

June 24, 1969

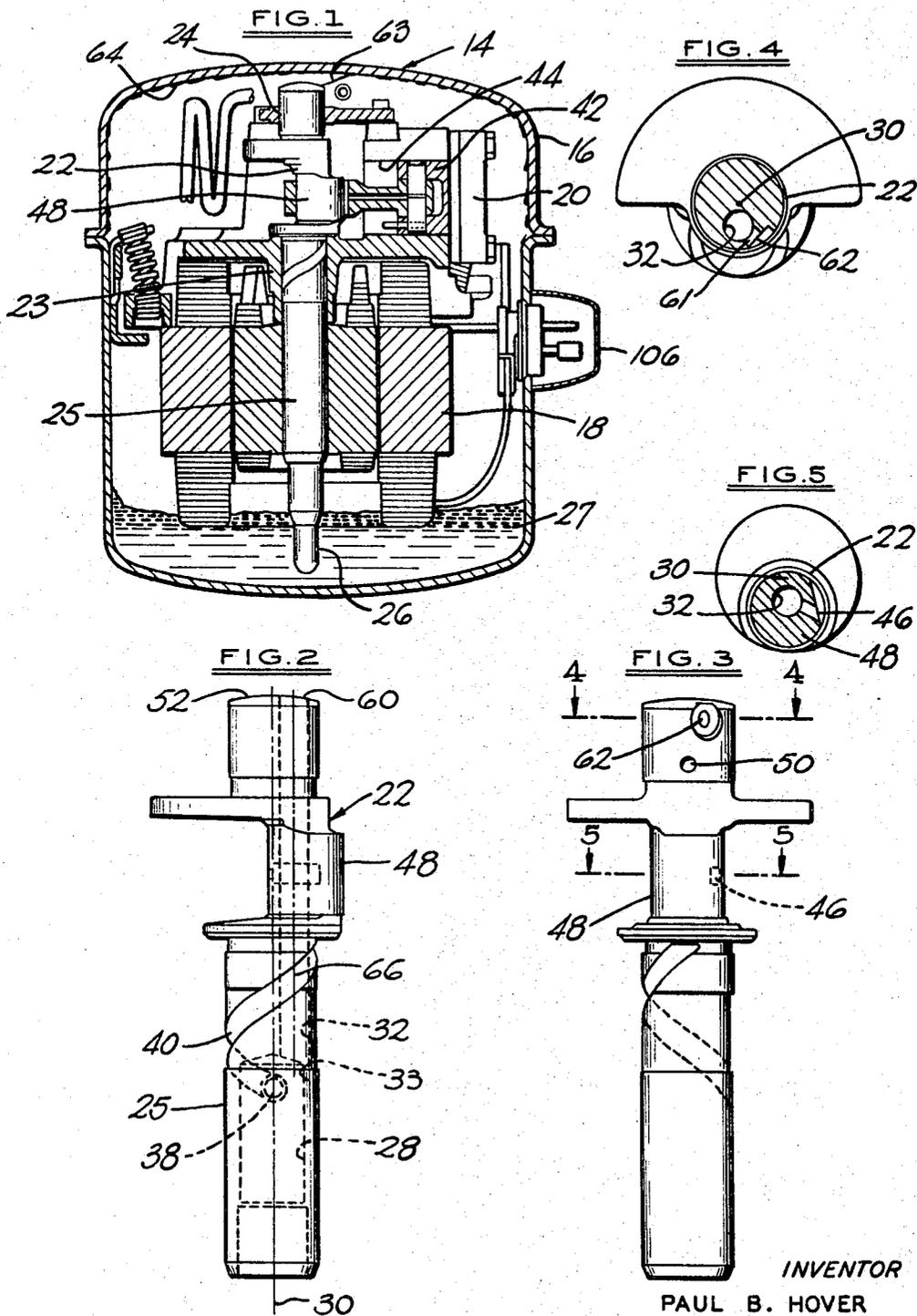
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3,451,615

