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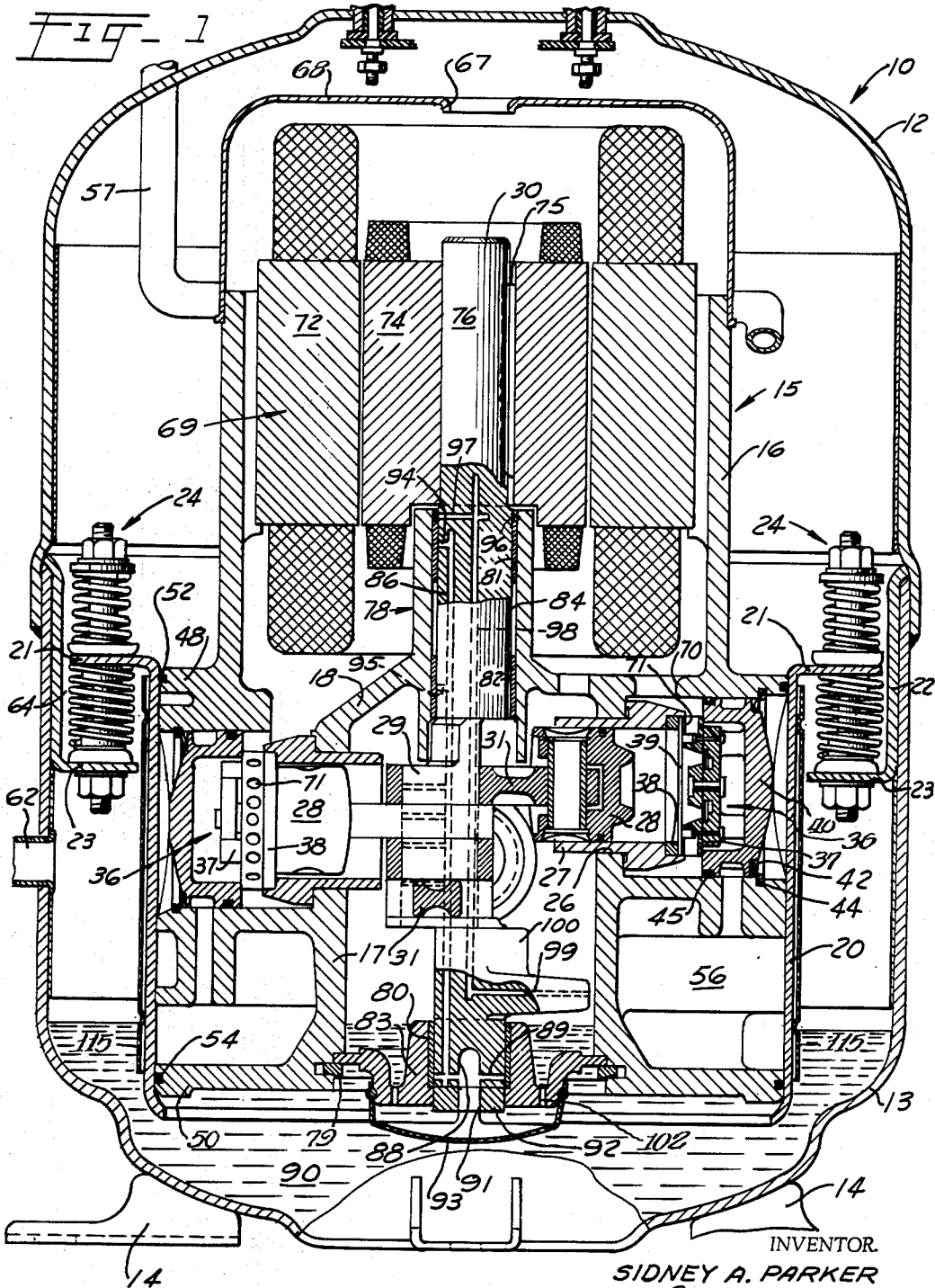
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3,248,044

