June 28, 1932. C. STEENSTRUP 1,864,678

COMPRESSOR FOR REFRIGERATING MACHINES

Original Filed May 18, 1926 2 Sheets-Sheet 1

Fig. 1.

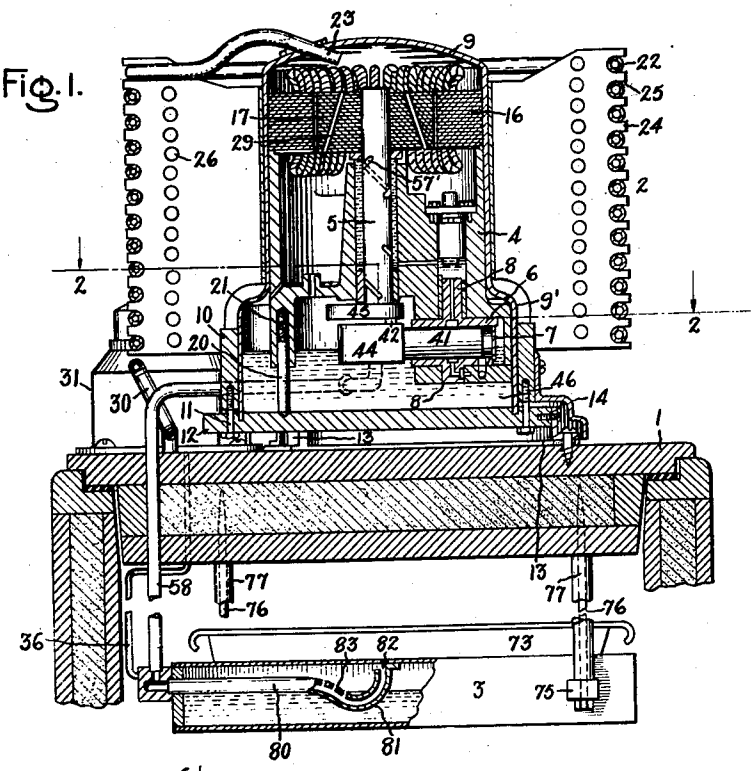
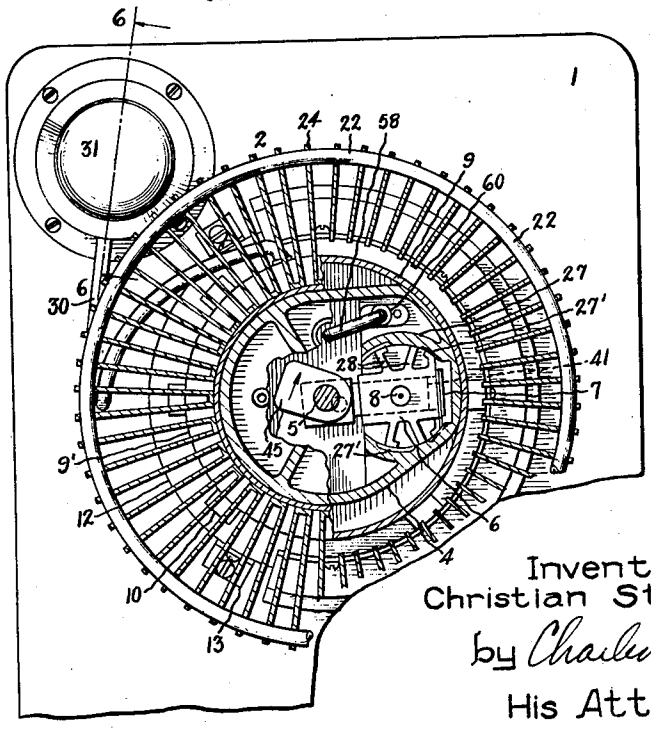


Fig. 2.



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Fig. 3.

