

March 3, 1942.

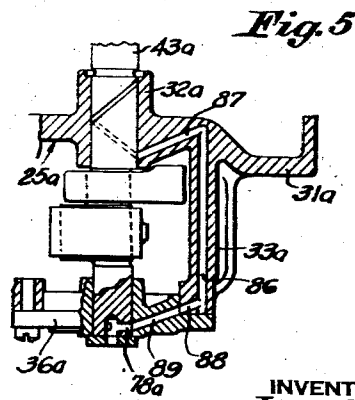
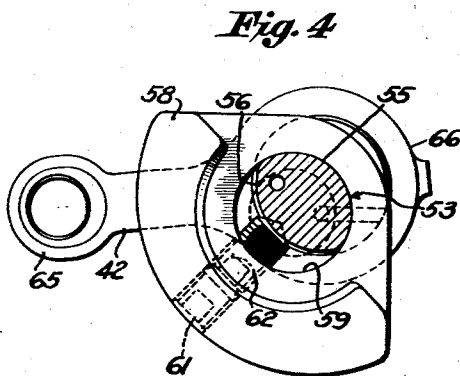
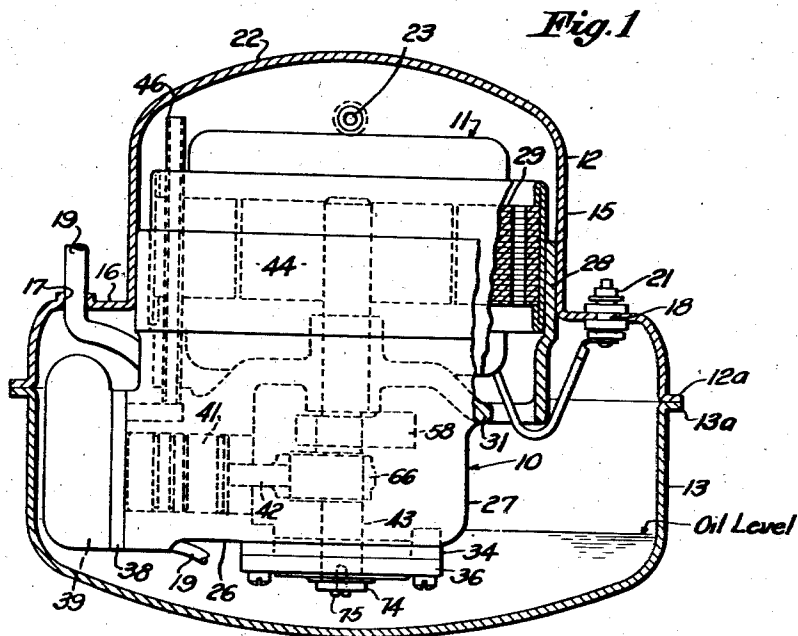
J. TOUBORG