REFRIGERANT COMPRESSOR LUBRICATION ARRANGEMENT

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3 Sheets-Sheet 1



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3 Sheets-Sheet 2

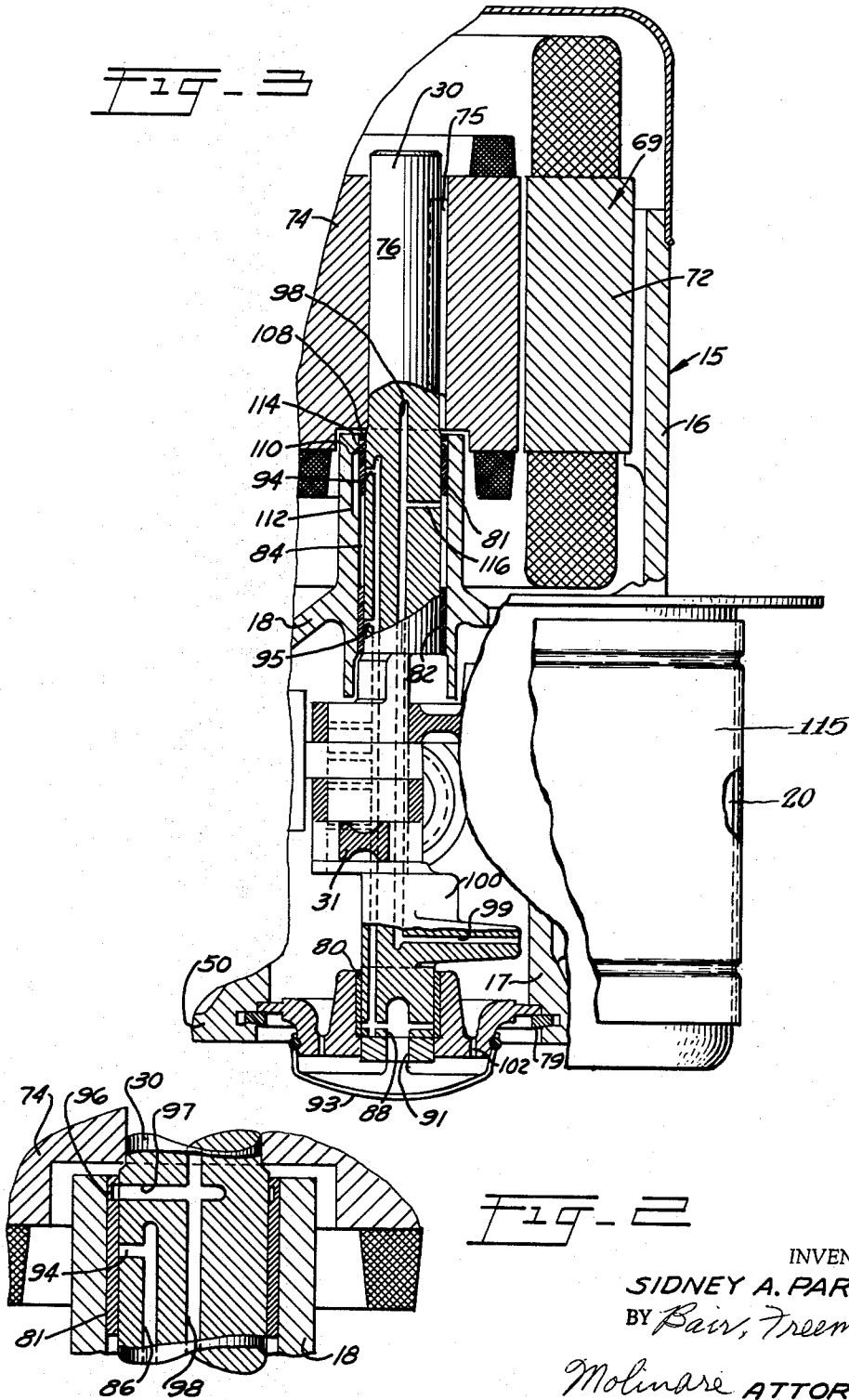


Fig. 2

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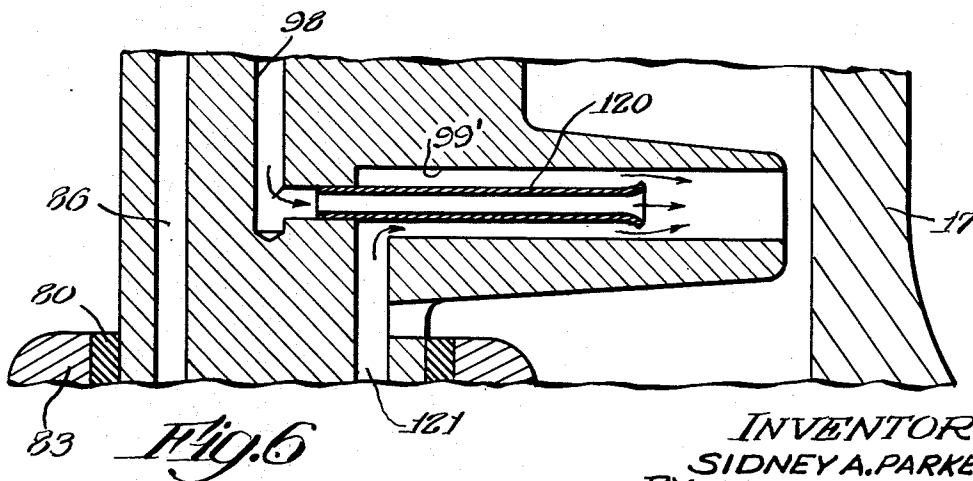
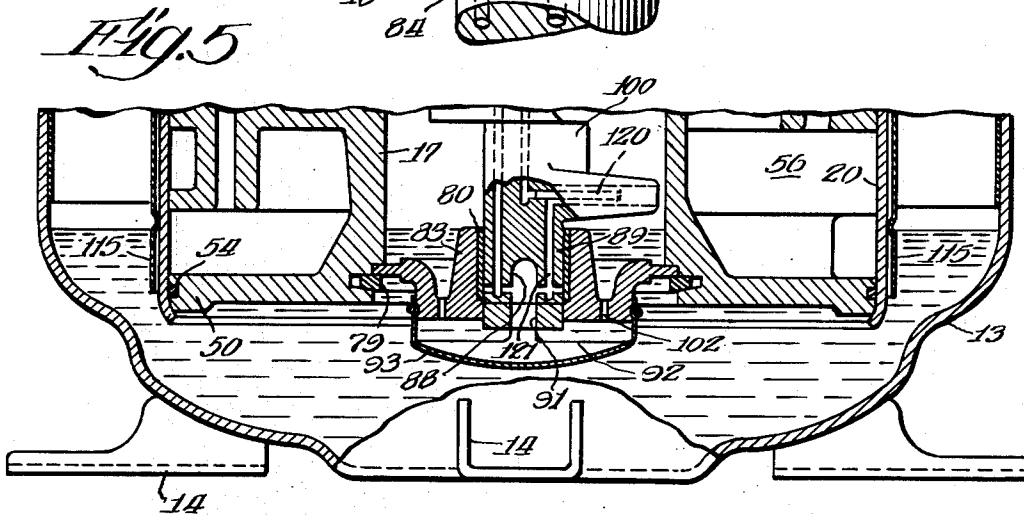
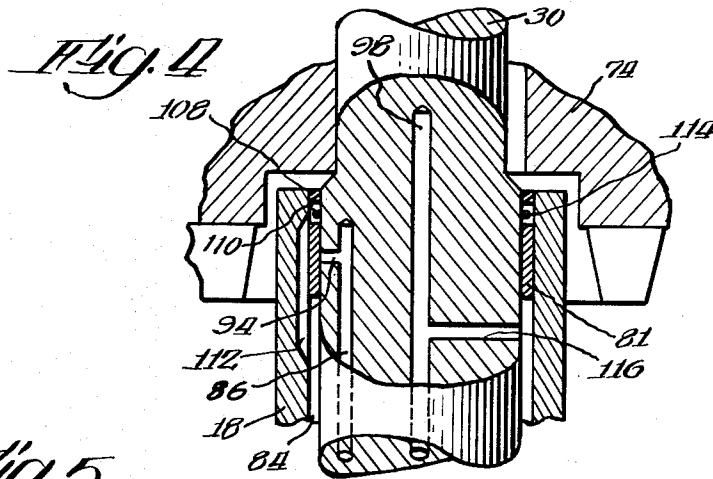
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REFRIGERANT COMPRESSOR LUBRICATION ARRANGEMENT

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3 Sheets-Sheet 3



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REFRIGERANT COMPRESSOR LUBRICATION ARRANGEMENT

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7 Claims. (Cl. 230-206)

This invention relates to a refrigerant compressor and, more particularly, to an improved hermetic refrigerant compressor of the type including a vertically extending crankshaft journaled in upper and lower bearings in a compressor block and having improved means for lubricating the upper bearings and returning lubricant from the upper bearings to the sump in a path separate from the flow path of suction gas through the compressor to prevent entrainment of lubricant in the suction gas.

