

[54] **COMPACT ROTARY SLIDING VANE COMPRESSOR FOR AN AUTOMOTIVE AIR-CONDITIONING SYSTEM**

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[57] **ABSTRACT**

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A gear-type oil pump, parallel mounted to the compressor's rear bearing plate and directly driven by the same shaft that drives the compressor's rotor assembly, delivers oil to that rotor assembly to effect lubrication and sealing, after which the oil flows into the compression chamber and becomes entrained in the refrigerant gas. Removal of the oil from the oil-laden discharge gas is accomplished by an oil separator located within a shell attached to the rear bearing plate and into which shell the discharge gas flows. Oil-free discharge gas exits through an outlet in the shell while the separated oil returns to a reservoir in the bottom of the shell, from which it is supplied to the oil pump inlet.

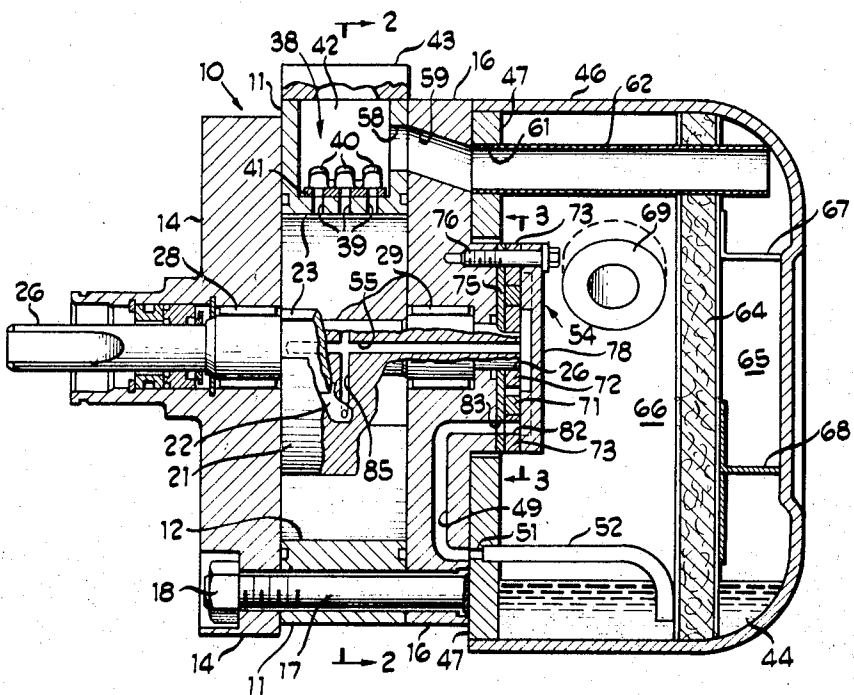
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 [51] Int. Cl. **F01c 21/04**, F01c 21/06, F03c 3/00
 [58] Field of Search 418/88, 82, 97, 98, 418/99, 93, 100