2,274,943

REFRIGERATION COMPRESSOR

Filed May 2, 1940

2 Sheets-Sheet 1



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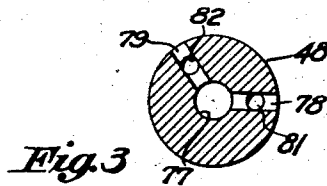
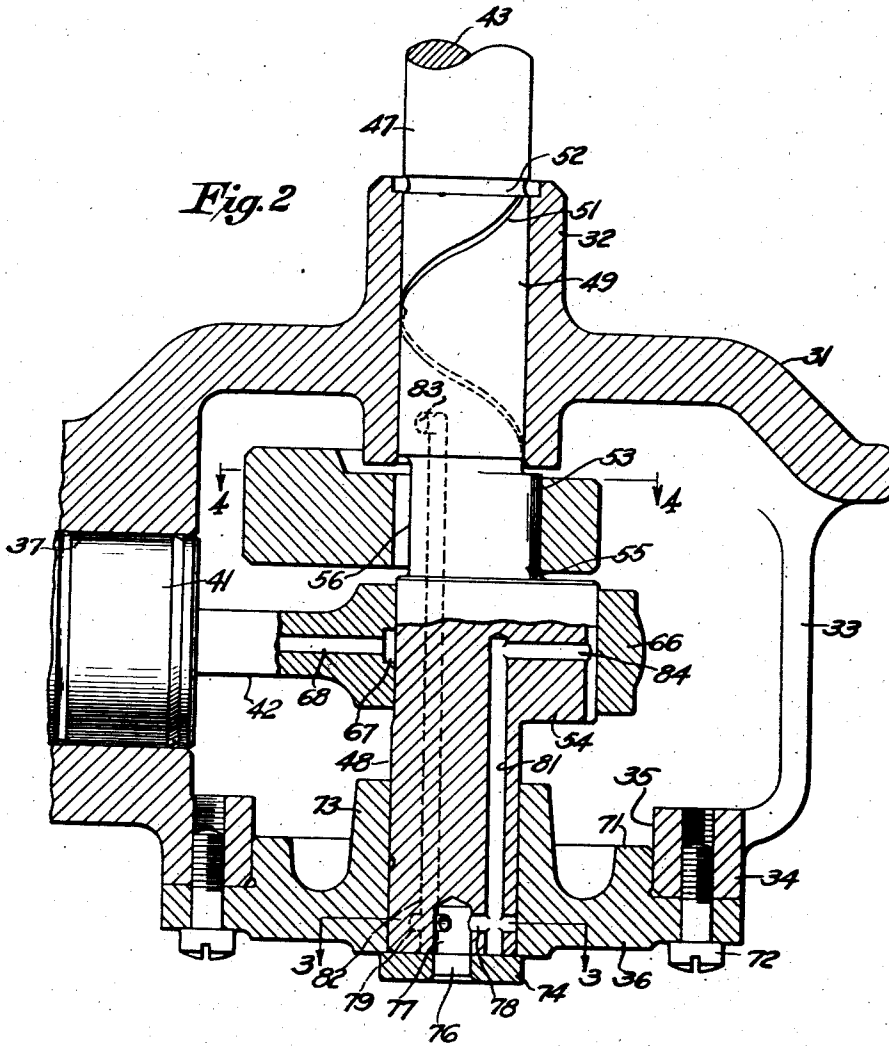
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UNITED STATES PATENT OFFICE

2,274,943

REFRIGERATION COMPRESSOR

Jens Touborg, Tecumseh, Mich.

Application May 2, 1940, Serial No. 332,973

4 Claims. (Cl. 230—206)

This invention relates to refrigeration compressors, particularly to the enclosed type known as hermetic compressors, and it is directed to the provision of improved means for making and operating such compressors, particularly with respect to a novel main shaft construction including pumping elements to supply lubricant to the shaft bearings and piston.

A common and well known form of hermetic compressor includes an overhead electric motor whose shaft is coupled to the connecting rod of a reciprocating compressor, all enclosed in a casing, and wherein lubricating oil is contained in the lower portion of the casing for supply to the working parts. In my prior patent, No. 2,146,097, of February 7, 1939, I have disclosed such general form, utilizing a cast shell for housing and mounting the motor and compressor, and providing the motor shaft with a dependent portion adapted to be connected to the connecting rod of the compressor piston.

In the above mentioned patent, I endeavored to provide for a supply of lubricating oil to the main bearing, by drilling the crank with a diagonal hole extending from the oil body to the main sleeve bearing, it being considered that in such a diagonal passage, every point therein would be a centrifugal pump which would lift the oil to the bearing. I moreover provided for substantial immersion of the crank portion in the oil bath, so that the piston would be lubricated by immersion and splashing.

Practical experience with the structure disclosed in that patent, as just referred to, has shown that, among other things, two unsatisfactory conditions are encountered. First, the drilling of a diagonal duct through a steel shaft, even when modern precision tools and methods are employed, is a difficult operation, and a significant percentage of the shafts are spoiled due to inaccurate drilling, and must therefore be rejected with attendant economic loss.