The trend in the refrigeration industry is toward more compact refrigerant compressors driven at relatively high speeds. In one type compressor design, a vertically extending crankshaft or drive shaft is journaled in upper and lower bearings in a compressor block that is resiliently supported within the sealed outer casing. The drive motor for the crankshaft is located above the compression mechanism in the compressor block.

Lubrication of the upper bearings has long been a problem. Lubricant must be supplied to the upper bearing surfaces on the crankshaft from the reservoir or sump defined in the bottom of the outer casing. One method of lubricating the upper bearing surfaces is to provide pump means in the crankshaft for raising lubricant from the sump to the required bearing surfaces. Often excess oil will be pumped from the top of the upper bearing into the motor compartment and be entrained in the suction gas commonly used to cool the motor for driving the crankshaft. The oil which is picked up in the suction gas reduces the oil in the sump and threatens proper bearing lubrication. Further, oil pumped into the refrigeration system will coat the interior of the heat exchangers, that is, the condenser and the evaporator, and act as an insulator, thereby reducing heat transfer between the refrigerant in the heat exchanger and the medium which is passed in heat exchange relationship with the heat exchanger. In addition, the efficiency of the compressor may be impaired if oil is entrained in the suction gas.

Another problem encountered with hermetic refrigeration compressors is that the refrigerant commonly employed, as for example, a hydrofluorocarbon having the trade name Freon, tends, to be miscible in the lubricant. The use of a relatively large supply of oil with a relatively small quantity of refrigerant would reduce or obviate the adverse effects caused by miscibility of the refrigerant and oil. However, use of a large supply of oil requires a large sump or reservoir and thus undesirably increases the size of the compressor. The trend is toward miniaturization of compressors coupled with minimization of the quantity of oil within the compressor.

It is desired in compressor design that the pumping rate of oil be as low as possible and in present design, an ideal pumping rate is considered to be one percent or less by weight of oil for the entire refrigerant and oil mixture. If the pumping rate is too high, the oil level in the compressor will be endangered and in the event of a high side leak, that is a leak between the compressor and the expansion means, oil will be lost from the reservoir or sump in a short time and compressor failure may result.

An object of the present invention is to provide a hermetic refrigerant compressor having means in the drive

shaft for lubricating the upper crankshaft bearing while preventing oil from being pumped from the compressor.

Another object of the present invention is to provide a reciprocating compressor with means in the crankshaft for pumping lubricant from the sump to the upper bearing means, means for sealing the upper bearing means from the motor, and means in the crankshaft for assuring return of lubricant from the region of the upper bearing means to the sump in a path separate from the flow path of suction gas through the compressor.

A further object of the present invention is to provide a reciprocating compressor with improved means for lubricating the upper bearing journaling the crankshaft which are relatively inexpensive to manufacture and which means will also prevent oil from being pumped from the compressor by entrainment in the suction gas. Further objects and advantages of this invention will be readily perceived from the following description.

The attached drawings illustrate preferred embodiments of my invention, in which:

FIGURE 1 is a view partly in section and partly in elevation of a compressor embodying the present invention;

FIGURE 2 is an enlarged cross-sectional view illustrating the portion of the drive shaft journaled in the upper bearing means;

FIGURE 3 is a view partly in section and partly in elevation of modified means for lubricating the upper bearings journaling the drive shaft while preventing the lubricant from being entrained in the suction gas;

FIGURE 4 is an enlarged detail view of the upper bearing of the compressor shown in FIGURE 3, more clearly illustrating the slinger construction; and

FIGURES 5 and 6 are detail views of a modified construction utilizing an ejector pump in the flywheel portion of the crankshaft for assuring proper pumping action in certain designs.

Referring to FIGURE 1, there is illustrated a refrigerant compressor 10 embodying the present invention. The compressor comprises a gas-tight housing including an upper shell 12 and a lower shell 13 integrally joined to one another, as for example, by welding. A plurality of legs 14 may be affixed to the lower shell 13 of the compressor for supporting the compressor in an upright position.

