 101. Inasmuch as the details of construction of the mechanically operated switching apparatus 101 form per se no part of this invention, the device 101 may take any suitable form, but in Figure 5 I have illustrated diagramatically its construction, so that its action may be clearly understood.

The shaft 88*d* of the motor 88 may have fixed thereto a collar 102 to which are pivotally connected arms 103 and 104 provided with suitable weights 103*a* and 104*a* at their outer ends. To the arms 103 and 104 are connected the links 105 and 106 respectively and their lower ends, as viewed in Figure 5, are hingedly connected to the hub 107*a* of a disk contacting member 107. The latter parts are arranged to slide axially along the shaft 88*d* while rotating therewith. Fixedly positioned above the disk member 107 are two contacts 108 and 109, so that upon a predetermined movement of the disk 107 along the shaft 88*d* in an upward direction, as viewed in Figure 5, the contacts 108 and 109 will be electrically bridged; another pair of contacts 110 and 111 are positioned fixedly to any suitable fixed part of the apparatus, but on the other side of the disk 107, so that upon a predetermined movement in the opposite direction, or downwardly, as viewed in Figure 5, contacts 110 and 111 will be electrically bridged. A spring 112 suitably connected to the arms 103 and 104 tends to swing these arms toward one another, and hence to urge the contact disk 107 in a downward direction, as viewed in Figure 5. With the rotor 88*a* of the motor 88 at rest, the spring 112 will thus hold the disk member 107 in bridging relation with respect to the contacts 110 and 111.

The contacts 110 and 111 control the circuit of the starting winding 88*c* of the motor 88. More specifically, the starting winding 88*c* will be seen to have one terminal thereof connected to the conductor 100 and hence to one of the line conductors, namely conductor 94; the other terminal of the starting winding 88*c* is connected as by conductor 113 to the fixed contact 110. Thus, with the parts positioned as shown in Figure 5, and assuming the switch 95 to close, not only will the main winding 88*b* of the motor 88 be energized, but also the starting winding 88*c*, the circuit of the latter being completed from the contact 110 through the disk 107, thence through contact 111 and by way of conductor 114 to conductor 99 and through switch 95 to the other line conductor 93. Both the main winding and the starting winding being thus energized, the motor 88 is started, and after it is brought up to substantially normal speed, the centrifugal action of the weights 103*a* and 104*a* becomes sufficient to overcome the effect of the spring 112 and the contact disk 107 is withdrawn from contact with the contacts 110—111, thus opening the circuit of the starting winding 88*c*. The motor having been brought up to substantially normal speed, it continues operation upon the one or main winding 88*b*. Thus, the blower 87 (see Fig. 2) is set into action to insure first the necessary circulation of the air or cooling medium past the condenser coils, the radiating fins 32 and the compressor 25.

The movement of the contact disk 107 out of engagement with contacts 110—111, as above described, is effective, however, to effect the electrical inter-connection of contacts 108 and 109, and to maintain this electrical interconnection as long as the prime mover or motor 88 is in operation, the continued centrifugal action of the device 101 insuring the maintenance of a good electrical inter-connection. The inter-connection of contacts 108 and 109 is effective to initiate the operation of the motor 42—44 which drives the compressor; more specifically, there is first closed by this inter-connection of contacts 108 and 109 the circuit of the main winding 45*a* of the compressor motor. This circuit may be traced as follows:—from the source 92, thence by way of line conductor 94, which is extended to be connected to the contact 109, thence through contact disk 107, contact 108, conductor 115 through the winding 116*a* of a relay generally indicated at 116, thence by way of conductor 117 through winding 45*a* and from the winding 45*a* through conductor 118 to conductor 99, the connection of the conductor 99 to the line conductor 93 having been closed by the thermostatically-controlled switch 95. Thus, the main winding 45*a* is initially energized.