Second, in actual operation, it has been discovered that the highly volatile refrigerant, which always gets mixed into the oil either by solution or mechanical entrainment, will tend to separate in the diagonal passage. The reason for this becomes apparent upon analysis. It is practically impossible to submerge the passage entirely, and there is therefore a portion of it that acts centrifugally, above the oil bath. This centrifugal action causes the oil and included refrigerant to separate, thereby creating globules of low density vapor in the impeller,

Since the centrifugal is inherently ineffective as a pump for vapor, the gas simply blocks the diagonal passage, and causes a vapor lock condition which interferes with the intended function of the pump. Lubrication of the main bearing is thereby diminished.

According to the present invention, I have devised an overhead motor type of compressor, with a substantially reduced depth for the oil body in the base of the casing, and with elimination of opportunity for vapor lock formations in that portion of the pumping mechanism which operates centrifugally. This I accomplish by means of a different form of shaft and pump, with associated bearing structure. As the present description proceeds, it will moreover be apparent that simplified machine operations may be utilized, thus curtailing spoilage losses, as well as providing for greater efficiency of operation.

In one aspect of this invention, I provide a main shaft having two spaced concentric portions, one of which receives the rotor for the driving motor, and the other of which is located below the compressor and which also includes a laterally disposed and submerged pumping element. I provide for the discharge of effluent from this constantly primed impeller into a vertical riser in which no effective centrifugal component exists to cause the stated separation of refrigerant and oil, and attendant vapor lock. The submerged impeller may discharge into one, or more, risers, depending upon the number of points to which the oil is to be taken. By providing spaced concentric shaft portions, as just described, and by forming the connecting rod crank at a mid portion of the shaft, I am moreover able to provide for positive feed of oil to the wrist pin, as well as the main bearing, and to "two-stage" or boost the oil pressure for this important delivery point.

In further explanation of the principle just enounced, it may here be added that I provide a shaft structure wherein the eccentric is offset from, or lies beyond, the trace of the concentric shaft sections. If a vertical riser from the submerged centrifugal be taken along the shaft to this eccentric portion, then the eccentric itself may be formed with a second centrifugal impeller, constantly supplied or primed by the first, and thereby producing an effluent whose effective head is much greater than that obtainable by utilizing either the concentric shaft section, or a dependent offset section, alone. The oil delivered in this fashion may in turn be led to the wrist pin through suitable connecting ducts.

Associated with such eccentric shaft portion is another portion between the concentric shaft sections, in which a counterweight may be positioned in a novel manner. This feature, in turn, is related to the general assembly of the compressor which, in this case, comprises a sheet metal housing and an included compressor casting, the latter being formed with an open portion for facilitating the insertion of the novel shaft structure and its assembly with the related parts.

Another related feature concerns itself with the bearing for the lower concentric shaft portion, which is so devised as to admit oil to the submerged centrifugal pump, and withal close certain passages which are formed as an incident of the manufacturing operations. This feature not only aids to curtail manufacturing costs, but also reduces tendencies toward vibration and wear, as the compressor is operated.

It may be noted that the invention as herein presented contains subject matter in common with my copending application Serial No. 327,063, filed March 30, 1940, wherein emphasis is laid upon a novel means for eliminating knock from the head end of the compressor under certain operating conditions. While such means may be used conjointly with the subject matter herein claimed, it will of course be understood that the present invention may also be used independently thereof, and accordingly is presented in this application.

The invention may be more clearly understood by reference to the following description, read in connection with the accompanying drawings, wherein:

Fig. 1 is a view, partially in side elevation and partially in section, of the assembled compressor;

Fig. 2 is an enlarged section through the compressor body showing particularly the shaft, bearing, and oil pump formation;

Fig. 3 is a section through the crankshaft, taken on the line 3—3 of Fig. 2;

Fig. 4 is a section, on a slightly reduced scale, on the line 4—4 of Fig. 2; and

Fig. 5 is a fragmentary section, on the scale of Fig. 1, showing a modification for the pump riser.