Resiliently supported within the outer housing or casing of the compressor 10 is a compressor block 15 which comprises a motor flange portion 16 and a cylinder crankcase portion 17 divided by a partition 18.

Surrounding the lower portion 17 of the compressor block or crankcase in spaced relationship to the lower shell 13 of the outer casing is an annular sleeve 20. Formed integrally at the top of the annular sleeve 20 is an out-turned, ring-like flange 21. An annular member 22 having a transversely disposed lower ring-like flange 23 is affixed to the lower shell 13. A plurality of resilient spring means 24 are provided between the flange members 21 and 22 for resiliently provided between the flange members 21 and 22 for resiliently supporting the compressor block 15 within the outer housing of compressor 10.

Formed within the compressor block 15 are a plurality of cylinders 26. Although a four-cylinder compressor is illustrated, the compressor may have more or less cylinders as will be understood by those versed in the art. Cylinder sleeves or liners 27 are provided in each of the cylinders 26 and a suitable piston 28 is adapted to reciprocate within each of the cylinder liners 27. The pistons 28 are operatively connected to the eccentric portion 29 of the vertically disposed crankshaft or drive shaft 30 by means of connecting rods 31.

Closing the end of each cylinder cavity is a valve as-

sembly 36. Such valve assembly may comprise a discharge valve unit 37, a suction valve plate 38, and a suction valve or reed 39.

Each valve assembly 36 is retained in position in the end of the cylinder by means including a cap 40 fixed in position by a Belleville spring or head washer 42 and a retaining ring 44. The cap or cylinder head 40 is sealed with respect to the wall of the cylinder 26 by means of the O-ring 45.

Provided on the compressor block 15 are a pair of annular circular sealing flanges 48 and 50. These flanges are provided with recesses within which are disposed O-rings 52 and 54 for sealing between the annular sleeve 20 and the respective flanges 48 and 50. Defined between the exterior of the compressor block or crankcase and the annular shell 20 is a space 56 into which discharge gases are passed from the cylinders 26 after compression. The hot discharge gases pass from the annular chamber 56 through a conduit 57 to the condenser of the refrigerating system in a known manner. The annular space 56 is preferably provided with a plurality of cavities to impart a muffling effect to the discharge gases which pass through space 56 from the cylinders of the compressor to the conduit 57.

Suction gas enters the casing of the compressor via suction line 62 which is affixed to the casing of the compressor. Annular heat shield 115 minimizes heat transfer between the suction gas and the discharge gas, preventing undesirable increase in suction gas temperature. The suction gas passes through a maze or space 64 defined between the flanges 21 and 23 into the top portion of the compressor. The suction gas then passes through opening 67 in the end cap or motor cap 68 affixed to the motor flange portion 16 of the compressor block and down over the electric drive motor 69, thereby cooling the motor. The suction gas passes through the motor compartment into the valve assemblies 36 and associated cylinders 26 via passage means comprising openings 70 in the partition 18 and openings 71 in the valve assembly 36. Thus, it is seen that the interior of the hermetic casing between the compressor block and the outer casing is substantially at suction pressure.

The motor 69 comprises a stator 72 which is mounted within the motor flange portion 16 of the compressor block 15. The stator 72 is inductively connected to the rotor 74 which is affixed to the upper portion 76 of the drive shaft 30, as for example, by a key 75.

The drive shaft 30 is journaled in upper bearing means 78 and lower bearing means 80 in the compressor block 15. As shown in FIGURE 1, the lower bearing means comprise an annular ring-like member made from suitable bearing material and supported in bearing head 83 which is secured to compressor block 15 by retaining ring 79. The upper bearing means comprise a first bearing 81 and a second bearing 82 spaced from the first bearing and cooperating therewith to define an annular space 84 about the shaft 30 and between the two bearings.

Provided in the shaft 30 are pump means for lubricating the upper and lower bearing means. Such pump means may comprise a vertically extending passage 86 in the shaft 30, which passage is offset from the axis of rotation of shaft 30 and is communicated with the eye 88 of the pump means in the shaft by means of a lateral or transversely disposed passage 89. The eye 88 of the pump means communicates with the sump 90 defined between the lower shell 13 and the annular sleeve 20 via a passage 91 in the thrust washer 92 and an opening in the lower bearing head 83. Filter or screen member 93 is affixed to lower bearing head 83.