The relay 116 may include a core 116*b* about which is positioned the winding 116*a* and coacting with these parts is a movable armature 116*c*. The armature 116*c* coacts with a fixed contact 116*b*, and is normally held out of engagement therewith by a spring 116*e*. The closure of the circuit of the main winding 45*a*, as hereinabove described, results in the flow through its corresponding circuit (as above traced) of an initial rush of current; this rush of current is above the normal value of current taken by the motor 42—44, and the spring 116*e* is so adjusted that this rush of current flowing

through the winding 116*a* of the relay 116 overcomes the action of the spring and moves the armature 116*c* into contact with the fixed contact 116*d*. This action is made effective to close the circuit of the starting winding 45*b*, it being noted that the armature 116*c* is connected by conductor 119 to the conductor 115, whereas one terminal of starting winding 45*b* is connected by conductor 120 to the fixed contact 116*b* and the other terminal of the winding 45*b* is connected by conductor 121 to the conductor 118. In effect, it will be seen that the relay 116 connects the starting winding 45*b* substantially in parallel with the main winding 45*a*. With the starting winding energized, the motor 42—44 is started to begin the operation of the compressor 25, it being noted that the blower or fan 87 had already been set into action. As soon as the motor 42—44 attains substantially normal speed (after which it may operate upon the main winding 45*a* alone) the rush of starting current above pointed out is decreased to a value approaching the normal current flow to the motor; this decrease in the initial rush of starting current decreases the strength of the relay winding 116*a* so that the armature 116*c* is released under the action of spring 116*e*, and the circuit of starting winding 45*b* is interrupted and held open to permit the continued operation (now at normal speed) of the compressor motor.

The operation of the apparatus may now continue to put the refrigerant through the cycle of operations as already hereinbefore noted, and as soon as the temperature of the material to be cooled is brought down to the desired value, the switch 95 is opened, thus interrupting the supply of energy to both prime movers, whence the operation of the apparatus is halted. The stopping of the motor 88, however, brings the contact disk 107 into electrical inter-connection with the contacts 110 and 111, thus completing the circuit to the starting winding 88*c* and placing the motor 88 in condition to be restarted upon the closure of the switch 95 should a subsequent temperature rise effect an operation of the switch 95, whence the above-described cycle of the electrical portions of the apparatus may be repeated.

It will be noted, however, that the stopping of the motor 88 in being effective to move the contact disk 107 out of bridging relation with the fixed contacts 108 and 109 interrupts the circuit of the compressor motor 42—44. The operation of the compressor motor and hence the compressor is thus placed in the direct control of the prime mover or motor 88, and it will be seen that therefore the compressor cannot be operated in case there is a failure for any reason of the motor 88, which passes the cooling medium in thermal contact with the condenser and compressor. Should, for example any defect arise in the motor 88 to make it inoperative, and hence to cause a failure of the cooling medium to be made active upon the condenser coils 31, the compressor cannot be operated, inasmuch as the prime mover therefor is under the control of the motor 88, specifically by way of the circuit controlled by the contacts 108 and 109. Thus, continuing compression of refrigerant with attendant heating, but without cooling, and with resultant danger, are effectively avoided; on the other hand, should the compressor motor become defective or inoperative for any reason, the continued operation of the motor 88 and hence of the fan 87 can produce no harmful results.

It might further be pointed out that an important advantage is achieved in controlling the action of the starting winding 45*b* of the motor 42—44 by means extraneous of the upper chamber 41, in which the motor 42—44 is encased. By the arrangement provided by this invention, specifically by the utilization of the relay 116, which may be placed or mounted in any convenient portion of the apparatus exteriorly of the casing 41—64, the making and breaking of the circuit of the starting winding with attendant sparking is removed from an atmosphere (such as may be contained within the upper chamber 41, see Fig. 4) which may be explosive, and thus the danger of initiating combustion or explosive action is dependably eliminated. Moreover, this arrangement eliminates from the interior of the casing 41—64 apparatus to which access for repair, readjustment and the like might be necessary in the course of the operation of the apparatus, and permits the location of such apparatus at any suitable point where ready access thereto may be conveniently had.

It will thus be seen that there has been provided in this invention a refrigerating apparatus in which the various objects above noted as well as others, together with many advantages, are effectively achieved. It will moreover be seen that the apparatus is of thoroughly practical, rugged and compact construction, of thoroughly dependable although automatic action throughout, and well adapted to meet the conditions of hard practical use.