COMPRESSOR LUBRICATING SYSTEM

Filed July 12, 1967

Sheet 1 of 2



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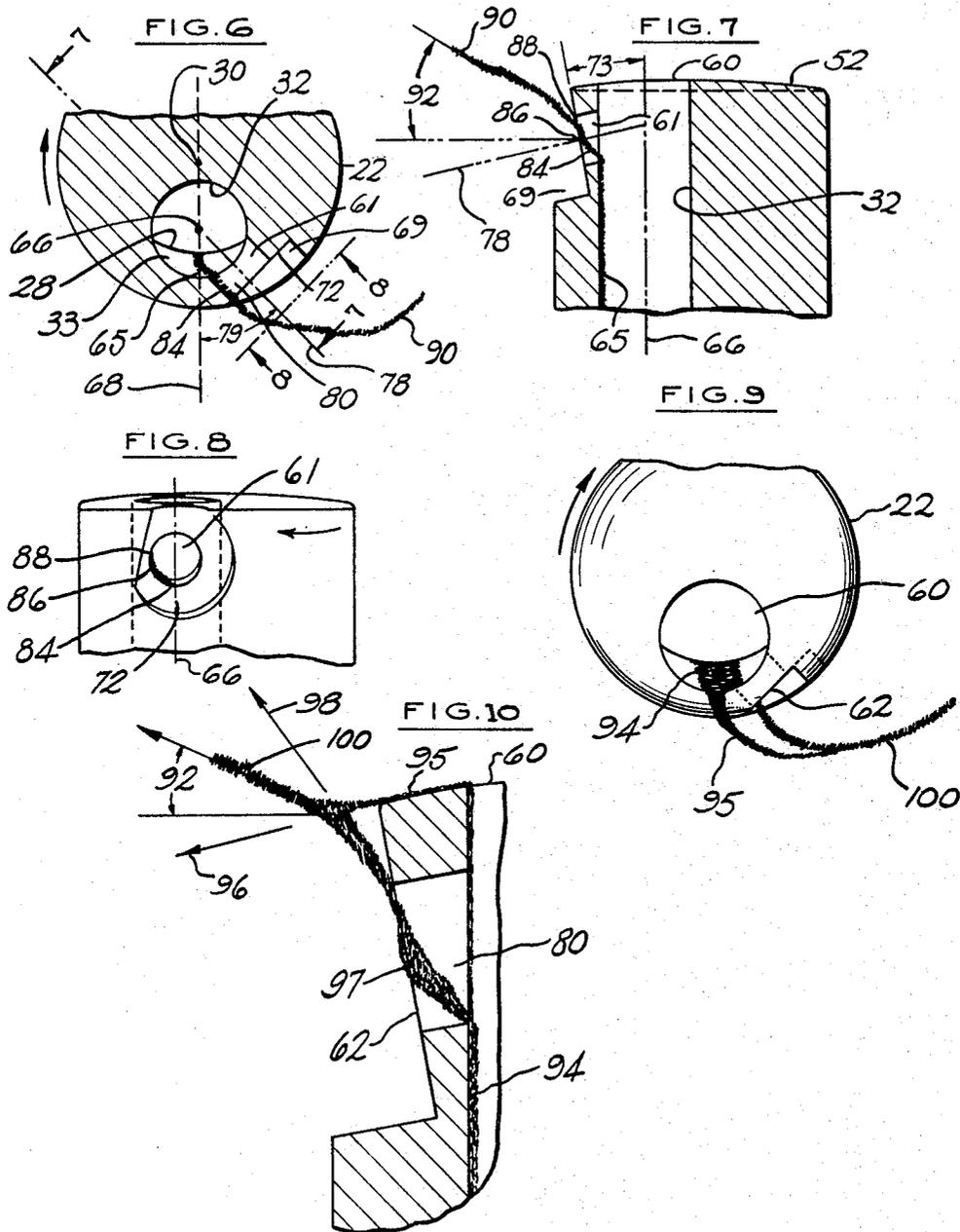
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Sheet 2 of 2



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COMPRESSOR LUBRICATING SYSTEM

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Filed July 12, 1967, Ser. No. 652,789

Int. Cl. F04b 39/02

U.S. Cl. 230—206

16 Claims

ABSTRACT OF THE DISCLOSURE

By way of information and not limitation, a compressor crankshaft has an eccentric bore which pumps lubricating oil through the crankshaft for distribution to various compressor parts. At the upper end of the crankshaft there is an axially directed port and a generally radially directed port for discharging oil from the bore. These two ports are arranged so that centrifugal force discharges oil from the bore through the radial port at low crankshaft speeds and through both ports at higher crankshaft speeds. Oil discharged at both speeds is directed toward the compressor shell at substantially the same vertical angle.