Referring first to Fig. 1 for a general description, there is shown a casting body 10 including a compressor which is operated by a driving motor 11 disposed above the compressor, both of which are wholly enclosed by a casing consisting of two abutting sheet metal shells 12 and 13. Each shell is formed on its open end with a flange, 12a and 13a respectively, which are welded to each other after the other parts have been properly assembled. The upper shell 12 is formed with a cylindrical portion 15 merging into a radial portion 16, and the radial portion is formed with openings 17 and 18, respectively provided to receive a refrigerant discharge conduit 19, and a binding post or connector 21 for the wires leading to the electric motor 11. The dome portion 22 of the shell 12 is also provided with an inlet fitting 23, through which returning refrigerant vapor is drawn into the casing.

As bearing on the use of the compressor for refrigerating purposes, it is believed sufficient here to note that in the usual compressor type of refrigeration machine, the volatile refrigerant medium is compressed by the compressor, then discharged into a condenser wherein it is cooled

with accompanying liquefaction, then admitted to an evaporator for expansion with accompanying absorption of heat, and is then returned to the compressor for a repetition of the cycle. As this is all well understood, no further illustration or explanation is deemed necessary here.

The compressor casting body 10 includes a main portion 25 in which is integrally included a cylinder block 26, crankcase section 27, and mounting flange 28. The mounting flange is pressed into tight engagement with the inner wall of the cylindrical portion 15 of the upper shell 12, and the inner surface of the flange in turn receives the stator 29 of the motor 11, which also may be pressed fitted. The crankcase portion 27 of the body 25 includes an upper wall 31 disposed laterally of the casting, in which is centrally formed a main bearing boss 32. The crankcase portion also includes a depending section 33, terminating in a lower horizontal wall 34 provided with a large cylindrical opening 35 which is ultimately covered with a separate lower bearing block 36. As will best appear from Fig. 2, the depending section 33 is open to permit access to the crankcase for assembly purposes.

The cylinder block portion 26 projects from the left as viewed in Fig. 2, or away from the crankcase opening. This portion is formed with a horizontal bore 37 constituting the compressor cylinder, and which is capped on its head end by a valve plate 38 and overlying cylinder head 39—these details being more fully illustrated in my aforesaid copending application.

The cylinder 37 receives a reciprocatory piston 41 which is connected through a connecting rod 42 to the crankshaft 43. The shaft, as it will now be clearly understood, is vertically mounted in the main casting 25, in the bearings formed in the parts 32 and 36, and the upper section of the shaft projects into the shell 12 to receive the rotor 44 of the motor 11. When the motor is excited the shaft 43 rotates, thus operating the compressor.

The motor stator 29 is provided with a longitudinal aperture in which is positioned a refrigerant inlet pipe 46 which communicates with the cylinder head 39 to admit returning vapor to the compressor. Vapors entering the shell assembly, through the fitting 23, flow into the compressor through the pipe 46, and excess amounts of oil returning therewith are separated and fall into the main oil body contained in the shell 13, as indicated in Fig. 1. It will be noted that the oil body has sufficient depth to cover the block 36, through which oil is supplied for lubricating purposes.

With this general explanation of the compressor assembly and operation, attention is now invited to Figs. 2 to 4, showing in greater detail the shaft construction. It will first be observed that the shaft 43 is provided with two aligned or concentric cylindrical portions 47 and 48 respectively, the upper of which receives the rotor 44, while the lower is mounted in the lower bearing block 36. The upper section 47 is contiguous with a section 49 disposed in the main bearing 32, and for lubricating purposes the section 49 is formed with a spiral oil groove 51 and a retaining groove 52.

The intermediate portions of the shaft 43, which are located within the crankcase portion, consist of a counterweight-receiving section 53 and an eccentric or crank section 54. These are, respectively, contiguous with the sections 49 and 48, and they are also contiguous with each other.

Each of the sections 53 and 54 is, however, offset from, or eccentric to, the concentric shaft sections 47, 49, and 48, at least in part. Thus, the counterweight section 53 is formed with a cylindrical surface 55 which is concentric with the axis of the shaft, and an opposed arcuate surface 56 which is concentric to the surface of the crank section 54. The section 54, necessarily, is formed with a cylindrical surface whose center is not coincident with the main shaft axis. There is accordingly provided a rotating shaft portion which lies beyond the concentric bearing sections, and which, as hereinafter more fully described, may be utilized to pump oil to the connecting rod bearings.