The upper end of the passage 86 communicates with the bearing surfaces between the shaft 30 and bearings 81 and 82 via lateral passages 94 and 95.

Normally, lubrication oil for the uppermost bearing 81 tends to be drawn over the upper bearing as a result of the pressure differential existing at the top of the compressor block adjacent to bearing 81. Such oil can be

come entrained in the suction gases passing over the motor 69 and may pass through the opening 70 and into the cylinder 26 through the suction valve 39. Such loss of oil from the sump might impair bearing lubrication. Further, oil may carry over into the refrigeration system and restrict refrigerant flow, as well as hamper heat transfer.

A further problem which exists at start-up of compressor operation is priming the pump means. At start-up, the passage 97 may be filled with oil or liquid refrigerant or both and passages 98 and 99 may be filled with refrigerant gas. For proper pumping action, the flow of oil must be from passage 97 through passages 98 and 99. It has been determined that proper pumping is dependent upon the respective radii or lengths of passages 97 and 99 and the respective densities of material in the passages. At a predetermined adverse condition for normal air conditioning and heat pump applications, the ratios of the radii to the densities are as follows:

$$\frac{r_2^2}{r_1^2} = \frac{\rho_1}{\rho_v}$$

where

r_1 = effective length of passage 97

r_2 = effective length of passage 99

ρ_1 = density of liquid in passage 97

ρ_v = density of vapor in passage 99

In one typical present application, assume a harsh design condition wherein passage 97 is filled with oil or oil and refrigerant liquid and passage 99 is filled with refrigerant vapor and further assume the refrigerant is at 0° F. and the vapor is superheated at 10° F. Under these circumstances, $\rho_1 = 62.4 \text{ \#/cu. ft.}$ and $\rho_v = .716 \text{ \#/cu. ft.}$ Therefore,

$$\frac{\rho_1}{\rho_v} = 87.3$$

for this particular design. The foregoing further assumes that the gas is essentially incompressible and there are no available energy losses from work or friction from the gas. Thus, it is seen that

$$\frac{r_2^2}{r_1^2}$$

must be greater than 87.3 for proper pumping action. From the foregoing, the respective lengths of passages 97 and 99 may be theroretically determined.

It will be appreciated that the vertical passage may be disposed in shaft 30 offset from the axis of rotation. This arrangement is advantageous for the desired pumping action can be obtained by utilizing shorter effective lengths of passageways 97 and 99.

Where there are limitations of effective arm length or length of passageways 97 and 99, it is difficult to obtain proper pumping action unless additional pumping force is provided. I have found that the pumping force may be materially increased without increasing pump size by utilizing an ejector pump in the lower transverse passage. In FIGURES 5 and 6, there are illustrated details of a modified compressor having an ejector pump arrangement. An elongated generally cylindrical nozzle 120 is provided in the passage 99'. At one end, the nozzle communicates with passage 98. The other end of the nozzle is disposed in passage 99' so as to provide an annular space therebetween. Passage 99' communicates with the eye 88 of the pump via passage 121. In operation, oil will be pumped from the sump via passage 121 as shaft 30 rotates and discharged through passage 99'. The high velocity of the oil passing the free flared end of nozzle 120 will create a suction effect and fluid will be drawn through passages 97 and 98 and the nozzle 120 and discharged from the end of passage 99' into the crankcase. Such construction materially increases the pumping action for a given size machine.

By this invention, means have been provided in the drive shaft for preventing oil passing into the motor compartment and being carried into the cylinders by the suction gas. Such means include an annular groove 96 (FIGURES 1 and 2) in the upper bearing 81, which groove 96 communicates with return passage means in the crankshaft for returning such lubricant to the sump without passage through the motor compartment, thereby preventing entrainment of lubricant in the suction gas. The return passage means comprise a lateral passage 97 which communicates with a generally longitudinally disposed passage 98. The passage 98, which is drilled in shaft 30 and then plugged at the end, is connected at its lower end with a transverse or lateral passage 99 formed in the counterweight portion 100 of crankshaft 30. The passage 99 functions as a pump to draw oil through the return passage means. Thus, it is seen that oil that might tend to become entrained in the suction gas is positively returned to the crankcase by means of the return passage within the drive shaft 30. The oil may be returned to the sump via passages 102 formed in the lower bearing head 83 and communicating the interior of the crankcase with the sump.