In one type of compressor-motor unit that is available commercially, compressor parts are lubricated by pumping oil through a passageway in the crankshaft of the compressor. The crankshaft passageway is eccentric to the rotational axis of the crankshaft to provide a pumping action. As the oil moves upwardly through the passageway, some of the oil is directed outwardly through suitable ports in the crankshaft to lubricate compressor parts. Oil that is not used for lubricating is expelled at or near the top of the crankshaft and returns by gravity to a sump in the lower portion of the compressor shell for recirculation.

Prior arrangements for discharging excess oil have certain disadvantages, particularly where a given compressor can operate at different crankshaft speeds or where crankshaft speeds are not uniform among different compressors of the same type. Crankshaft speed also varies somewhat depending on the load. Additionally, a given type of compressor operating on 60 cycle alternating current for domestic use may run at one speed, say 3150-3550 r.p.m., and the same type of compressor operating on 50 cycles alternating current for foreign use will run at a lower speed, say 2600-2950 r.p.m. For most effective operation of the unit, substantially all of the excess oil should be sprayed against the compressor shell in a substantially uniform pattern at all crankshaft speeds. This will provide improved cooling of the oil and also cause temperature variations at the shell to closely and uniformly follow temperature variations at other compressor-motor parts. This latter feature is particularly important in units having an overload protection circuit for the compressor that is responsive to the temperature of the shell. If the temperature of the compressor shell uniformly follows the temperature of other compressor-motor parts inside the shell at all crankshaft speeds, the protection circuit can be designed for higher sensitivity and it will operate more uniformly as compared to prior art units.

The objects of the present invention are to provide a lubricating system for a compressor-motor unit that overcomes the aforementioned disadvantages; that provides improved and more uniform cooling of the lubricating oil and the compressor-motor unit; that provides more uniform temperature variation at the compressor shell in response to temperature variation at other compressor-

motor parts within the shell; and that provides more effective, more uniform and more predictable operation of the unit as compared to units having prior art lubricating systems.

Other objects, features and advantages of the present invention will become apparent in connection with the following description, the appended claims and accompanying drawings in which:

FIG. 1 is a vertical sectional view of a hermetically sealed compressor-motor unit incorporating a lubricating system of the present invention;

FIG. 2 is a view of the crankshaft in the compressor-motor unit of FIG. 1;

FIG. 3 is a side view of the crankshaft shown in FIG. 2;

FIG. 4 is a horizontal section taken on line 4-4 of FIG. 3 through a generally radial discharge port on the upper end of the crankshaft.

FIG. 5 is a horizontal section taken on line 5-5 of FIG. 3;

FIG. 6 is an enlarged fragmentary horizontal section from FIG. 4;

FIG. 7 is a vertical section taken on line 7-7 of FIG. 6 and also illustrates an oil stream leaving the crankshaft at low crankshaft speeds.

FIG. 8 is a fragmentary side view taken on line 8-8 of FIG. 6;

FIG. 9 is an enlarged fragmentary top view of the crankshaft; and

FIG. 10 is an enlarged vertical section corresponding to FIG. 7 and illustrating an oil stream leaving the crankshaft at high crankshaft speeds.