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1 Claim, 4 Drawing Figures



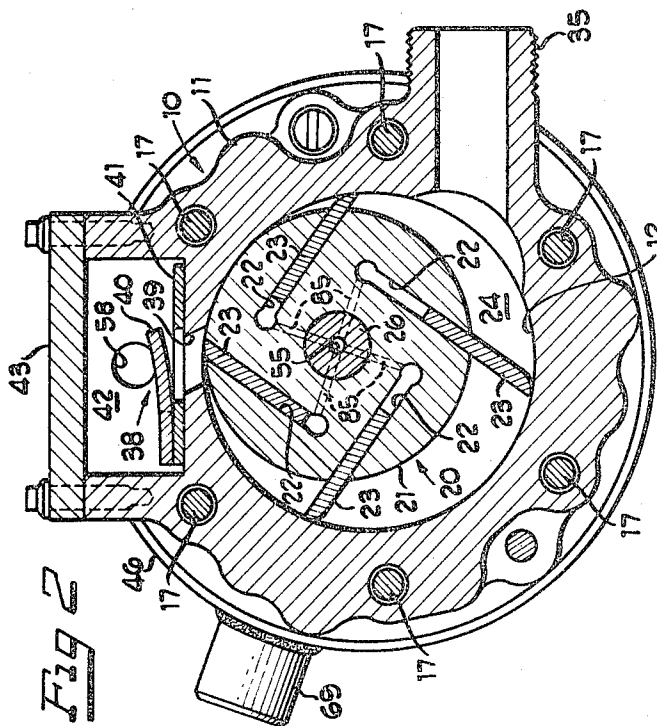


Fig 2

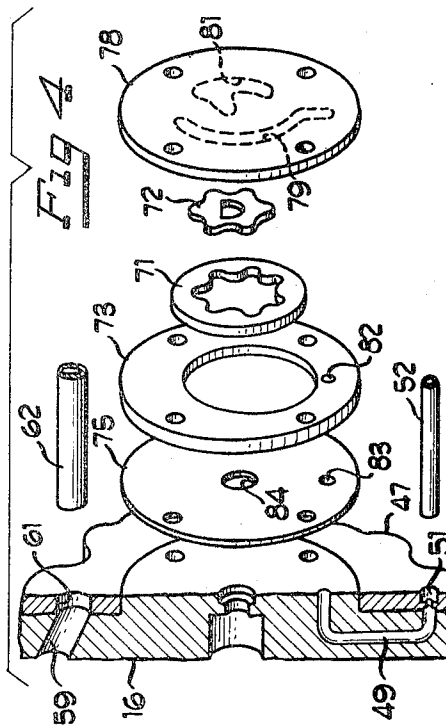


Fig 4

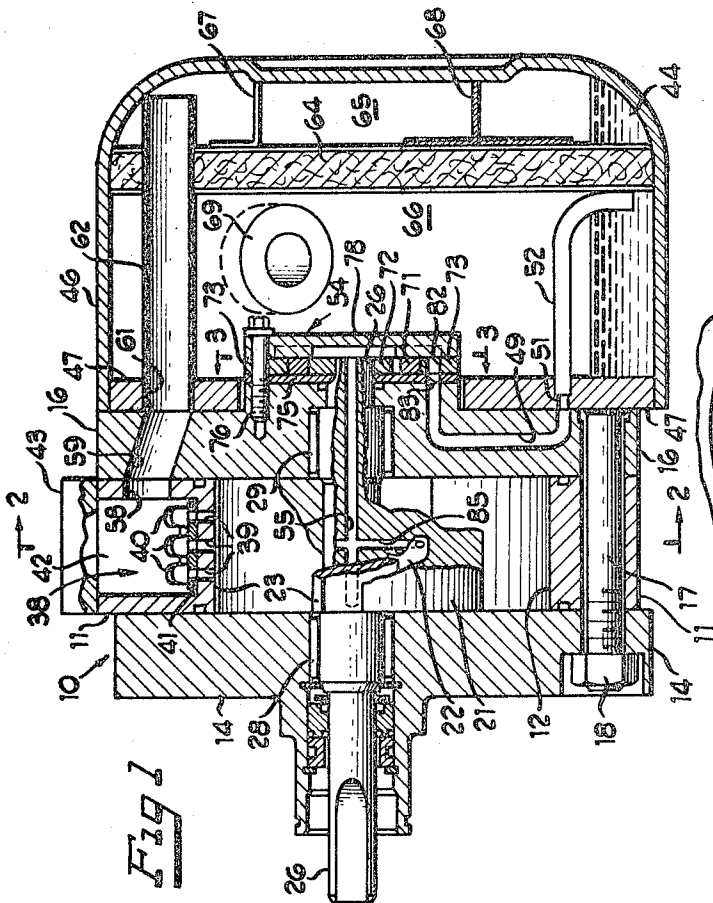


Fig 1

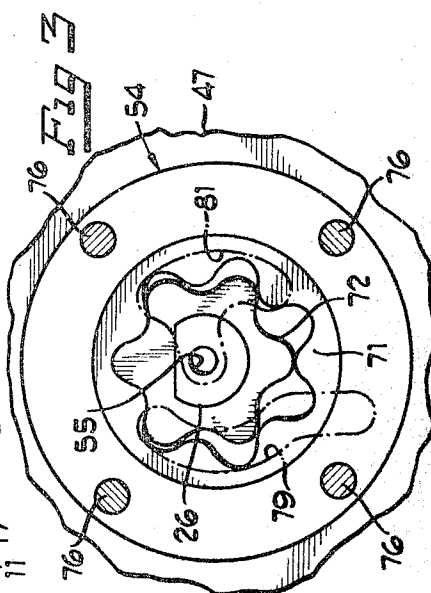


Fig 3

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COMPACT ROTARY SLIDING VANE COMPRESSOR FOR AN AUTOMOTIVE AIR-CONDITIONING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a rotary compressor of the sliding vane type and is especially suitable for use in an automotive air-conditioning system.

