ABSTRACT OF THE DISCLOSURE

A crankcase construction for a hermetic compressor of the piston type wherein the electric motor compressor unit is spring suspended within the hermetically sealed casing. The crankcase is substantially closed to define a sealed cavity within which the connecting rod and crankshaft travel during transmittal of driving force from the driveshaft to the piston of the compressor. The sealed cavity is provided with a venting passage or passages which are particularly oriented to help balance or cancel out reaction forces and thereby, in conjunction with the substantially closed crankcase, significantly reduce the amount of vibration of the motor-compressor unit on its spring mounts in the casing.

An object of the present invention is to provide an improved hermetic compressor crankcase construction which contributes to a significant reduction in vibration and noise level of the compressor on its spring mount in a hermetic casing.

Another object is to provide a hermetic compressor crankcase construction of the above character which also reduces the foaming action at the start up of the compressor such that the oil level does not fall below the inlet to the oil pump, thereby overcoming a problem of loss of lubrication at start up.

Other objects as well as features and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a vertical center section along the axis of the motor-compressor unit embodying the crankcase construction of the present invention.

FIG. 2 is an end elevational view of the unit shown in FIG. 1 taken in vertical section on the line 2—2 of FIG. 1, portions of the motor-compressor unit being broken away to illustrate detail.

FIGS. 3, 4 and 5 are fragmentary perspective views of first, second and third embodiments respectively of the crankcase construction of the present invention, the crankcase being viewed from beneath with the bottom cover plate removed.

FIG. 6 is a side elevational view of fourth and preferred embodiment of the crankcase construction of the invention, a portion being broken away to better illustrate detail.

FIG. 7 is a top plan view of the crankcase of FIG. 6.

FIG. 8 is a perspective view of the crankcase construction of FIGS. 6 and 7.

Referring in more detail to FIGS. 1 and 2, a refrigerant compressor unit 10 is illustrated which comprises a hermetically sealed casing or housing 11 made up of a lower half 12 joined to an upper half 14 and containing a motor-compressor unit 18. Unit 18 includes a stator 22, rotor 24, crankshaft 26 driven by rotor 24, connecting rod 28 having its big end 30 journalled on the throw 32 of the crankshaft and its small end 34 connected by a wrist pin 36 to a piston 38 which reciprocates in a cylinder bore 40 in the cylinder block 42 of the compressor.

Block 42 is herein shown by way of example cast integrally with the crankcase 44 of the compressor which in turn serves as the supporting frame of unit 18. Unit 18 is supported in spaced relation from the interior wall of the casing by a plurality of spring supports 20 such as those disclosed in a copending application of Billy B. Hannibal and Paul B. Hover ser. No. 670,240, filed Sept. 25, 1967, and assigned to the assignee herein, now U.S. Patent No. 3,445,059. Thus crankcase 44 has outwardly projecting ears 46 provided with threaded holes 48 in which the lower ends of spring supports 20 are individually screw threaded.

The top wall 50 of crankcase 44 is either completely imperforate as shown in FIGS. 3 and 4 or substantially imperforate as shown in FIGS. 5–8 inclusive wherein special vents are provided as described with respect to certain of the embodiments described hereinafter. Wall 50 may include a hub portion 52 in which crankshaft 26 is journaled. The lower side of crankcase 44 is hermetically closed, preferably by a separate bottom 54 secured by studs 56 to crankcase 44. Plate 54 also has a hub portion 58 which serves as the lower or outboard journal for the outboard end 60 of crankshaft 26. A suitable centrifugal oil pump 62 may be secured to the lower end 60 of the crankshaft which, in response to rotation of the crankshaft, pumps oil from the oil sump 64 in the casing up through oil supply passages 66 in the crankshaft 26. Unit 18 also has the usual dual refrigerant gas intake pipes 70 and 72 which are open at their upper ends to the interior atmosphere of the casing and are connected at their lower ends to a manifold 74 which communicates with the inlet valve chamber 75 of the compressor.