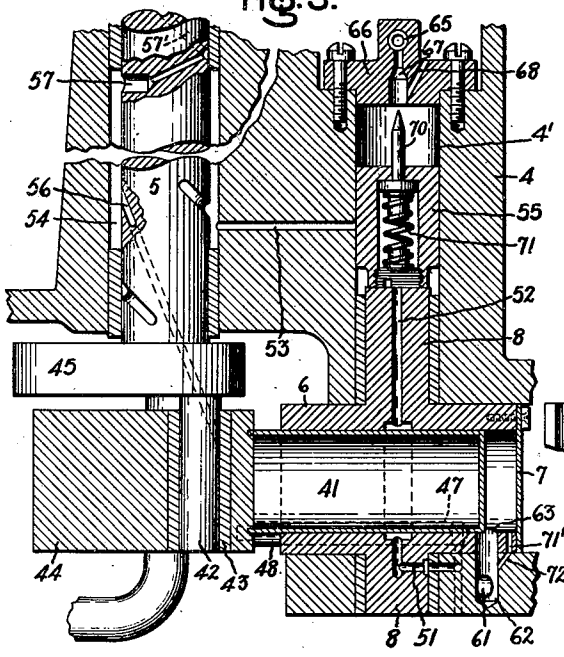


Fig. 4.

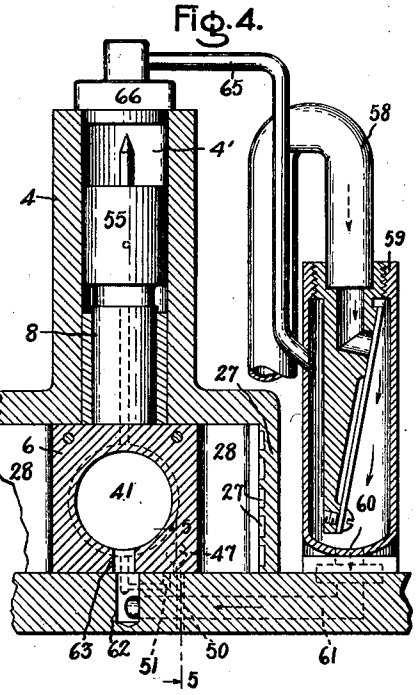


Fig. 6.

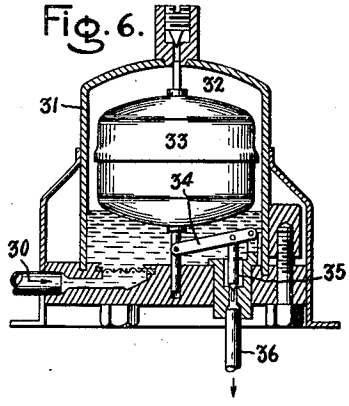


Fig. 5.

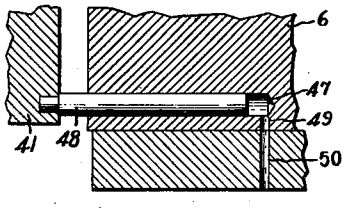
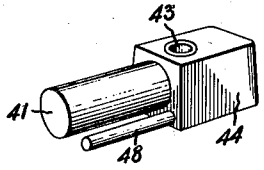


Fig. 7.



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Patented June 28, 1932 1,864,678

UNITED STATES PATENT OFFICE

CHRISTIAN STEENSTRUP, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

COMPRESSOR FOR REFRIGERATING MACHINES

Original application filed May 18, 1926, Serial No. 109,960. Divided and this application filed May 17, 1928. Serial No. 278,589. Renewed February 28, 1931.

The novel fin and condenser construction, oil and refrigerant separating arrangement, refrigerator evaporator, and combination of this evaporator with a refrigerator cabinet, disclosed but not claimed in this application are claimed in my copending application, Serial No. 109,960, filed May 18, 1926, of which my present application is a division.

My invention relates to refrigerating apparatus and particularly to refrigerating machines of the type especially adapted for domestic use and an object of my invention is the provision of an improved machine of this character which shall be simple in construction, quiet and efficient in operation, durable, manufacturable at relatively low cost and have other desirable qualities which adapt it for such use.

The machine involving my invention employs a refrigerant which boils at a relatively low temperature and is caused to pass through a cycle which consists in allowing the refrigerant in the liquid form to evaporate and thus absorb heat, compressing the vaporized refrigerant, and removing the heat therefrom to cause it to condense into the liquid form again, this cycle being continuously repeated during the operation of the machine.

My invention will be better understood from the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a vertical sectional view of a machine embodying my invention; Fig. 2 is a cross sectional view thereof taken on the line 2—2 of Fig. 1; Fig. 3 is an enlarged fragmentary view of Fig. 1; Fig. 4 is a cross sectional view of parts shown in Fig. 3; Fig. 5 is a fragmentary cross sectional view taken on line 5—5 of Fig. 4; Fig. 6 is a cross sectional view taken on line 6—6 of Fig. 2; and Fig. 7 is a perspective view of the pistons of the compressor and oil pump.