FIG. 1 illustrates a hermetically sealed compressor-motor 14 comprising the usual hermetically sealed shell 16 with a motor 18 and a compressor 20 mounted together on shell 16 with the compressor disposed above the motor. The compressor-motor may be generally conventional and thus will be described in detail only to the extent necessary to an understanding of the present invention. The compressor 20 includes a crankshaft 22 journaled in bearings 23, 24 and having a crankshaft extension 25 that serves as the rotor shaft for motor 18. Mounted on the lower end of the crankshaft 22 is a sump pump 26 projecting into a pool of lubricating oil 27 collected in the lower portion of shell 16. In the lower portion of crankshaft 22 is an axial bore 28 (FIG. 2) concentric with the rotational axis 30 of the crankshaft and communicating at its lower end with pump 26. The upper end of bore 28 communicates with a smaller longitudinal bore 32 offset radially from bore 28 by a shoulder 33 and extending upwardly therefrom parallel to axis 30 so as to be eccentric thereto. Although in the preferred embodiment, pump 26 comprises the stepped pick-up tube shown in FIG. 1 and disclosed and claimed in a copending United States application, Ser. No. 636,476, filed May 5, 1967, other conical-centrifugal pumps, such as described in United States Patent No. 2,287,203 may be used to lift oil from the bottom of shell 16 upwardly through bore 28 and into bore 32. Because bore 32 is offset slightly radially outwardly from bore 28 (at shoulder 33), the oil receives additional lift as it moves from bore 28 to bore 32 due to centrifugal force. Crankshaft 22 has the usual porting arrangements for lubricating various compressor parts. Bearing 23 is lubricated by means including a port 38 and a spiral groove 40. A piston 42 and a cylinder 44 are lubricated by means including a port 46 (FIG. 5) in a crankpin 48 and bearing 24 is lubricated by means including a radial port 50 (FIG. 3).

Bore 32 opens upwardly at a top face 52 on crankshaft 22 to form an axial discharge port 60 (FIGS. 2 and 9). Crankshaft 22 also has a generally radial passageway 61 communicating at its inner end with bore 32. The outer end of passageway 61 opens at the side of crankshaft 22,

forming a second discharge port 62 just below face 52 generally in line with the radially outermost edge of port 60. Excess oil which does not pass through the various lubricating ports 38, 46 and 50 reaches the top of bore 32 where it is expelled from crankshaft 22 through either port 62 or both ports 60, 62 and directed against shell 16.

In accordance with the present invention, the arrangement and construction of ports 60, 62 are such that excess oil leaves crankshaft 22 in a stream designated generally at 63 (FIG. 1). The oil stream 63 is directed upwardly and outwardly toward an inner top surface 64 of shell 16 at a vertical angle within a predetermined angular range to assure that all or substantially all of the oil contacts the shell for effective cooling of the oil and uniform temperature variation of the shell in response to temperature variations at motor 18 and compressor 20. As the rotational speed of crankshaft 22 increases, the oil stream 63 would tend to become more upwardly inclined. However, with increased crankshaft speeds, oil also leaves crankshaft 22 via port 60. The oil leaving port 60 combines with the oil leaving port 62 in such a way that the combined stream remains at approximately the same vertical angle as the stream issuing from port 62 alone at low crankshaft speeds.

Referring in greater detail (FIGS. 6-10) to the arrangement and construction of ports 60, 62, bore 32 has a circular transverse cross section and a vertically disposed longitudinal axis 66. The diameter of bore 32 and the location of axis 66 are such that bore 32 is located radially of axis 30 and oil is forced radially outwardly in bore 32 by centrifugal force. Oil moves upwardly in bore 32 toward ports 60, 62 as a narrow film 65 located along a radially outermost zone of bore 32. Axis 66 lies in a vertical plane 68 which also contains axis 30. Rotation of crankshaft 22 is clockwise as viewed in FIGS. 6 and 9. The top face 52 of crankshaft 22 is dome-shaped, inclining slightly downwardly and radially outwardly from axis 30. Port 60 is slightly elliptical due to the downward curvature of face 52.