As many possible embodiments may be made of the above invention, and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driv-

ing said compressor and having a starting winding, means forming a substantially fluid tight casing having included therein said compressor and said motor, a condenser for receiving compressed fluid from said compressor, means for circulating cooling fluid in thermal contact with said condenser, a prime mover for driving said circulating means, a cooling device adapted to have expanded into it condensed fluid from said condenser, means for controlling the operation of said motor but dependent upon the state of operation of said prime mover, means responsive to the temperature of said cooling device for controlling the operation of said prime mover, and means exterior of said casing means for controlling the circuit of said starting winding of said motor substantially in accordance with the speed of said motor.

2. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, means forming a substantially fluid tight casing having included therein said compressor and said motor, a condenser for receiving compressed fluid from said compressor, means for circulating cooling fluid in thermal contact with said condenser, a prime mover for driving said circulating means, a cooling device adapted to have expanded into it condensed fluid from said condenser, means for controlling the operation of said motor but dependent upon the state of operation of said prime mover, means responsive to the temperature of said cooling device for controlling the operation of said prime mover, and a relay responsive to the current flow to said motor adapted to open circuit the starting winding of the motor upon the starting current to the latter returning to a substantially normal value.

3. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, means forming a substantially fluid tight casing having included therein said compressor and said motor, and automatic means exterior of said casing for controlling the circuit of said starting winding substantially in accordance with the speed of said motor.

4. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means forming a substantially fluid tight casing and having included therein said compressor and said prime mover, means for circulating a cooling fluid in thermal contact with said compressor, a prime mover for operating said circulating means, and means dependent upon the state of operation of said last-mentioned prime mover for controlling the supply of energy to said first-mentioned prime mover.

5. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means forming a substantially fluid tight casing and having included therein said compressor and said prime mover, a condenser for receiving compressed fluid from said compressor, means for passing a cooling medium in thermal contact with said condenser, a prime mover for operating said last-mentioned means, and means dependent upon the state of operation of said last-mentioned prime mover for controlling the operation of said first-mentioned prime mover.

6. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means forming a substantially fluid tight casing and having included therein said compressor and said prime mover, means for passing a cooling fluid in thermal contact with said compressor, a prime mover for operating said last-mentioned means, and means dependent upon the state of operation of said last-mentioned prime mover for controlling the operation of said compressor by said first-mentioned prime mover.

7. In apparatus of the nature of that herein described, in combination, a refrigerating system having included therein two mechanically actuated apparatuses, one of which is a compressor, a prime mover for driving one of said apparatuses, a prime mover for driving the other of said apparatuses, means responsive to the temperature produced by said system for starting and stopping said prime movers, and means controlled by the operation of one of said prime movers for controlling the other prime mover.

8. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means forming a substantially fluid tight casing and having included therein said compressor and said prime mover, means for circulating a cooling fluid in thermal contact with said compressor, a prime mover for operating said circulating means, and a centrifugally responsive device controlled by said last-mentioned prime mover for controlling the operation of said first-mentioned prime mover.

9. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means for condensing fluid compressed by said compressor, means forming a substantially fluid tight casing and having included therein said compressor and said prime mover, means for circulating a cooling fluid in thermal contact with said compressor, a prime mover for operating said circulating

means, a heat exchange device, means for expanding compressed fluid from said condensing means into said device, means dependent upon the state of operation of said last-mentioned prime mover for controlling the operation of said first-mentioned prime mover, and means responsive to the temperature of said heat exchange device for controlling the operation of said second-mentioned prime mover.

10. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, means forming a substantially fluid-tight casing having included therein said prime mover and said compressor and shaped to provide one compartment within which is supported said prime mover and another compartment within which is contained said compressor, means for condensing and collecting compressed fluid and also lubricant from said compressor and adapted to permit separation of the lubricant from the condensed fluid therein to take place, means adapted to return separated lubricant to the moving parts of said compressor, and means for preventing ingress of fluid from said compressor into the compartment in which is contained said prime mover.

11. In apparatus of the nature of that herein described, in combination, a compressor, and a prime mover for driving said compressor, means forming a substantially fluid-tight casing having said compressor mounted in one portion thereof and said prime mover in another portion thereof, means sub-dividing said casing into said two portions and having extending therethrough the driving shaft of said compressor, means for receiving from said compressor compressed fluid and lubricant and adapted to permit condensation of said fluid and its separation from said lubricant to take place, means for returning lubricant to the moving parts of said compressor, and an expansible sleeve about said driving shaft having one end thereof in fluid-tight connection with said shaft and having its other end provided with means for bearing against said casing-dividing means for preventing ingress of fluid from said compressor to the portion of said casing in which said prime mover is mounted.