In the drawings I have shown at 1, by way of example only, the top or cover of a refrigerator cabinet such as may form a part of a domestic installation. Mounted on the top 1 is the compressor and condenser unit 2 and beneath the top and within the cabinet is the evaporator 3.

The compressor which in certain respects is similar to that disclosed in the application of Clark Orr, Serial No. 756,336, filed Dec. 16, 1924, upon which Patent No. 1,725,472 was granted August 20, 1929, and assigned to the same assignee as the present application, comprises a frame 4 in which the drive shaft 5 is journalled and in which the oscillating cylinder 6 having the exhaust valve 7 is pivotally mounted by means of the trunnions 8. The moving parts are enclosed by the metal casing 9 whose lower portion is enlarged and is connected with the upper portion by the flared portion 9′. By means of lugs 10 secured to the exterior of the enlarged portion and bolts 11, the casing is held down tightly against the bottom plate 12, which plate is supported on the top 1 by the angle brackets 13. A suitable apron 14 covers this plate and the lower part of the casing to present a better appearance. Fitting in the upper portion of the casing 9 is the stator 16 of an electric motor whose rotor 17 is secured to the shaft 5. The upper edge of the frame 4 is resiliently held against the stator 16 by the pins 20 and the coil springs 21.

Surrounding the casing 9 is the condenser comprising the coil of pipe 22 whose intake 23 is at the top of the casing. A series of fins 24, preferably of good heat conducting material, extend radially from the casing 9 and have their outer edges provided with recesses 25 for receiving the separate turns of the condenser coil 22 and making good thermal connection therewith. The inner ends of the fins are firmly secured to and in good heat conducting relation with the upper portion of the casing 9, as for example by soldering or brazing, and are shown, see Fig. 2, as formed in pairs each with a short connecting portion in contact with the casing. Certain of the fins are firmly secured also to the anchoring lugs 10, whereby they bridge the flared portion 9′ and serve to stiffen the casing at this point. The fins 24 intermediate their inner and outer edges each have a row of holes 26

which, as shown in Fig. 1, is closer to the outer edge than the inner edge. By these fins, heat is conducted away from both the casing 9 and the condenser coil 22, the row of holes 26 forming a zero line of temperature gradient in the fins. The fins 24, therefore, serve the triple purpose of providing a support for the condenser coil, of radiating heat from the casing, and of radiating heat from the condenser coil.

As shown in Fig. 2, the frame 4 is formed with an arcuate wall 27 forming a circular cavity centrally within which the cylinder is pivotally mounted. On the sides of the cylinder are the radial projections or fins 28, which have sliding engagement with the wall 27. Thus there is formed an exhaust chamber between the end of the cylinder and the wall 27, and two pairs of similar expansion chambers of varying size between the fins 28 and the wall 27, the chambers comprising the first pair being larger than the exhaust chamber, and the chambers comprising the second pair being larger than the first. At suitable points, the wall 27 is provided with small cut-away portions 27′, which under the control of the fins 28, permit the compressed refrigerant to pass successively from the exhaust chamber to the first and to the second expansion chambers, and then pass into the main casing. The arrangement, preferably, is such that the oscillatory movement of the cylinder following a compression stroke admits compressed refrigerant from the exhaust chamber to the two first expansion chambers, and at the same time refrigerant in the two second expansion chambers is allowed to pass into the main casing. As the cylinder oscillates in the opposite direction, and on the compression stroke, refrigerant may expand from the first expansion chambers to the second. The compressed refrigerant thereby undergoes a series of slight expansions before being delivered to the space within the casing 9, which effectually muffles the sound thereof.

The vaporized refrigerant, which is preferably sulphur dioxide, after being compressed, passes upward through the motor to the condenser intake 23. As the motor employed preferably has a very small air gap, I have provided openings 29 through the rotor 17 for the free passage of the refrigerant. These openings, as will be noted upon reference to Fig. 1, are inclined so that the lower end is at a greater distance from the shaft than the upper end. When the rotor is in rapid rotation, any oil particles which are entrained in the compressed refrigerant will be separated out by centrifugal force as they pass through the openings and will be caused to flow downward or away from the intake 23.