The side wall of crankshaft 22 is recessed inwardly at 69 just below face 52 and radially outwardly of port 60. The bottom of recess 69 forms a flat generally chordal face 72 containing port 62. Face 72 begins slightly trailing plane 68 and extends into crankshaft 22 beyond port 62. Face 72 is also inclined downwardly and inwardly of crankshaft 22 below port 62 at a slight vertical angle 73 which is about 10° in the preferred embodiment. Recess 69 is a fragmentary counterbore in the preferred embodiment, although the particular configuration is not essential to the present invention. The generally radial passageway 61 extends inwardly from port 62 through the side wall of crankshaft 22 and opens at its inner end into bore 32. Passageway 61 has a longitudinal axis 78 that intersects plane 68 at a horizontal angle 79 from plane 68. Axis 78 is perpendicular to face 72 and thus axis 78 and passageway 61 are inclined downwardly from axis 66 at 10° in the preferred embodiment. Also in the preferred embodiment, angle 79 is 45°. The diameter of passageway 61 and the angle of axis 78 are such that a leading wall portion 80 of the passageway intersects bore 32 closely adjacent plane 68 to intercept the oil 65 at low crankshaft speeds. As viewed in FIG. 6, the leading wall portion 80 is clockwise from the bottom of passageway 61. This arrangement assures that oil entering passageway 61 moves upwardly and generally radially outwardly on the leading wall 80.

In the operation of the lubrication system described hereinabove, when crankshaft 22 rotates at a relatively slow speed, pump 26 lifts oil 27 from the lower portion of shell 16 through bore 28 and into the eccentric bore 32. Due to the eccentricity of bore 32 and its offset relation to bore 28, the oil receives additional lift as it moves into bore 32. At relatively slow crankshaft speeds, the oil moves upwardly through bore 32 in the relatively narrow film 65. When the oil film 65 encounters passageway 61, it

enters passageway 61 on the leading wall 80, that is, slightly leading the bottom of the passageway. At low crankshaft speeds, when the trailing portion of film 65 encounters passageway 61, surface tension and cohesion of the oil film causes all of the oil to move into passageway 61. Centrifugal force causes the oil in passageway 61 to move upwardly and radially outwardly along wall 80 as illustrated at 84 (FIGS. 6 and 7). The oil 84 passing outwardly through passageway 61 tends to exit from the port 62 at the most forward or leading location on the port designated at 86 (FIG. 8). However, due to the upwardly and radially outwardly inclination of face 72, the oil 84 continues upwardly along the intersection edge between passage 61 and face 72 and leaves crankshaft 22 at a point designated by numeral 88. At low crankshaft speeds, oil from port 62 leaves in a stream 90 inclined upwardly and radially outwardly from the crankshaft toward surface 64 of shell 16. The vertical angle 92 at which stream 90 leaves crankshaft 22 is chosen so that all or at least most of the oil strikes the top of the shell 16. In the preferred embodiment, the vertical angle 92 is on the order of from 10-30° for the particular arrangement of shell 16 and the top of the crankshaft 22 shown in FIG. 1. Although each particle of oil in stream 90 follows a linear path once it leaves crankshaft 22, as the crankshaft 22 rotates the oil stream 90 will appear to spiral outwardly and rearwardly as illustrated in FIG. 6. Oil in stream 90 flows down the inner surface of the shell due to adhesion and gravity and returns to the bottom of the shell. The oil transfers heat from motor 18 and compressor 20 to shell 16 which in turn transfers heat to the surrounding environment.