Before proceeding with such description, it will be noted that the shaft section 53 receives a one-piece counterweight 58 which is formed with a cylindrical bore 59, adapted to be disposed about the section 53, and which bore is of the same radius as that of the surface 55. The counterweight is also tapped to receive set screws 61, 62, the innermost of which engages a socket 63 formed on the shaft section 53, to secure the counterweight in its assembled position.

The piston 41 is connected to the shaft 43 by the connecting rod 42, the small end 65 of which (see Fig. 4) is connected to a wrist pin (not shown) in the usual manner. The big end 66 is formed as a strap encircling the eccentric 54. The inner surface of the strap is also formed with an oil receiving groove 67 which communicates with a duct 68 drilled through the rod 42, and leading to the small end 65. Thus, upon the provision of means for feeding oil to the groove 67, it will be apparent that lubricating oil may be supplied under pressure to both ends of the connecting rod 42, thus lubricating the eccentric and the piston wrist pin.

It will be observed that the described structure presents an interesting problem in assembly, and the various sections of the shaft 43 are so made and dimensioned, with respect to each other and the associated parts, as to solve this problem. Let it be assumed that the several parts are ready for assembly. The piston 41, with the connecting rod attached thereto by the wrist pin connection, is inserted in the cylinder 37. The counterweight 58 is then disposed above the strap portion 66, the crankcase opening being large enough for this purpose.

The shaft 43 is then inserted in an upward direction through the lower opening 35, and it will be observed that its concentric sections 47 and 49 pass freely through the strap and counterweight openings. These upper shaft sections then move through the main bearing 32. The counterweight section 53, of course, passes freely through the strap 66, but as it comes up to the counterweight bore 59, it is necessary to offset the counterweight with respect to the shaft, and this can be done because the bore 59 has a diameter the same as the offset cylindrical surface 55, while the arcuate surface 56 lies within the trace of the concentric sections. At the same time, the connecting rod may be moved back and forth in the cylinder block, thus permitting the strap 66 to encircle the eccentric portion 54. Upon tightening up the set screws 61 and 62, the parts just described are brought into assembled relation, as shown in Figs. 2 and 4. The shaft 43 is then located in the bearing 32, with its lower section 48 aligned therewith.

The lower section 48 is mounted in the bearing block 36, which is formed with a centering

flange 71 engaging the inner surface of the opening 35, and which is secured to the main body 25 by screws 72. The central portion of the block 36 is formed with a bearing boss 73 which is open at its lower end, and within which the lower shaft section 48 is supported. Disposed over the lower end of the boss 73 is a thrust bearing plate 74 which is secured to the block 36 by screws 75 (see Fig. 1). The plate 74 is also provided with a central opening 76 to admit oil from the main oil body to the lower end of the shaft 43.

The lower end of the shaft 43, and in the section 48, is drilled for a limited distance with an axially disposed bore 77, which constitutes the eye of a centrifugal pump, and which is aligned with the opening 76. The section 43 is also drilled with two radial passages 78 and 79 which communicate with the eye 77. The shaft section 43 is then drilled with vertical passages 81 and 82, which are offset from but parallel to the main shaft axis, and which respectively intersect the radial passages or vanes 78 and 79. It will be noted that the passage 81 continues to a point substantially half way up the eccentric section 54, while the passage 82 continues up through the eccentric and counterweight sections to terminate adjacent the lower part of the bearing section 49. Each of these vertical passages constitutes a riser, or discharge pipe, for its associated centrifugal pump formed by the vanes 78 and 79.