Compressor 10 as thus far described, except for the substantially closed vented configuration of the crankcase, is conventional and well understood in the art and therefore it is believed that its construction and operation need not be further described herein.

The crankcase construction of the present invention is based in part on the discovery that some of the vibration encountered with prior piston-type hermetic compressors is due to the "open" type crankcase construction, e.g., wherein the wall of the crankcase disposed diametrically opposite the cylinder bore has a relatively large opening providing free communication between the crankcase and the sealed atmosphere of the casing, as compared to the present invention wherein the back side of the crankcase 44 is closed in by the wall 76 as illustrated in FIG. 1. The vibration of the motor-compressor unit of such prior compressors on its spring mounting in the hermetic casing has been found to be caused by the gas in the crankcase being alternately drawn into and expelled from the crankcase by the action of the underside 78 of piston 38 moving back and forth and thus forming a movable wall communicating with the crankcase chamber 80. The inertial effects of this column of gas as well as the jet effects in the column reaching the wall of casing 11 sets up a force system between the spring suspended motor-compressor unit and the casing which in turn causes the unit to oscillate on its spring suspension and thereby produce vibrations which are undesirable from the standpoint of noise, compressor mounting requirements and part damage and wear attributable to vibratory stresses.

In accordance with the present invention, vibration of the above character is reduced by providing a crankcase 44 which is almost fully closed around the connecting rod cavity 80, thereby isolating the gases exposed to the back side 78 of piston 38 from the gases in the space 82 between crankcase 44 and casing 11 of compressor 10. The gases in the crankcase cavity 80 now will be com-
pressed against the interior walls of cavity 80. Since the crankcase is a rigid part of the cylinder block casting, the reaction forces are "locked up" in this casting and hence balanced internally so that they do not set up a force system between the suspended unit 18 and the hermetic casing 11 which otherwise would tend to produce vibrations.

However, it is not feasible to completely close or hermetically seal the crankcase cavity from the surrounding atmosphere in casing 11 because pressure would then build up in the crankcase due to the unavoidable small leakage past the rings of the piston 38, and such pressure build up would undesirably affect lubricant flow to the bearings. Also, it is necessary to provide a vent from the crankcase cavity to the surrounding casing to allow oil which collects in the crankcase to return to the sump 64. In accordance with the present invention, the necessary venting is achieved without sacrificing the desirable effect of a closed crankcase by providing one or more venting passages which are aligned in a plane 150 and 250 and dynamic gas forces existent in the compressor casing and structure and/or other sources of vibration inducing reaction forces such that a balancing effect is obtained tending to damp or cancel out vibration inducing forces. Before describing the particular preferred venting arrangement of crankcase 44 shown in FIG. 6, it is believed that the invention will be better understood by first describing three illustrative embodiments of the invention comprising crankcase units 144, 244, and 344 of FIGS. 3, 4 and 5 respectively. Each of these units is identical to crankcase 44 except for the gas venting arrangement thereof, and they are shown for clarity of illustration viewed from slightly below with the bottom plate 54 removed.

Referring first to FIG. 3, unit 144 has the generally cylindrical cavity 80 defined by top wall 50, bottom plate 54 (not shown), the structure of the cylinder block 42 at one end, the diametrically opposite back wall 76, and the curved side walls 146 and 148. In this embodiment cavity 80 is vented to the surrounding casing chamber 82 by a pair of diametrically opposed vent passages 150 and 152 extending respectively through side walls 146 and 148. Passages 150 and 152 are preferably coaxial and their common axis is coincident with the axis of crankshaft 52 and perpendicular to the axis of bore 40. With this arrangement the reaction forces produced by the gases being forced through vents 150 and 152 in response to contraction and expansion of chamber 80 as a result of piston reciprocation are oriented opposite to one another and for practical purposes produce an equal magnitude, as indicated schematically by arrows 150' and 152' in FIG. 3. Hence, these reaction forces cancel each other, thereby providing a balanced relationship which does not produce any forces between unit 18 and the casing suspension to induce vibration of the motor-compressor unit 18. Preferably vents 150 and 152 are located more closely adjacent upper wall 50 than to bottom plate 54 so that the crankcase has some oil retaining capacity. Vents 150 and 152 thus serve as overflow openings so that oil accumulating in cavity 80 can drain back to sump 64. Vents 150 and 152 also prevent pressure build up in crankcase cavity as a result of gas leakage past the piston rings from the compression chamber 41.