At higher crankshaft speeds, more oil is pumped into bore 32 and subjected to greater centrifugal forces which cause the oil to move upwardly in bore 32 in a substantially wider film 94 (FIG. 9). At these higher crankshaft speeds and higher oil velocities, all of the oil in the wide oil film 94 does not enter the passageway 61 and thus that portion of film 94 leading passageway 61 continues upwardly and leaves bore 32 via port 60 at the radially outermost portion thereof. Centrifugal force, gravity and adhesion cause an oil stream 95 leaving port 60 to flow in a generally downwardly and radially outwardly direction on the top face 52 as illustrated by arrow 96 (FIG. 10). At these higher crankshaft speeds, some oil 97 enters passageway 61 where it is subjected to greater centrifugal forces than at low speeds. The increased centrifugal force imparts greater lift to oil 97 as it moves on wall 80 so that oil 97 tends to leave crankshaft 22 from port 62 at a steeper vertical angle (arrow 98) than at low speeds. However, the oil stream 95 from port 60 leaves crankshaft 22 just above where the oil 97 from port 62 leaves the crankshaft, and the two streams of oil from ports 60, 62 converge into a combined stream 100 (FIG. 10). The arrangement of ports 60, 62 is such that the combined stream 100 is vertically inclined from horizontal at substantially the same vertical angle (angle 92, FIGS. 7 and 10) as the single oil stream 90 from port 60 at slow crankshaft speeds. With crankshaft speed variations at the higher crankshaft speeds, variations in the velocity and direction of the oil in stream 97 are offset by generally proportional velocity variations of the oil in stream 95 so that the direction of stream 100 remains substantially constant. Thus, at higher speeds, oil in stream 100 strikes shell 16 at substantially the same angle and pattern as the oil in stream 90 at low speeds.

With the lubricating system described hereinabove, excess oil is directed against the shell in a uniform pattern throughout 360° rotation of the crankshaft and the pattern remains relatively uniform at all crankshaft speeds. This represents a substantial improvement over prior art lubricating systems wherein the direction of the oil stream leaving the crankshaft is more or less random and unpredictable by comparison to the present invention. With

the present invention, the particular angle at which the oil stream (90, FIG. 7; 100, FIG. 10) leaves crankshaft 22 and strikes shell 16 can be chosen so that substantially all of the oil reaches the shell and flows downwardly on the inner surface of the shell without excessive splattering. The direction of the oil stream leaving crankshaft 22 is selected to assure that the oil remains in contact with shell 16 for the longest possible time as it flows downwardly on the inner surface of the shell to the sump. Thus, for example, the angle of the oil stream is directed toward the top of shell 16 rather than toward the side of the shell so that it must travel further along the shell to reach the bottom. This increases the amount of heat transferred from the oil to the shell. Thus, additional and more uniform cooling of the oil and of the compressor and the motor is achieved as compared to prior art lubricating systems. Cooling of the oil is efficient at different compressor speeds for a given compressor and relatively uniform for different compressors of the same general type. Uniform and efficient distribution of the oil also tends to provide relatively uniform temperature variation at the shell in response to temperature variations at other compressor parts. Since the temperature of the shell closely and uniformly follows the temperature of other compressor parts at all crankshaft speeds, improved and more effective overload protection circuits can be used. For example, in FIG. 1 there is an overload protection apparatus 106 mounted on the exterior of shell 16. The overload protection circuit is generally conventional and operates in response to the temperature at the shell. With improved temperature response at the shell according to the present invention, the overload protection circuit can be designed with greater sensitivity and less tolerance than would have to be allowed for nonuniform temperature response with prior art units.

It will be apparent that passageway 61 (axis 78) is not on a true radius of crankshaft 22 (axis 30) although it is radial to bore 32 (axis 66). Thus, the term "radial" is used broadly herein to describe port 62 and passageway 61 and is intended to include arrangements where there is a radial displacement between the port and the oil film so that centrifugal force can propel the oil radially outwardly through the passageway.

It will be understood that the compressor lubricating system has been described hereinabove for purposes of illustration and is not intended to indicate limits of the present invention the scope of which is defined by the following claims.

I claim:

1. In a compressor having a crankshaft provided with a bore through which lubricating fluid is pumped and wherein said crankshaft has discharge means on an upper end portion thereof which is spaced from a shell of said compressor and adapted to fling lubricating fluid from said bore outwardly of said crankshaft against said shell and wherein said bore opens at a top face of said crankshaft to form a first port of said discharge means, that improvement wherein said discharge means further comprises a generally radial passageway in said upper portion of said crankshaft, said passageway having a radially inner end opening into said bore below said first port and a radially outer end opening at a side of said end portion below said first port to form a second discharge port, said second discharge port being in substantially constant communication with said space between said shell and said upper end portion of said crankshaft throughout substantially a full 360° rotation of said crankshaft so that fluid in said bore is discharged from said second port and flung against said shell throughout substantially a full 360° rotation of said crankshaft substantially free of obstruction from other compressor parts.