An automotive compressor preferably should satisfy a variety of different requirements, some of which are conflicting. It should have high capacity, but yet minimum size because of space limitations inside an automotive engine compartment. It should be durable and reliable and of rugged construction so that it is capable of functioning properly and trouble-free over a long service life and under adverse conditions, while still being of economical construction in order that its cost may be maintained relatively low. Moreover, an automotive compressor should be quiet in operation, producing very little noise, vibration and torque pulsation. In accordance with the present invention, all of these requirements have been successfully fulfilled for the very first time in a single compressor. A compact compressor has been invented having all of the above qualities without unduly sacrificing any one quality for the sake of another.

It is, therefore, an object of the invention to provide a uniquely constructed rotary sliding vane compressor having more advantages, capabilities and desirable features than any previously developed rotary compressor.

SUMMARY OF THE INVENTION

The compact rotary sliding vane compressor of the invention comprises a casing which includes front and rear bearing plates separated by a cylinder structure. The casing defines a closed cavity having a cylindrical wall, provided by and formed in the cylinder structure, and a pair of spaced parallel end walls provided by the bearing plates. A slotted rotor is eccentrically positioned within the cavity to define with the cylindrical wall and the end walls a crescent-shaped compression chamber. Suction and discharge ports communicate with the compression chamber. A drive shaft for the rotor is journaled in the bearing plates and has one of its ends projecting outwardly of the front bearing plate to facilitate driving of the shaft, while its other end projects outwardly of the rear bearing plate. A plurality of vanes are slidably mounted or retained in the slots of the rotor and engage the cylindrical wall, when the drive shaft is driven, to compress refrigerant gas introduced through the suction port and to discharge that gas through the discharge port at a higher pressure. A shell, attached to the casing, has a discharge outlet and contains a reservoir of lubricating oil. A lubricating system lubricates the rotor, vanes and drive shaft and also seals the high and low pressure sides of the compressor from each other. The system includes the oil reservoir and a gear-type oil pump mounted to the rear bearing plate in parallel relationship and directly coupled to the aforementioned other end of the drive shaft so as to be driven thereby. Lubricating oil flows into the compression chamber and entrains into the refrigerant gas during compression, as a result of which the high pressure gas is heavily oil laden as it flows through the discharge port. There are means for delivering the high pressure, oil-laden gas from the discharge port into the shell. Finally, the compressor comprises an oil separator lo-

cated within the shell for separating the entrained oil from the high pressure refrigerant gas to produce oil-free discharge gas at the entrance of the shell's discharge outlet, the separated oil flowing into the reservoir from which it is supplied to the inlet of the oil pump.

DESCRIPTION OF THE DRAWING

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description in conjunction with the accompanying drawing in which like reference numbers identify like elements, and in which:

FIG. 1 is a side view, with portions broken away and partly in cross-section, of a rotary sliding vane compressor constructed in accordance with the present invention;

FIG. 2 is a sectional view taken along the plane of section line 2—2 in FIG. 1 and primarily illustrates the casing and rotor assembly of the compressor;

FIG. 3 is a fragmentary sectional view taken along the plane of section line 3—3 in FIG. 1 and provides an end view of the oil pump; and,