12. In apparatus of the nature of that herein described, in combination, means forming a substantially fluid-tight casing having mounted in one portion thereof a compressor and having mounted in another portion thereof a prime mover connected to said compressor through a driving shaft, a condenser for receiving and condensing therein fluid compressed by said compressor, a receiver adapted to receive condensed fluid and lubricant from said condenser and to permit separation of the lubricant from the condensed fluid to take place, means for returning to the moving parts of said compressor separated lubricant, and means for preventing escape of fluid from said compressor into that portion of said casing in which said prime mover is mounted.

13. In apparatus of the nature of that herein described, in combination, means forming a substantially fluid-tight casing having included therein a prime mover and a compressor, a condenser shaped to surround said casing and adapted to receive compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said casing and said condenser, a prime mover for driving said last-mentioned means, and means dependent upon the operation of said last-mentioned prime mover for controlling the operation of said first-mentioned prime mover.

14. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said prime mover, said compressor and said condenser, a prime mover for driving said last-mentioned means, and means responsive to the operative condition of said last-mentioned prime mover for controlling the operation of said first-mentioned prime mover.

15. In apparatus of the nature of that herein described, in combination, a compressor, an electric motor for driving said compressor, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said compressor and said condenser, a prime mover for driving said last-mentioned means, and means controlled by the operation of said prime mover for controlling the circuit of said motor.

16. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover for driving said compressor, a condenser for receiving compressed fluid from said compressor, mechanically actuated means for passing a cooling fluid in thermal contact with said condenser, and means dependent upon the state of operation of said last-mentioned means for controlling the operation of said prime mover.

17. In apparatus of the nature of that herein described, in combination, a compressor, a prime mover therefor, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a single phase induction motor for operating said last-mentioned means and having a starting winding, and means arranged to cut out said starting winding when said motor has attained substantially full speed, said

means being arranged to control the supply of energy to said prime mover.

18. In apparatus of the nature of that herein, described, in combination, a compressor, a prime mover therefor, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a single phase induction motor for operating said last-mentioned means and having a starting winding, and a centrifugally responsive device driven by said motor for cutting out said starting winding upon said motor attaining substantially full speed, said device being arranged to cut off the supply of energy to said prime mover upon said motor becoming ineffective.

19. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a prime mover for operating said last-mentioned means, a relay responsive to the current flow to said motor for controlling the circuit of said starting winding, and means under the control of said prime mover for closing the circuit to said motor and relay.

20. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a prime mover for operating said last-mentioned means, a relay responsive to the current flow to said motor for controlling the circuit of said starting winding, and a centrifugally responsive device operated by said prime mover and arranged to control the circuit to said motor and relay.

21. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a single phase induction motor for driving said last-mentioned means and having a starting winding, a relay responsive to current flow to said first-mentioned motor for controlling the circuit of the starting winding thereof, and means under the control of said last-mentioned induction motor for cutting out the starting winding thereof upon the attainment thereby of substantially full speed and to control the circuit of said first-mentioned motor and relay.

22. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a single phase induction motor for driving said last-mentioned means and having a starting winding, a relay responsive to current flow to said first-mentioned motor for controlling the circuit of the starting winding thereof, and a centrifugally responsive device operated by said last-mentioned induction motor and arranged to cut out the starting winding thereof upon said motor attaining substantially full speed and to control the circuit of said first-mentioned motor and relay.

23. In apparatus of the nature of that herein described, in combination, a compressor, a single phase induction motor for driving said compressor and having a starting winding, means forming a substantially fluid-tight casing having included therein said compressor and said motor, a condenser for receiving compressed fluid from said compressor, means for passing a cooling fluid in thermal contact with said condenser, a prime mover for operating said last-mentioned means, a relay responsive to current flow to said motor for controlling the circuit of said starting winding and positioned exteriorly of said casing, and means under the control of said prime mover for controlling the circuit of said motor and relay.

24. In apparatus of the nature of that herein described, in combination, means forming a substantially fluid-tight casing having included therein a prime mover apparatus and a compressing apparatus, a bearing supported by said casing means for rotatably supporting the shaft of one of said apparatuses, and means enclosing said bearing and sealing the latter from the interior of said casing means.