The outlet end of the condenser coil 22 connects by the pipe 30 with casing 31 forming a float chamber 32, shown located at a rear corner of the cover 1. In this chamber is the float 33 (see Fig. 6) which, by means of the lever 34, operates the valve 35 to control the flow of liquefied refrigerant to the evaporator through pipe 36.

Machines of this type are designed to run intermittently in accordance with the temperature in the cabinet. The starting and stopping of the driving motor is automatically controlled and, when running, the motor is operated at relatively high speed. It is highly desirable, however, to have such a machine operate as quietly and as free from vibration as possible. I have therefore devised improved means for balancing the moving parts of my machine such that at normal running speed noise and vibration are reduced to a very low value (see Fig. 3). As stated in the beginning of the description, the compressor involves a single oscillating cylinder 6 mounted on trunnions 8 which are journalled in the frame 4. One end of the cylinder is closed by the valve 7 and projecting from the other end thereof is the piston 41 which, for the most part, is made hollow to reduce its mass. The main drive shaft 5 carries an eccentric member, shown in the present case as a crank pin 42, which is journalled in a bearing sleeve 43 carried by the piston 41. Beyond the crank pin I provide the piston with the counterweight portion 44 having such mass that the piston is substantially balanced on the crank pin whereby the center of gravity of the piston and the center of the crank pin substantially coincide. In conjunction with the above, I provide the shaft 5 with the counterweight 45 opposite the crank pin 42 and having such mass that it substantially balances the combined mass of the crank pin and the piston. In this connection, it is to be understood that the part connecting the shaft and the crank pin is considered as a part of the crank pin. As so constructed, the moving parts comprising the shaft, crank pin and piston are so balanced that even though operated at a relatively high speed, but little vibration and noise are perceptible.

To provide adequate lubrication of the various moving parts, the cylinder and piston are partially immersed in a bath 46 of lubricating oil contained in the casing 9 from which the oil is forced to parts arranged above the bath. Referring to Figs. 4, 5 and 7, in one corner of the cylinder 6 and longitudinal thereof is the bore 47 in which slides the oil pump piston rod 48 whose outer end is fixed to the piston 41. The inner end of the bore 47 is adapted to connect by the passage 49 alternately with the passages 50 and 51 as the cylinder oscillates, whereby oil is pumped from the bath 46 to the lower trunnion bearing, to an oil groove in the cylinder wall and on up through passages 52 and 53 to the oil space 54 surrounding that portion

of the drive shaft between its upper and lower bearings. Between passages 52 and 53 is the piston 55 mounted to slide in a suitable bore in the frame 4, and which is raised by oil pressure from the oil pump until the two passages connect with each other. Oil hole 56 in the shaft 5 leads from the oil chamber 54 down through the crank pin 42 to the bearing 43 therefor. A second oil hole 57 in the shaft leads from the oil chamber 54 to the spiral oil groove 57', by which oil is supplied to the thrust bearing above, from which bearing oil may freely escape through suitable grooves, and thus relieve the oil pump of excessive back pressure. It will be noted that the discharge end of the oil hole 57 is covered by the lower end of the upper shaft bearing, and that this hole from its entrance to approximately the center of the shaft is of much larger diameter than the remaining portion. This is for a definite purpose. In the case of a direct connected machine, such as that illustrated, which is adapted to run at a relatively high speed, the effect of centrifugal force on the flow of oil through the oil holes in the rotating members must be given due consideration. Should the flow of oil through the oil hole 56 leading to the crank pin, for example, become broken, the centrifugal force of oil at the entrance to this oil hole may be sufficient to prevent its entering the oil hole, since oil hole 57 provides a relatively free path of escape for the oil. However, by making the entrance portion of the oil hole 57 of much larger diameter than the exit portion, and larger than hole 56, the larger mass of oil contained in the larger portion of hole 57 will prevent the flow of oil through this hole until the pressure in the oil space 54 shall have built up sufficiently to cause the oil to flow inward through this hole. Even after the oil flow is established through the holes 56 and 57, a certain predetermined pressure will be maintained in the space 54 by reason of the larger size of the entrance portion of oil hole 57, but this pressure will not rise to such a value as to impose an excessive back pressure upon the oil pump.