Referring to FIG. 4, crankcase unit 244 is closed except for the pair of venting passages 246 and 248 provided in the side wall of the crankcase. Vent passages 246 and 248 are like passages 150 and 152, and are located in the side walls of the crankcase, but their respective axes 250 and 252 intersect one another at an angle of less than 180° and are oriented relative to the axis 40' of bore 40 at equal acute angles. Hence the resultant forces due to acceleration and deceleration of the gas columns in the respective vents 246 and 248 may be resolved as indicated schematically in FIG. 4 by the parallelogram resolution of forces associated with each of the axes 250 and 252 of the respective vent passages. Considering first vent 246 it will be seen that the resultant force represented by the arrow 254 may be resolved into a component 256 and a component 258. Likewise, the resultant force associated with the column of gas in passage 248 may be represented by the arrow 260 which may be resolved into two components represented by the arrows 262 and 264. The two components 256 and 262 are coincident with one another and of equal magnitude and act in opposite directions and therefore, cancel one another out, similar to the relationship of the venting reaction forces of FIG. 3.

If the force components shown in FIG. 4 are assumed to be the reaction forces acting on crankcase unit 244, then the condition producing this force system will be the movement of the piston on its compression stroke which is expanding the volume of the cavity 80 and therefore drawing gas via vents 246 and 248 from casing cavity 82 into crankcase cavity 80. Under this condition there is a force exerted by the piston on the gas behind it, tending to "suck" the gas along with the piston, and this is balanced by an equal and opposite reaction force exerted by the gas on the piston in the direction of axis 41. This force is also a potential vibration inducing force which may also be balanced by orienting the crankcase vents in accordance with the present invention as shown in FIG. 4. Thus components 258 and 264 both act in the same direction, parallel to axis 41, and at equal distances from the center of gravity of unit 18 so as not to induce a rotational couple.

Components 258 and 264 are designed to cumulatively equal the aforementioned reaction force exerted on the piston by the gas being accelerated behind the piston.

Crankcase unit 344 illustrated in FIG. 5 comprises a third embodiment of a substantially closed crankcase with the vents provided in top wall 50 of the crankcase cavity 80 instead of in the side walls as in the crankcase units 144 and 244. Preferably, two or more vents 346, 348 are formed so as to extend parallel to the axis 53 of hub 52, and the vents are arranged in a balanced angular relationship around axis 53. Thus if just two vents are provided they are disposed diametrically opposite one another relative to axis 53, and if three vents are provided they are disposed at 120° intervals along the case of the crankcase as shown in FIG. 5, two of these vents 346 and 348 being shown, the spacing is accordingly reduced to 90° intervals. By keeping this balanced angular orientation relative to axis 53 the cumulative resultant reaction force (indicated schematically by arrow 390) from the gas columns surging through the venting ports will be coincident with axis 53, which approximates coincidence with the center of gravity of the unit, and hence no significant rotational couple will be produced by the plurality of vents. The resultant reaction force produced by the vents 346, 348, etc. will, assuming the piston is on a suction stroke, tend to push the crankcase unit 344 downwardly as viewed in FIGS. 1 and 5. This reaction force is designed to balance an upward lifting reaction force produced by the gas being sucked into intake pipes 70 and 72 and manifold 74 as indicated by the arrows in FIG. 2. Hence, this system will tend to balance still another source of vibration inducing forces in the motor compressor unit while still providing a venting arrangement for pressure build up in the crankcase and overflow port for return of oil to the sump and retaining the advantages of a closed crankcase. Another advantage of the crankcase unit 344 illustrated in FIG. 5, is the ability to locate the vents 346, 348, etc. so that the resultant force from the gas columns from said vents is against the rotor 24 and/or stator 22 so that no unbalanced force reacts on the housing 41.