FIG. 4 is an exploded view in perspective illustrating the various parts of the oil pump.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The disclosed compressor has a casing 10 which includes a cylinder structure 11 having a cylindrical bore or wall 12 extending therethrough, a front bearing plate 14, and a rear bearing plate 16, all secured together by a series of six studs 17 and nuts 18, only one of which nuts is shown in FIG. 1. Casing 10 provides a closed cavity formed by cylindrical wall 12 and bearing plates 14 and 16 which serve as spaced parallel end walls for the cavity. The rotor assembly 20, eccentrically positioned within the cylindrical cavity, includes a slotted rotor 21 having a series of four slots 22 arranged circumferentially and each extending along a plane parallel to the rotor's axis. The closed end of each slot, for convenience, may be referred to as the bottom end. Each of a series of four reciprocating vanes 23 is slidably mounted in a respective one of slots 22. The eccentric positioning of rotor assembly 20 within cylindrical wall 12 is obtained by rotatably mounting rotor 21 on an axis offset with respect to the axis of wall 12. Such eccentric mounting creates a crescent-shaped compression chamber 24 between rotor 21, wall 12, and the two end walls or bearing plates 14 and 16.

Rotor 21 has a drive shaft 26 journaled in bearings 28 and 29 affixed to plates 14 and 16 respectively. The left end of shaft 26 (as viewed in FIG. 1) projects outwardly of front bearing plate 14 to facilitate driving of that shaft. Since the illustrated embodiment is especially adapted for automotive use, it is contemplated that a V-belt pulley and clutch mechanism (not shown) would be coupled to the left end of shaft 26 to permit the compressor to be driven by the engine fan belt or accessory drive belt of the automobile. Of course, the disclosed compressor may be employed in many different environments and may be used in other than refrigeration or air-conditioning systems to compress a variety of different gaseous fluids. Whatever the driving

means, it may conveniently be coupled to drive shaft 26.

The compressor is designed to operate when rotor assembly 20 revolves in a clockwise direction as viewed in FIG. 2. In a manner to be explained, under all operating conditions vanes 23 will be forced outwardly to their positions shown in FIG. 2 in order to firmly bear against cylindrical wall 12 and establish a fluidtight, sealed connection thereto. In operation, suction refrigerant gas from the evaporator of the automotive air-conditioning system is admitted to an inlet 35 formed in cylinder structure 11. As is illustrated in FIG. 2, this refrigerant gas flows into the suction portion of compression chamber 24. As the rotor is driven clockwise, the gas is trapped between two adjacent vanes 23 and carried forward toward the discharge area. As this occurs, the volume between the adjacent vanes is reduced thereby resulting in a corresponding increase in pressure of the gas. A discharge valve assembly 38 is located in the discharge zone for assuring proper compression of the gases issuing from a series of three outlet or discharge ports 39, bored in cylinder structure 11, and for preventing reverse flow of gases back into compression chamber 24. The valve assembly 38 is of the reed type comprising the three valve reeds 40 and the valve seat 41. The compressed refrigerant gas emanating from ports 39 flows into a chamber 42 defined by cylinder structure 11 and a cover plate 43.

The processing of the high pressure gas after it is delivered to chamber 42 will be considered later. At this juncture it is desirable to describe briefly the lubricating system in the compressor. A flow of lubricating oil to the various bearing surfaces and moving components is, of course, required to provide proper lubrication and to seal the high and low pressure sides of the compressor from each other. Furthermore, the lubricating system also produces pressurized oil for controlling vanes 23. More particularly, a reservoir of oil or sump 44 is provided in the lower portion of a shell 46, the open end of which is attached and hermetically sealed to a mounting ring 47 in turn affixed and sealed to rear bearing plate 16. Oil passages 49 and 51, formed in plate 16 and mounting ring 47 respectively, and pick-up tube 52 establish a flow path between the oil sump and the inlet of oil pump 54, the details of which will be described hereinafter. Suffice it to say at this point that the oil pump receives oil from reservoir 44 at the compressor's discharge pressure and delivers pressurized oil into the axially extending bore 55 of drive shaft 26 and, through passages not specifically shown, to all of the surfaces requiring lubricating and sealing, and these include surfaces on rotor 21, vanes 23 and drive shaft 26.

Oil flows radially outward along each of the two flat faces of rotor 21 and then generally into the suction portion of compression chamber 24, since that portion will have the lowest pressure in the system. Oil thus entrains into the refrigerant gas during compression, and a consequence of which the high pressure gas flowing through valve assembly 38 and into chamber 42 is heavily laden with oil. This entrained oil must be removed from the gas because substantial quantities of oil in the discharge gas reduces the heat transfer in the condenser and evaporator. In addition, it is much more difficult to supply a sufficient amount of oil to the compression chamber to attain the necessary sealing between the rotor and chamber surfaces.