Referring now to FIGURES 3 and 4, there is illustrated a compressor embodying a modified arrangement for lubricating the upper bearing means while preventing the entrainment of oil in the suction gas. In this embodiment of the invention, means are provided for positively sealing the upper bearings from the motor compartment and also means are provided for slinging lubricant from the surface of the drive shaft and returning same to the sump.

The sealing means comprise an annular washer-like member 108, made from a suitable sealing material, as for example Teflon, and disposed about the drive shaft in spaced relationship to the upper bearing 81.

Between the bearing 81 and the chamber 110 defined between the seal 108 and the bearing 81 are passage means for communicating the chamber 110 with the annular space 84 between the bearings 81 and 82. The passage means 112 may comprise a groove formed in the exterior surface of the bearing 81 or a groove formed in the mating surface of the compressor block adjacent to the upper bearing 81.

Operatively affixed to the shaft 30 and movable within the chamber 110 is a slinger ring 114. The slinger ring preferably comprises a resilient O-ring. If desired, an annular metallic, ring-like member may be affixed to the shaft. The slinger ring 114 functions to brake the surface tension of the oil particles and direct the oil particles away from the surface of shaft 30. The slinger ring 114 slings oil from the shaft and aids in returning oil or lubricant from the upper bearing means to the sump via the return passage means in the shaft 30. The return passage means comprise a laterally or transversely disposed passage 116 in shaft 30 which communicates the generally longitudinally extending passage 98 in the shaft with the annular space 84. The lower end of the vertically extending passage communicates with a transversely or laterally disposed passage 99 in the counterweight portion 100 of the shaft 30 for returning oil to the lower portion of the compressor block. Oil in the crankcase may return to the sump 90 defined between the exterior of the annular shell 20 and the interior of the outer casing through opening 102 defined in lower bearing head 83. The modified construction of FIGURE 3 has means for separately sealing the upper bearing from the motor compartment and also means for positively breaking the surface tension of lubricant on the drive shaft and returning the lubricant to the sump from the upper bearing region.

The reason that seal means are desirable between the upper bearing means and the motor compartment is because of the resultant pressure differential at the top of the upper bearing means tending to draw oil out from the bearings into the motor compartment. As aforementioned, the

interior of the compressor between the compression mechanism and the outer housing is substantially at suction pressure, whereas the interior of the crankcase may be pressurized in operation due to the bypassing of discharge gas between a piston and its associated liner.

The present invention provides for maximum lubrication of the upper bearing means, which are spaced from the lubricant contained in the sump, while at the same time providing for a relatively low pumping rate of oil. As aforementioned, it is desired in compressor design that the pumping rate of oil should be as low as possible commensurate with the desired result of assuring proper lubrication of the bearing surfaces. The present design reduces the oil in circulation and thereby minimizes the likelihood that the efficiency of the compressor and of the refrigerating system will be adversely effected by having too much oil in circulation.

Further, the present compressor design uses only a relatively small quantity of oil in the compressor. The space necessary to house the oil may be minimal, thus permitting a more compact compressor design. Thus, it is seen that by the present invention, improved compressor lubrication means have been provided in an efficient and relatively inexpensive manner.

While I have described presently preferred embodiments of my invention, it will be understood that my invention is not limited thereto, since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a reciprocating compressor, a housing, means defining a crankcase in said housing, cylinder means in said crankcase, piston means movable in said cylinder means, a vertically disposed drive shaft in said crankcase, upper bearing means for journaling the crankshaft, the upper end of said crankshaft being operatively connected to a motor, the lower end of said crankshaft extending into a lubricant sump in said housing, conduit means for conveying discharge gases from said cylinder means, conduit means for discharging suction gas into said housing for passage over said motor to said cylinder means, the improvement comprising first pump means in said crankshaft for forcing lubricant from the sump to said upper bearing means for lubricating the upper bearing means, and second pump means in said crankshaft for returning lubricant from the region of said upper bearing means in a path separate from the flow path of suction gas to prevent lubricant from being entrained in the suction gases passing over the motor into the cylinder means.