When the machine is restarted after an interval of rest it may happen, especially if the main piston is on the suction stroke, that the pressure in the casing acting upon the forward end of the piston is so great that starting is made difficult or even is prevented. To avoid this condition, I have provided means by which pressure is admitted to the cylinder for equalizing the pressures on the front and rear ends of the piston for the first few strokes, at least, or until the motor has had an opportunity to gain speed. In this connection, reference is made to Figs. 3 and 4. The suction pipe 58 from the evaporator, after entering the casing 9, connects with the casing 59 of the check valve 60, beyond which it connects by passage 61 with the port 62 of the compressor, thence by intake port 63 to the interior of the cylinder. Equalization of the pressure on opposite sides of the piston is effected by admitting pressure from the space within the casing 9 to the rear end of the cylinder. For this purpose, a small by-pass pipe 65 leads from the check valve casing 59 to the plate 66 covering the bore 41 where it connects with one side of the valve seat 67 formed therein, the opposite side of the valve seat connecting by the passage 68 with the interior of the casing 9. Piston 55 has mounted therein a valve 70 lightly pressed outwardly by the spring 71 so that when the piston moves upwardly under the pressure of oil, the valve 70 engages its seat while a space still exists between the piston and the plate 66. The arrangement is such that, as long as the piston is raised an amount sufficient to permit the oil to pass between passages 52 and 53, the valve 70 will be held against its seat. When the machine stops, the loss of oil pressure permits the piston 55 to descend, thus opening the valve 70 by which the pressure in the casing 9 is communicated with the intake of the compressor. If the piston is on the suction stroke, the intake ports being thus in alignment, the pressures on the two ends of the piston are equalized. This condition will continue for subsequent suction strokes until sufficient oil has been pumped to raise the piston 55 and close off the valve 70. Since the intake port 63 is spaced slightly from the end of the cylinder, I have provided the cylinder with a small opening 71' close to the end, which opening connects, when the piston is on the suction stroke, with a small opening 72 leading to the port 62.

The evaporator 3, which, as stated above, is located within the cabinet of which I have shown only the upper portion and the cover 1, in the present embodiment, is illustrated in the form of a horizontal flat plate, preferably located near the cover but spaced therefrom sufficiently to permit its being used as a shelf upon which may be placed articles to be frozen, as for example, a tray 73 for making ice cubes. The evaporator is shown comprising a rectangular casing having four side walls, a top, and a bottom, opposite side walls having lugs 75 through which extend supporting bolts 76. The bolts pass through spacing sleeves 77 and are secured into the cover 1. Inlet pipe 36 from the float valve casing 31 connects with the evaporator casing at one side thereof. The outlet or suction pipe 58 is also shown connecting with the evaporator casing at one side thereof, but its connection differs from that of the inlet pipe in that the portion 80 thereof within the casing extends to a point substantially equally distant from the four sides. The evaporator casing is intended to be only partially full of liquid refrigerant, the depth of re-

frigerant being about one half the depth of the casing. On the surface of the refrigerant there may be a thin layer of oil, shown for example in Fig. 1 of the drawings by the heavier shade lines, the space above the liquid refrigerant and oil being of course filled with vaporized refrigerant. The pipe 80 is shown having a goose-neck end portion 81, the open end 82 being close to the top wall of the casing, and in the curved portion are several small holes 83 which are located slightly above the level of the liquid refrigerant. Through these small holes 83 any oil which collects on the surface of the liquid refrigerant is slowly withdrawn. This construction avoids the necessity of exact leveling of the machine, for since the outlet is located centrally of the evaporator casing, there may be considerable deviation from exact level without affecting the relative level of the liquid at the outlet and without danger of liquid refrigerant being pumped up by the compressor.

The cycle of operation of my machine, briefly, is a follows: The liquid refrigerant in the evaporator 3 is vaporized as a result of heat received from the surrounding medium. The vapor drawn up through pipe 58 by the compressor is compressed and discharged through the muffler formed at the sides of the compressor cylinder 6 into the space within the casing 9. Passing up through the inclined discharge openings 29 in the rotor of the driving motor, it enters the condensing coil 22 through the pipe 23. The compressed vapor, while in the casing 9, loses a certain amount of heat through the fins 24, and more heat is lost while it traverses the coil 22 through direct radiation therefrom and through the same fins 24. The vapor finally condenses and flows through pipe 30 into the float chamber 32, from which it escapes through float valve 35 into the evaporator 3.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A compressor comprising a drive shaft, an oscillatable cylinder, a piston therein, and means carried by the shaft and engaged by the piston for operating the same, said piston having a counterweight arranged beyond said means and said shaft having a counterweight arranged opposite said means.