2. In a compressor having a crankshaft provided with a bore through which lubricating fluid is pumped and wherein said crankshaft has discharge means on an upper end portion thereof spaced from a shell of said compressor

to fling lubricating fluid from said bore outwardly of said crankshaft against said shell, that improvement wherein said discharge means further comprises a generally radial passageway in said upper portion of said crankshaft, said passageway having a radially inner end opening into said bore and a radially outer end opening at a side of said end portion to form a discharge port, said discharge port being in substantially constant communication with said space between said shell and said upper end portion of said crankshaft throughout substantially a full 360° rotation of said crankshaft so that fluid in said bore is discharged from said port and flung against said shell throughout substantially a full 360° rotation of said crankshaft substantially free of obstruction from other compressor parts.

3. The device set forth in claim 2 wherein said discharge means further comprises a generally chordal face on the side of said crankshaft, said face is inclined downwardly and radially inwardly on said crankshaft, and said port opens at said face so as to form an intersecting edge between said face and said second passageway inclined upwardly and radially outwardly to impart additional lift to lubricant discharged from said port.

4. A lubricating system for an apparatus having a rotatable body therein, said body having a passageway therethrough to conduct lubricating oil through said body, means for moving oil through said passageway while said body rotates, said passageway being disposed in said body to extend in substantially the same direction as the rotational axis of said body and being offset radially from said axis so that when said body is rotating centrifugal force tends to propel said oil radially outwardly from said axis but radially outward movement of the oil is limited by the inner wall of the body bounding said passageway, first discharge means on said body operatively communicating with said passageway and opening exteriorly of said body so that when said body rotates at one speed centrifugal force propels oil through said first discharge means and outward from said body directed within a predetermined angular range relative to a radial plane through said body, and second discharge means on said body operatively communicating with said passageway and opening exteriorly of said body so that when said body rotates at a second speed centrifugal force propels oil through said second discharge means to combine with oil leaving said body via said first discharge means and direct combined oil leaving said body within said predetermined angular range where oil leaving said body via said first discharge means would otherwise be directed outside of said predetermined angular range unless combined with oil leaving said body via said second discharge means.

5. In a lubricating system wherein lubricating oil moves through a passageway in a vertically disposed rotating shaft and wherein oil is discharged from said passageway and directed horizontally outwardly from said shaft in a stream by discharge means on the shaft, that improvement wherein said discharge means maintains said oil stream at a predetermined substantially constant vertical direction relative to said shaft as the rotational speed of said shaft varies comprising first discharge port means communicating from said passageway through said shaft and being constructed so that at one rotational speed of said shaft oil from said passageway leaves the shaft through said first discharge port means in a stream having a predetermined vertical direction relative to the shaft, the vertical direction of said stream tending to deviate from said predetermined vertical direction when the rotational speed of said shaft varies from said first rotational speed to a second rotational speed, and second discharge port means communicating from said passageway through said shaft and being constructed so that at said second rotational speed oil from said passageway leaves said shaft through said second discharge port means in a direction to combine with oil leaving said shaft from said first port means

and maintain said combined oil stream at substantially said predetermined vertical direction.

6. A lubricating system for a compressor of the type having a rotatable crankshaft, a passageway in said crankshaft for conducting lubricating oil through the shaft, lubricating outlets on said shaft to conduct oil from said passageway to other compressor parts, means for moving oil through said passageway while said shaft rotates, and discharge means on said shaft downstream of said lubricating outlets and communicating from said passageway through the wall of said shaft to conduct oil from said passageway and discharge the oil exteriorly of the shaft when said shaft is rotating, said discharge means comprising first discharge port means constructed so that at one rotational speed of said shaft oil from said passageway leaves said shaft through said first discharge port means in a stream having a predetermined direction relative to said shaft, and second discharge port means constructed so that at a second rotational speed of said shaft oil from said passageway leaves said shaft through said second discharge port means in a direction to combine with oil leaving said shaft from said first discharge port means and maintain the direction of said combined stream of oil from said first and said second discharge port means at substantially said predetermined direction relative to said shaft.