It will be noted, however, that since the passages 81 and 82 are vertically disposed and are parallel to the shaft axis, there is no point therein more remote from the center of rotation than any other point, and accordingly there is no horizontal component through which centrifugal force may be developed. On the other hand, the passages 78 and 79 lie wholly in a plane perpendicular to the axis of rotation, and therefore every point therein is effective as a centrifugal pump during rotation, but not as a riser or discharge pipe subjecting such passage to a pressure head. The centrifugal pumps are, therefore, constantly submerged and accordingly constantly primed, and are not susceptible of binding or blocking by gas formations, since the oil body itself places the eye 77 under some measure of positive pressure, rather than a negative suction pressure.

Accordingly, upon rotation of the shaft 43, the passages 78 and 79 form centrifugal impellers, drawing oil from the main body and discharging it into the risers 81 and 82, wherein, due to the absence of a centrifugal component, the whole available kinetic head of the pump is converted into pressure head. It is interesting to note that, while these impellers are very small, as compared to the dimensions of the usual centrifugal pump, it has nevertheless been demonstrated that they develop adequate energy to pump the oil, under the speeds of rotation employed in compressors of this nature.

It is moreover quite apparent that the oil discharged from the vanes 78 and 79 would not be effectively elevated in the risers 81 and 82, if the open ends of the vanes, and the lower ends of the risers, were not covered. Rather than put plugs in these openings, which would add to the expense of manufacture, the open ends are utilized to advantage, by covering them with the bearings 73 and 74. Thus, the open ends of the vanes 78 and 79 communicate with the inner surface of the radial bearing 73, to supply a

limited amount of oil thereto as needed, while the lower ends of the risers 81 and 82 are covered by the bearing 74. Obviously, very little oil is fed through these openings, but an additional assurance is provided thereby against failure of lubrication.

The riser 82 terminates in a lateral opening 83 drilled in the main bearing section 49, and thus supplies oil to the bearing 32, for distribution by the groove 51. The circumferential groove 52 retains some oil for return by gravity as required, and hence the main bearing is adequately lubricated at all times.

The riser 81, however, terminates in a radial duct 84 which is drilled through the offset section of the eccentric 54, and oil supplied through the riser 81 may therefore be discharged into the groove 67, both to lubricate the strap bearing, and also for discharge through the duct 68 to supply oil to the small end 65 of the connecting rod. From what has been stated with respect to the development of centrifugal force, it is apparent that the duct 84, being disposed in a plane normal to the axis of rotation, in itself constitutes a centrifugal pump. Thus, by providing two radial portions, and a connecting vertical portion, there is formed in effect a two stage centrifugal pump, whose capacity is much greater than that of a single pump.

I do not wish to be too strictly limited by this explanation of the principle, because the structure obviously possesses certain differences from the usual multi-stage centrifugal. It is apparent, however, that the lower submerged pump 78 discharges its effluent to the inlet of a second pump 84, and the second pump discharges its effluent with greater force. It may be otherwise said that the first centrifugal acts as a priming pump for the second centrifugal, since the vane 84 is located above the oil body, and therefore is not self-priming. In any event, observation shows that a greatly increased pumping action is obtained, and adequate quantities of oil are supplied to the eccentric and wrist pin, and to the cylinder walls.

In the embodiment of the invention just described, the risers are formed in the shaft itself, and it may be deemed expedient to replace the riser for the bearing 32 with an exterior riser. In such event, the structure shown in Fig. 5 may be utilized. As the general arrangement of parts is the same, these are designated by like reference numerals with the suffix *a*, and without repetition of description.

The crankcase portion of the main body 25a is formed with a depending portion 33a, which is vertically drilled with a riser duct 86, an upper discharge duct 87 communicating with the bearing 32a, and a lower lateral duct 88 communicating with the outer flanged surface of the bearing block 36a. The block, in turn, is drilled with a passage 89 to connect the riser 86 with the discharge opening of the vane 78a formed in the shaft 43a. As the shaft rotates, the oil is driven by the centrifugal pump through the stationary riser and duct system, to supply oil under pressure to the overhead bearing.