FIGS. 6, 7 and 8 illustrate a preferred embodiment of
the invention wherein crankcase unit 44 has a pair of venting passages 500 and 502 which are cast as slots instead of being formed as holes, thereby facilitating their manufacture. Passages 500 and 502 may be readily bored in the casting by following the configuration of the surfaces directly connecting said motor to said plunger 7 to conform.

The orientation of passages 500 and 502 represents a composite of the various factors considered with respect to crankcase units 144, 244 and 344 described previously.

The actual opening to the crankcase cavity 80 of each passage includes an area A (FIG. 7) opening in the top wall 50 of the crankcase, and an area B (FIG. 6) opening in the side wall of the crankcase. The resultant passage with respect to the direction of gas flow between the crankcase cavity and the surrounding chamber 82 in response to piston reciprocation within the cavity may be considered to be equivalent to a crankcase unit containing venting ports 246 and 248 plus venting ports 346, 348. The resultant reaction force is represented by arrows 504 and 505 in the schematic three-dimensional parallelogram resolution diagrams of FIGS. 6 and 7. Resultsants 504 and 505 each has an upwardly acting component 506 and 508 respectively which cumulatively function as the equivalent of resultant reaction force 350 of the system of FIG. 5. The other two components of the three component resolution 504 and 505 consist of two opposite directed, equal magnitude components 510 and 512 (FIG. 7) which cancel one another, and two components 514 and 516 corresponding to components 258 and 264 of FIG. 4. Hence, the venting system of unit 44 combines the advantages of all three embodiments 144, 244 and 344 and in addition is more economical to manufacture.

All of the aforementioned substantially closed crankcase provides a further advantage in that they help overcome a problem of lubricant pump-out which may occur upon start-up of the compressor. This condition results from the well known refrigerant frothing phenomenon at start-up where a rapid pressure drop in chamber 82 causes the gaseous refrigerant dissolved in the lubricant in sump 64 to boil up into suds or bubbles, and the oil entrained with the suds is pumped through the compressor and out of the casing. Part of this frothing action occurs due to the immediate drop in pressure in the compressor casing as soon as the compressor starts pumping gas from the casing, causing liquid refrigerant to vaporize and bubble up. However, in those units with "open" crankcases, the frothing action is also due to the agitation or impeller effect of the rotating crankshaft and connecting rod as well as the reciprocating piston acting on the liquid refrigerant-lubricant solution in the oil sump, these parts tending to whip the liquid into a froth as soon as they start to move in the liquid sump. By closing the compressor crankcase in accordance with the present invention as described previously herein, the rotating or moving parts are covered or isolated from the sump and hence this contributing factor to foaming is eliminated. Removing this cause of frothing has been found to sufficiently reduce the foaming action at start-up to a point where the oil level does not fall below the inlet to the oil pump, which is all that is required to overcome the problem of loss of lubrication at start-up.

I claim:

1. In a compressor, the combination of a sealed housing, a motor-compressor unit mounted in said housing including a piston reciprocable in a cylinder, crank means operably connecting said motor to said piston to convert rotary motion imparted by said motor into reciprocating motion of said piston and a crankcase defining a cavity enclosing said crank means and communicating with the space in said casing disposed exteriorly of said crankcase, said venting means being oriented in a direction such that gas pulsations therethrough produced in response to reciprocation of said piston tend to reduce vibration of said unit relative to said housing produced by operation of said motor-compressor unit, said venting means comprising a pair of coaxial vent passages disposed diametrically opposite one another in said crankcase, each of said passages connecting at one end to the crankcase cavity and at the other end to the space in said housing exteriorly of said crankcase.

2. The combination set forth in claim 1 wherein said pair of vent passages are disposed in opposite side walls of said crankcase, wherein said crank means is rotatable about a vertical axis disposed generally centrally of said crankcase cavity and said vent passages are located closer to the upper end than to the lower end of said crankcase cavity.