7. A compressor-motor unit comprising a housing, a compressor mounted in the housing and having a crankshaft rotatable about a vertically disposed axis, liquid lubricant in said housing, a sump in the lower portion of the housing for collecting said lubricant, a passageway in said crankshaft extending in a direction generally axially of said crankshaft, said passageway including an upper portion in the upper portion of the crankshaft eccentric to the rotational axis of said crankshaft, pump means for moving lubricant from said sump upwardly into said passageway, first discharge means on said upper crankshaft portion operatively communicating with said upper passageway portion and constructed so that at low crankshaft speeds lubricant leaves said crankshaft in a stream directed generally radially outwardly of said shaft toward said housing within a predetermined range of vertical angles relative to a radial plane through said shaft, and second discharge means on the upper crankshaft portion operatively communicating with said upper passageway portion and constructed so that at higher crankshaft speeds lubricant leaving said crankshaft via said second discharge means combines with lubricant leaving said crankshaft via said first discharge means to form a combined stream directed generally radially outwardly from said crankshaft toward said housing within said predetermined range of vertical angles whereby lubricant leaves said crankshaft in a stream at a substantially constant direction relative to said crankshaft at both said low and said higher crankshaft speeds to contact said housing in a predetermined zone that remains substantially constant at both said low and said higher crankshaft speeds.

8. The device set forth in claim 7 wherein said first discharge means includes a port opening at a side of said crankshaft in a direction generally radially outwardly of said crankshaft to direct said stream upwardly and outwardly from said crankshaft toward said housing at low crankshaft speeds and said second discharge means includes a second port disposed above said first port and opening generally axially of the crankshaft eccentric to said rotational axis.

9. The device set forth in claim 8 wherein said upper portion of the crankshaft extends above adjacent com-

pressor parts and said first port and said second port are in substantially constant communication between said upper passageway portion and the interior of said housing throughout substantially a full 360° rotation of said crankshaft.

10. The device set forth in claim 8 wherein said second port opens at a top end face of said crankshaft above said first discharge port and said end face slopes downwardly and radially outwardly from said second port toward said first port so that at said higher crankshaft speeds lubricant leaving said second port is directed downwardly and radially outwardly by said face toward said first discharge port to combine with lubricant leaving said crankshaft through said first port.

11. The device set forth in claim 8 wherein said upper passageway portion opens at a top face of said crankshaft to form said second port, said upper passageway portion has a longitudinal axis disposed in a vertical plane which contains said rotational axis, and said first port has an axis extending therethrough and intersecting said longitudinal axis at a vertical angle with respect to said radial plane.

12. The device set forth in claim 11 wherein said first discharge means comprises a second passageway having a radially outer end opening at the side of said crankshaft to form said first port and a radially inner end opening at said first mentioned passageway closely adjacent said vertical plane.

13. The device set forth in claim 12 wherein said second passageway has its wall contoured such that when said crankshaft rotates lubricant entering the inner end of said second passageway is directed upwardly along said passageway wall as lubricant is propelled radially outwardly through said second passageway due to centrifugal force.

14. The device set forth in claim 13 wherein said first discharge means further includes a generally chordal face on the side of said crankshaft, said face is inclined downwardly and radially inwardly of said crankshaft, and said first port opens at said face so as to form an intersecting edge between said face and said second passageway inclined upwardly and radially outwardly to impart additional lift to lubricant discharged from said first port.

15. The device set forth in claim 8 wherein said first discharge means comprises a second passageway communicating at its radially inner end with said first passageway and opening at its radially outer end at a side of said crankshaft to form said first port, said second passageway having a wall that directs lubricant upwardly and radially outwardly when lubricant is moved through said second passageway by centrifugal force.

16. The device set forth in claim 15 wherein said first passageway opens upwardly at a generally horizontal upper face on said crankshaft to form said second port and said upper face slopes downwardly and radially outwardly from said second port to direct lubricant leaving said second port in a downwardly and radially outwardly direction due to centrifugal force.

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