From the foregoing description, it will be seen that this invention resides in a hermetic compressor of the overhead motor type, wherein the cooperative parts have been so devised as to force the lubricant in the lower shell under pressure to the bearings, and wherein a totally submerged and constantly primed centrifugal pump is utilized to develop the initial pressure on the

oil. It will be seen that the provision of the pump and riser structure is effected in conjunction with a main shaft whose various sections are correlated to the functions of supplying oil and operating the parts of the compressor, and that a lower bearing structure is provided in such fashion as also to constitute a part of the pump, as well as the general assembly.

My invention resides in these related parts cooperating to produce an improved and less expensive compressor, and while I have described the invention with reference to specific embodiments thereof, it will be understood that it is not intended to be strictly limited thereto, but is intended to embrace those modifications and variations which are within the scope of the combinations and parts set forth in the following claims.

I claim:

1. A hermetic compressor comprising a shell, a vertically mounted motor positioned within the shell, a piston-in-cylinder compressor mounted within the shell and below the motor, upper and lower axially aligned shaft bearings connected to said motor and compressor, one of said bearings being disposed adjacent the motor and the other of said bearings being disposed below the compressor and adjacent the lower portion of the shell, said lower shell portion being adapted to receive an oil body immersing at least a portion of said lower bearing, a main shaft having concentric portions radially mounted in both of said bearings, said shaft having a concentric portion extending above said upper bearing for connection to said motor, an eccentric portion formed on said shaft intermediate said bearings, a connecting rod for said compressor connected to said eccentric portion, a horizontally disposed radial passage formed in said lower concentric shaft portion and having open communication with the wall of said lower bearing at its outer end and with the shaft axis at its inner end, an axial passage in the lower end of the shaft communicating with the radial passage thereby to admit oil to said radial passage for centrifugal pumping, and a vertical passage drilled through said shaft in spaced relation to said axis and parallel thereto, said vertical passage extending from said radial passage through said eccentric portion to said upper bearing portion.

2. The hermetic compressor of claim 1, wherein said vertical passage is open to the lower end of said shaft, and wherein a thrust bearing is secured to said lower radial bearing to abut the end of said shaft and to cover the lower open end of said passage.

3. A hermetic compressor comprising a casting body formed with a mounting flange portion and a compressor portion, a shell enclosing the body and supporting said casting body, a motor mounted within the flange portion, said casting body being formed with an assembly and bearing block opening concentric to said mounting flange portion and below said compressor portion, a bearing formed in said body above said compressor portion and in alignment with said opening, a drive shaft connected to said motor and extending downwardly through said bearing to said opening, said shaft having concentric end portions and an intermediate eccentric portion for operatively connecting the shaft to the compressor portion, a bearing block adapted to be secured to said body portion to close said opening, said block having a lower radial bearing aligned with said first named bearing, a thrust plate se-

cured to said block and covering the end of the shaft disposed in said lower bearing, an axially aligned opening formed in said thrust plate, an axial bore formed in the lower end of the shaft and extending thereinto a limited distance, a laterally disposed duct drilled in said shaft normal to the axis thereof from the surface of said shaft to said axial bore, said duct being open at its outer end and wholly disposed within the surface of said lower bearing, said shell being adapted to contain oil to a depth sufficient to submerge said thrust plate with the eccentric shaft portion above said oil, and riser ducts communicating with said first duct and with said upper bearing, said first duct being blocked from recirculation of oil to said body directly by said lower bearing and thrust plate.

4. In a refrigerant compressor of the type described, a compressor body having upper and lower bearings, a crankshaft rotatably carried by the

5 bearings, a thrust bearing on the body closing the lower bearing and serving as a support for the lower end of the shaft, a shell structure enclosing the compressor and having an oil reservoir wherein oil is maintained at a level above said lower bearing, a centrifugal pump impeller formed in the portion of the shaft within said lower bearing and comprising an open axial hole in the lower end of the shaft constituting the eye of the impeller, a communicating radial hole constituting an impeller arm whose outer end is closed by the lower bearing, a longitudinal hole in the shaft communicating with said arm and extending upward, a bearing lubricating port communicating with said longitudinal hole, and means connecting said impeller eye with the oil reservoir comprising a hole formed in said thrust bearing aligned with said impeller.

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