3. In a compressor, the combination of a sealed housing, a motor-compressor unit mounted in said housing including a piston reciprocable in a cylinder, crank means operably connecting said motor to said piston to convert rotary motion imparted by said motor into reciprocating motion of said piston and a crankcase defining a cavity enclosing said crank means and communicating with the side of said piston remote from the compression chamber of said compressor, said crankcase having venting means extending between said crankcase cavity and the space in said casing disposed exteriorly of said crankcase, said venting means being oriented in a direction such that gas pulsations therethrough produced in response to reciprocation of said piston tend to reduce vibration of said unit relative to said housing produced by operation of said motor-compressor unit, said venting means comprising three components, first and second vent passages generally diametrically opposed relative to one another and to the axis of rotation of said crank means, said first and second passages being oriented relative to one another to respectively produce first and second resultant reaction forces each resolvable into three components; a first component acting in a direction coincident with the first component of the other resultant force and equal in magnitude therewith to cancel the resultant effect of said first component; a second component acting in the direction of piston travel and together with said second components tending to balance the reaction effect of said remote side of said piston acting on the gas in said crankcase cavity, and a third component acting in a direction generally parallel to the direction of gas flow into said motor-compressor unit, said third components together generally tending to balance the reaction force caused by said suction of gas into said motor-compressor unit.
5. The combination set forth in claim 4 wherein said crankcase comprises a casting including a cylinder block of the compressor, a top wall transverse to the rotational axis of said crank means, a bottom wall generally parallel to and spaced from said top wall, a rear wall remote from the cylinder of the compressor and a pair of side walls interconnecting the rear wall with said cylinder block, said venting means comprising a pair of slots formed in the side walls of said crankcase intersecting the interior surface of said side walls of said crankcase as well as a portion of the interior surface of said top wall of said crankcase.

6. In a compressor, the combination of a sealed housing, a motor-compressor unit mounted in said housing including a piston reciprocable in a cylinder, crank means operably connecting said motor to said piston to convert rotary motion imparted by said motor into reciprocating motion of said piston, said motor being disposed generally above said compressor and said crank means being oriented for rotation about an upright axis, and a crankcase defining a cavity enclosing said crank means and communicating with the side of said piston remote from the compression chamber of said compressor, said crankcase having venting means extending between said crankcase cavity and the space in said casing disposed exteriorly of said crankcase, said venting means being oriented in a direction such that gas pulsations therethrough produced in response to reciprocation of said piston tend to reduce vibration of said unit relative to said housing produced by operation of said motor-compressor unit, said venting means comprising a plurality of vents extending between said crankcase cavity and the space in said casing disposed exteriorly of said crankcase such as to provide equal angular spaced relation around the axis of rotation of said crank means and extending parallel thereto.

7. In a compressor, the combination of a sealed housing, a motor-compressor unit mounted in said housing including a piston reciprocable in a cylinder, crank means operably connecting said motor to said piston to convert rotary motion imparted by said motor into reciprocating motion of said piston and a crankcase defining a cavity enclosing said crank means and communicating with the side of said piston remote from the compression chamber of said compressor, said crankcase having venting means extending between said crankcase cavity and the space in said casing disposed exteriorly of said crankcase, said venting means being oriented in a direction such that gas pulsations therethrough produced in response to reciprocation of said piston tend to reduce vibration of said unit relative to said housing produced by operation of said motor-compressor unit, said venting means comprising a plurality of vents disposed with their axes intersecting at an angle of less than 180° and at equal acute angles relative to the direction of travel of said piston such that the gas reaction forces created by each of said vents in response to reciprocation of the piston produces a resultant reaction force resolvable into two components; a first component acting in a direction opposite to the first component of the other vent and of a magnitude such that said first components cancel each other out, and a second component acting in the direction of piston travel and together with the second component of the other vent tending to balance the reaction component produced by the action of said remote side of said piston on the gas of said crankcase.

References Cited

UNITED STATES PATENTS

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