25. In apparatus of the nature of that herein described, in combination, means forming a substantially fluid-tight casing having included therein a prime mover apparatus and a compressing apparatus, a bearing supported by said casing means for rotatably supporting the shaft of one of said apparatuses, and means enclosing said bearing and sealing it from the interior of said casing means, said means including a removable member accessible from the exterior of said casing means.

26. In apparatus of the nature of that herein described, in combination, means forming a substantially fluid-tight casing having included therein a compressor and a motor having a common shaft, means rotatably supporting said shaft including a bearing member supported by said casing

means, means forming an enclosure for said bearing including a sleeve-like member at one end of said bearing extending about the shaft and sealing said bearing from the interior of said casing means, and a removable member at the other end of said bearing and arranged to be accessible from the exterior of said casing means.

27. In apparatus of the nature of that herein described, in combination, a refrigerating system having included therein two mechanically actuated apparatuses, one of which is a compressor, a prime mover for driving one of said apparatuses, a prime mover for driving the other of said apparatuses, means forming a substantially fluid-tight casing and having included therein said compressor and the prime mover therefor, means responsive to the temperature produced by said system for starting and stopping said prime movers, and means controlled by the operation of one of said prime movers for controlling the other prime mover.

28. In apparatus of the nature of that herein described, in combination, a refrigerating system having included therein two mechanically actuated apparatuses, one of which is a compressor, an electric motor for driving one of said apparatuses, an electric motor for driving the other of said apparatuses, means responsive to the temperature produced by said system for controlling said motors, and means controlled by the operation of one of said motors for controlling the operation of the other.

29. In apparatus of the nature of that herein described, in combination, a refrigerating system having included therein two mechanically actuated apparatuses, one of which is a compressor, a single phase motor having a starting winding for driving said compressor, means forming a substantially fluid-tight casing and having included therein said compressor and the driving motor therefor, a prime mover for driving the other of said apparatuses, means controlled by the operation of said prime mover for controlling the operation of said motor, and means exterior of said casing for controlling the circuit of said starting winding.

30. In apparatus of the nature of that herein described, in combination, a compressor, a single-phase induction motor for driving said compressor and having a starting winding, means forming a substantially fluid tight casing having included therein said compressor and said motor, switching means adapted to connect said motor to a source of electrical energy, and a relay exterior of said casing for controlling the action of said starting winding, said relay becoming operative in response to circuit-closing operation of said switching means to make said starting circuit effective for assisting the starting of said motor, and adapted, in response to said motor achieving substantially full speed, to affect said starting circuit to discontinue the starting action thereof.

31. In apparatus of the nature of that herein described, in combination, a compressor, an electric motor for driving said compressor and adapted to be connected to a source of electrical energy, means forming a substantially fluid tight casing having included therein said compressor and said motor, electrically acting means associated with said motor for facilitating the starting thereof upon said motor being connected to said source, and means exterior of said casing operative substantially in response to and in accordance with the speed of said motor for controlling said last-mentioned means.

32. In apparatus of the nature of that herein described, in combination, a compressor, an electric motor for driving said compressor and adapted to be connected to a source of electrical energy, means forming a substantially fluid tight casing having included therein said compressor and said motor, electrically acting means associated with said motor for facilitating the starting thereof upon said motor being connected to said source, and a relay exterior of said casing responsive to current flow from said source and adapted, when the said current has been reduced to substantially normal value upon said motor having achieved substantially full speed, to affect said last-mentioned means and to cause the latter to discontinue the starting action thereof.

33. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a prime mover for driving one of said apparatuses, a prime mover for driving the other of said apparatuses, and a centrifugally-responsive device actuated by one of said prime movers for controlling the operation of the other of said prime movers.

34. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, an electric motor for driving one of said apparatuses, a prime mover for driving the other of said apparatuses, a switch for controlling the circuit of said electric motor, and a centrifugally-responsive mechanism operated by said prime mover for controlling said switch.

35. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, electric motor means for actuating said ap-

paratuses, means responsive to the temperature produced by said system for controlling the circuit of said motor means, and means dependent upon the state of operation of said motor means for affecting said circuit.

36. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, electric motor means for actuating said apparatuses, means responsive to the temperature produced by said system for controlling the circuit of said motor means, a switch for controlling said circuit, and means dependent upon the state of operation of the motor means driving one of said apparatuses for controlling said switch.

37. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a rotor for driving one of said apparatuses, a rotor for driving the other of said apparatuses, field-producing means acting upon said first-mentioned rotor, means responsive to the temperature produced by said system for stopping and starting said rotors, field-producing means controlled by said first-mentioned rotor for acting upon said second-mentioned rotor, and means forming a fluid-tight casing for enclosing said compressor and the rotor and associated field-producing means for driving said compressor.

38. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a rotor for driving one of said apparatuses, a rotor for driving the other of said apparatuses, field-producing means acting upon said first-mentioned rotor, means responsive to the temperature produced by said system for stopping and starting said rotors, and field-producing means controlled in its effectiveness upon said second-mentioned rotor by the speed of rotation of said first-mentioned rotor.

39. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a rotor for driving one of said apparatuses, a rotor for driving the other of said apparatuses, field-producing means acting upon said first-mentioned rotor, means responsive to the temperature produced by said system for stopping and starting said rotors, field-producing means for said second-mentioned rotor, and means whereby said last-mentioned field-producing means is effective to cause effective rotation of said second-mentioned rotor only when the speed of rotation of said first-mentioned rotor is above a certain value.

40. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a rotor for driving one of said apparatuses, a rotor for driving the other of said apparatuses, field-producing means acting upon said first-mentioned rotor, means responsive to the temperature produced by said system for stopping and starting said rotors, field-producing means controlled by said first-mentioned rotor for acting upon said second-mentioned rotor, means forming a fluid-tight casing for enclosing said compressor and the rotor and associated field-producing means for driving said compressor, a starting winding associated with the field-producing means that is enclosed in said fluid-tight casing means, and means exterior of said fluid-tight casing means for controlling the circuit of said starting winding.

41. In refrigeration apparatus, in combination, a refrigeration system having included therein two mechanically-actuated apparatuses, one of which is a compressor, a rotor for driving one of said apparatuses, a rotor for driving the other of said apparatuses, field-producing means acting upon said first-mentioned rotor, means responsive to the temperature produced by said system for stopping and starting said rotors, field-producing means controlled by said first-mentioned rotor for acting upon said second-mentioned rotor, means forming a fluid-tight casing for enclosing said compressor and the rotor and associated field-producing means for driving said compressor said enclosed field-producing means including an electromagnetic winding, and a relay outside of said fluid-tight casing means and responsive to a function of the current supplied to said winding for controlling the circuit of the latter.

42. In refrigeration apparatus, in combination a compressor, a condenser, an evaporator, a fan for cooling said condenser, a prime mover for driving said compressor, a prime mover for driving said fan, means responsive to the temperature produced by said evaporator for controlling said prime movers, and means relating one of said prime movers to the other to cause its operation to be dependent upon the operation of the other.

43. In refrigeration apparatus, in combination, a compressor, a condenser, an evaporator, a fan for cooling said condenser, a prime mover for driving said compressor, a prime mover for driving said fan, means responsive to the temperature produced by said evaporator for controlling said prime movers, and means causing one of said prime movers to become effective only after the other prime mover has achieved a certain speed.

44. In refrigeration apparatus, in com-

bination, a compressor, a condenser, an evaporator, a fan for cooling said condenser, a rotor and field-producing means therefor for driving said compressor, means forming a sealed casing for enclosing said compressor and said rotor and its field-producing means, a rotor for driving said fan, field-producing means for said fan rotor, and means whereby one of said field-producing means is dependent upon coaction between the other of said field-producing means and the rotor associated with the latter.

45. In refrigeration apparatus, in combination, a compressor, a condenser, an evaporator, a fan for cooling said condenser, a rotor and field-producing means therefor for driving said compressor, means forming a sealed casing for enclosing said compressor and said rotor and its field-producing means, a rotor for driving said fan, field-producing means for said fan rotor, and means causing the effectiveness of one of said field-producing means to be dependent upon the speed of rotation of the rotor associated with the other of said field-producing means.

In testimony whereof, I have signed my name to this specification this 24th day of Feb., 1925.

ALAN VARLEY LIVINGSTON.