2. A reciprocating compressor as in claim 1 including means for sealing the upper bearing means from the motor.

3. In a reciprocating compressor, a housing, means defining a crankcase in said housing, cylinder means in said crankcase, piston means movable in said cylinder means, a vertically disposed drive shaft in said crankcase, upper bearing means for journaling the crankshaft, the upper end of said crankshaft being operatively connected to a motor, the lower end of said crankshaft extending into a lubricant sump in said housing, conduit means for conveying discharge gases from said cylinder means, conduit means for discharging suction gas into said housing for passage over said motor to said cylinder means, the improvement comprising pump means in said crankshaft for forcing lubricant from the sump to said upper bearing means for lubricating the upper bearing means, means for sealing the upper bearing means from the motor, return passage means in the crankshaft for returning lubricant from the region of said upper bearing means to the sump, and means independent of said pump means for forcing lubricant through said return passage means, whereby lubricant is pumped through the crankshaft to the upper bearing means and then returned through the crankshaft in a flow path separate from the path of the suction gas.

4. In a refrigerant compressor of the type comprising a vertically disposed drive shaft journaled in upper bear-

ing means in a compressor block and having the lower end thereof immersed in lubricant contained in a sump in the compressor, first passage means in said drive shaft communicating with said lubricant in said sump, a lateral passage connecting said first passage means with a vertical duct in said drive shaft offset from the longitudinal axis of said drive shaft, lateral passage means communicating the exterior of said drive shaft with said vertical duct for lubricating the upper bearing means, the improvement comprising a relatively short lateral return passage in the drive shaft communicating with the exterior of the drive shaft adjacent to the upper bearing means, a vertically disposed return duct communicating with the lateral return passage and a relatively long lateral return passage in the drive shaft communicating with the vertically disposed return duct for returning lubricant to the sump in the compressor.

5. A refrigerant compressor as in claim 4 including means on the drive shaft for breaking the surface tension of the lubricant and returning lubricant through the relatively short lateral return passage, the return duct, and the relatively long lateral return passage in the drive shaft.

6. In a reciprocating compressor, a housing, means defining a crankcase in said housing, cylinder means in said crankcase, piston means movable in said cylinder means, a vertically disposed drive shaft in said crankcase, upper bearing means for journaling the drive shaft, the upper end of said drive shaft being operatively connected to a motor, the lower end of said drive shaft extending into a lubricant sump in said housing, means for conveying discharge gases from said cylinder means and out of said housing, means for receiving suction gas into said housing from a suction line for passage over said motor to said cylinder means, the improvement comprising pump means in said drive shaft for forcing lubricant from the sump to said upper bearing means for lubricating the upper bearing means, means disposed about the drive shaft for sealing the upper bearing means from the motor, said upper bearing means comprising a first upper bearing and a second lower bearing spaced from said first bearing so as to define an annular space about the drive shaft between said bearings, groove means between the first upper bearing and the crankcase for communicating the top of said up-

per bearing with said annular space, return passage means defined in the drive shaft for returning lubricant from said annular space to the sump, and slinger means adjacent the top of said first upper bearing for flinging lubricant from the shaft and through said groove means, annular space and return passage means, whereby lubricant passes through the drive shaft to the upper bearing means and is then returned through the drive shaft in a flow path separate from the path of the suction gas.

7. In a reciprocating compressor, a housing, means defining a crankcase in said housing, cylinder means in said crankcase, piston means movable in said cylinder means, a vertically disposed drive shaft in said crankcase having an enlarged flywheel portion, upper bearing means for journaling the crankshaft, the upper end of said crankshaft being operatively connected to a motor, the lower end of said crankshaft extending into a lubricant sump in said housing, conduit means for conveying discharge gases from said cylinder means, conduit means for discharging suction gas into said housing for passage over said motor to said cylinder means, pump means in said crankshaft for forcing lubricant from the sump to said upper bearing means for lubricating the upper bearing means, means for sealing the upper bearing means from the motor and means in said crankshaft for returning lubricant from the region of said upper bearing means to the sump in a path separate from the flow path of suction gas through the compressor to prevent entrainment of lubricant in the suction gas, said lubricant returning means including a first transverse passage, a vertically disposed passage communicating at one end with said first transverse passage, a second transverse passage in said flywheel portion of said drive shaft, and an ejector nozzle in said second transverse passage communicating at one end with said vertically disposed passage for increasing the flow of lubricant through said lubricant returning means.

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