2. A compressor comprising a drive shaft, a piston operating member carried thereby, an oscillatable cylinder, and a piston therein engaging said operating member, said piston being substantially balanced on said operating member and said drive shaft having means thereon for substantially balancing the piston and the piston operating member.

3. A compressor comprising a drive shaft, an eccentric member carried thereby, an oscillatable cylinder, and a piston therein having a bearing for the eccentric member, said piston having a counter-weight portion arranged to bring the center of gravity of the piston substantially coincident with the center of the eccentric member, and said drive shaft having a counterweight portion constructed and arranged to substantially balance the combined weight of the eccentric member and the piston.

4. A compressor comprising a frame, an oscillatable cylinder mounted thereon, and a piston in the cylinder, said frame and cylinder having cooperating passages and parts to control the flow of refrigerant, said cylinder having a bore in the wall thereof, and a piston rod fitting said bore, forming an oil pump, said cylinder and frame having other cooperating passages and parts for controlling the flow of lubricating oil.

5. A compressor comprising a frame, a shaft journalled therein, oil ducts extending through the shaft from the periphery thereof, one of said ducts providing a relatively free escape for oil, oil pumping means in communication with both of said ducts, said one duct having the entrance portion thereof enlarged whereby the oil therein produces a predetermined back pressure on the pumping means.

6. A compressor comprising a frame, a shaft carrying an eccentric member, spaced bearings for the shaft in said frame whereby an oil chamber is formed around an intermediate portion of the shaft, an oil pump adapted to supply oil to said oil chamber, an oil duct leading from said chamber through the shaft to said eccentric member, a second oil duct leading from said chamber through the shaft to a shaft bearing and providing a relatively unimpeded flow of oil therethrough, the entrance portion of said second oil duct having a diameter greater than the remaining portion thereof and greater than said first oil duct, whereby a predetermined oil pressure is maintained in said oil chamber.

7. A closed compression system having a refrigerant compressor therein including a piston and cylinder, oil pumping means, driving means for the compressor and oil pumping means, and means responsive to a predetermined pressure of oil from said pumping means for equalizing the pressure of the refrigerant on opposite sides of said piston.

8. A compressor comprising a cylinder and piston for compressing refrigerant, an oil pump connected to be operated simultaneously therewith to produce a pressure of oil and means actuated by the reduction in oil pressure incident to the stopping of the pump for equalizing the refrigerant pressure on the opposite sides of the piston.

9. A compressor comprising a cylinder and piston for compressing refrigerant, an oil pump, common operating means for said piston and pump, means forming a passage connecting opposite sides of said piston, a

valve controlling said passage, and means responsive to a predetermined pressure of oil for holding said valve closed.

10. A compressor including a cylinder having intake and discharge ports, a by-pass affording communication between the ports of said cylinder, oil pumping means, and means controlled by the pressure of said oil pumping means for opening and closing the by-pass between the ports of said cylinder.

11. A compressor including a cylinder having intake and discharge ports, a by-pass affording communication between the ports of said cylinder, oil pumping means, and means including a valve and piston controlled by the pressure of said oil pumping means for opening and closing the by-pass between the ports of said cylinder.

12. A compressor comprising an oscillatable cylinder, a piston therein, said cylinder having an intake passage spaced from the end thereof, and means effective at the initial suction strokes of the piston to admit pressure to said passage, whereby the pressure on opposite ends of the piston is partially equalized, said cylinder having an additional passage therein connecting the intake passage with the cylinder bore at a point close to one end of the cylinder.

13. A compressor comprising a frame, a cylinder oscillatably mounted thereon, a piston in the cylinder, said frame and cylinder having cooperating ports for controlling the passage of refrigerant, said cylinder having a longitudinal bore in a wall thereof forming an oil pump cylinder, a piston therein, said frame and cylinder also having cooperating ports for controlling the flow of oil from said oil pump.

14. A compressor comprising a frame and an oscillatable cylinder mounted therein, said frame and cylinder cooperating to form a pocket between them, and means for directing the exhaust from said cylinder through said pocket.

15. A compressor comprising a frame having an opening therein, and an oscillatable cylinder mounted therein, said cylinder having projections thereon forming a pocket with said frame, and means for directing the exhaust from the cylinder through said pocket.

16. A compressor comprising a frame having an opening therein, and an oscillatable cylinder mounted therein, said cylinder having lateral projections thereon forming with the frame a plurality of communicating pockets, and means for directing the exhaust from the cylinder successively through said pockets.

17. A compressor comprising a frame having a circular opening therein, and an oscillatable cylinder mounted therein, said cylinder having a plurality of fins projecting from the sides thereof and forming with the frame a plurality of communicating pockets, and means for directing the exhaust from the cylinder successively through said pockets for muffling the same.

18. A compressor comprising a frame having a circular opening therein, and an oscillatable cylinder concentrically mounted therein, said cylinder having a plurality of laterally projecting fins engaging the wall of said opening and thereby forming a plurality of expansion chambers of varying size, the wall of said opening being formed with passageways cooperating with said fins as the cylinder oscillates, whereby the exhaust from the cylinder is successively admitted to and discharged from the expansion chambers.

19. A compressor including a cylinder having intake and discharge ports, a casing enclosing the compressor, said cylinder discharging into said casing, a piston in said cylinder having the crank end thereof subject to the pressure in said casing, oil pumping means actuated in accordance with the speed of the compressor, and means controlled by the pressure of said oil pumping means for equalizing the pressure on opposite sides of said piston.

20. A compressor including a cylinder having intake and discharge ports, a casing enclosing the compressor, said cylinder discharging into said casing, a piston in said cylinder having the crank end thereof subject to the pressure in said casing, oil pumping means actuated in accordance with the speed of the compressor, and means including a valve and oil actuated piston controlled by the pressure of said oil pumping means for equalizing the pressure on opposite sides of said piston.

21. A compressor including an oscillating cylinder having trunnion, a frame having a bearing supporting said trunnion and a bore in alignment with said bearing, oil pumping means actuated in accordance with the speed of the compressor, and means including a piston arranged in the bore of said frame and controlled by the pressure of said oil pumping means for equalizing the pressure on opposite sides of said piston.

22. A compressor including an oscillating cylinder having a trunnion, a frame having a bearing supporting said trunnion and a bore in alignment with said bearing, means including a piston arranged in the bore of said frame for loading and unloading said compressor, and means controlled in accordance with the operation of said compressor for operating said unloading means.

23. A refrigerating machine including a closed compression system containing oil, a motor and a refrigerant compressor enclosed in said system, means responsive to oil pressure for controlling loading of said compressor, and means including a pump for the oil

in said system and driven by said motor for controlling loading of said compressor.

24. A refrigerating machine including a closed compression system containing lubricating oil, a motor and a refrigerant compressor enclosed in said system, means driven by said motor for supplying the oil in said system under pressure to lubricate said machine, and means controlled by the pressure of oil delivered by said oil supplying means for controlling loading of said compressor.

25. A refrigerating machine including a closed compression system provided with a casing containing a body of oil, a motor and a refrigerant compressor in said casing above the body of oil therein, means for supplying oil under pressure from the body of oil in said casing, and means responsive to the pressure produced by said oil supplying means for controlling loading of said compressor.

26. A refrigerating machine, including a closed compression system provided with a casing containing a body of lubricating oil, a motor and a refrigerant compressor arranged in said casing above the body of oil therein, a lubricating system for said motor and compressor including means for supplying oil under pressure from the body of oil in said casing to said motor and compressor for lubricating them, and means controlled by the pressure of oil in said lubricating system for loading said compressor.

27. A refrigerating machine including a closed compression system provided with a casing containing a body of lubricating oil, a motor and a refrigerant compressor arranged in said casing above the body of oil therein, means for supplying oil under pressure from the body of oil in said casing to said motor and compressor for lubricating them, means controlled by the pressure of oil from said oil supplying means for equalizing the pressure in the intake and exhaust passages of said compressor to unload said compressor until said motor attains normal speed.

28. A refrigerating machine including a closed compression system provided with a casing containing a body of lubricating oil, a motor and a refrigerant compressor arranged in said casing above the body of oil therein, said compressor discharging into said casing, means for supplying oil under pressure from the body of oil in said casing to said motor and compressor for lubricating them, means controlled by the pressure of oil from said oil-supplying means for admitting high pressure gas from said casing to the intake of said compressor to unload said compressor until said motor attains normal speed.

In witness whereof, I have hereunto set my hand this 16th day of May, 1928.

CHRISTIAN STEENSTRUP.