Oil separation in the disclosed compressor takes place within shell 46. A passageway formed by bores 58, 59 and 61 in cylinder structure 11, bearing plate 16 and mounting ring 47, respectively, together with tube 62 communicates chamber 42 to the extreme end of shell 46. Tube 62 extends through an oil separating filter screen 64 comprised of gas permeable material, such as coarse mesh metal fibers as in a scouring pad. The periphery of separator 64 has the same contour as that of the shell so that its edges fit against the internal diameter of the shell. In this way, separator 64 constitutes a partition to define two different chambers 65 and 66 within shell 46. Element 67 serves as a support bracket for separator 64, while element 68 constitutes a baffle.

In operation of the oil separator, the discharge gas together with the entrained oil flows out of chamber 42 and into chamber 65 through the conduit provided by bores 58, 59 and 61 and tube 62. At that point the velocity of the gas is greatly reduced as it expands into a much larger volume. In expanding, the gas strikes the end of shell 46 and reverses direction as a consequence of which most of the oil separates on the rear surface of the shell and flows down into sump 44. The gas with the remaining oil, after striking the shell and reversing its flow direction, now heads toward the front of the compressor passing through oil separator 64 where the residual oil coalesces and runs down into reservoir 44. The discharge gas flowing into chamber 66 will thus be oil-free. A discharge outlet 69 mounted on shell 46 permits the gas to flow out of chamber 66. Baffle 68 prevents the turbulent gas from reaching and stirring up oil pool 44 and re-entraining oil back into the gas.

Consideration will now be given to the manner in which the lubricating system functions to provide variable pressure oil flow to effect the desired control of vanes 23. Oil pump 54 is of the conventional internal gear-type having a freely rotatable internally-toothed outer gear 71 (see especially FIGS. 3 and 4) driven by an externally-toothed inner gear 72 eccentrically positioned within gear 71. More specifically, the right end of drive shaft 26 projects outwardly from casing 10 and is keyed to inner gear 72 to drivingly connect the shaft to the gear. Outer gear 71 is mounted for free rotation on an axis spaced or offset from that of shaft 26 and inner gear 72 by means of an eccentric bearing ring 73 rigidly affixed to, but separated by a spacer 75 from, rear bearing plate 16 by means of four cap screws 76. Since gear pump 54 has a relatively small depth or thickness dimension, it is effectively parallel mounted to rear bearing plate 16. This arrangement contributes substantially to the compactness of the compressor.

As best seen in FIG. 3, inner gear 72 has one less tooth than gear 71, and a plurality of separate pumping chambers are effectively defined between those gears. Cover plate 78, also held in place by cap screws 76, has a pair of arcuate cutaway or recessed cavities 79, 81 to provide inlet and outlet passages for the oil pump. For convenience, the recessed passages are shown in FIG. 3 in dashed construction to illustrate most clearly the fluid connections to and from the oil pump. Cavity 79 has a vertically depending leg which communicates through holes 82 and 83, in ring 73 and spacer 75 respectively, to the upper end of passage 49 formed in bearing plate 16. Hence, a flow path exists between sump 44 and the inlet of the oil pump. Cavity 81, on the other hand, has a laterally projecting portion extending

to the central area of cover plate 78 to fluidly connect the pump outlet to axial bore 55 via bore 84 formed in spacer 75.

In operation of oil pump 54, as drive shaft 26 is driven inner gear 72 likewise rotates (in a counter-clockwise rotation as viewed in FIG. 3) and one portion of each inner gear tooth is always in sliding sealing contact with a portion of an outer gear tooth to maintain the pumping chambers sealed from each other. The chambers effectively revolve about the axis of shaft 26 and each progressively increases to a maximum volume and then decreases to a minimum volume. Passage or inlet port 79 is located so that it communicates with the chambers that are increasing in volume and thus at a relatively low pressure, while outlet port 81 fluidly couples to those chambers that are decreasing in volume and hence at a high pressure.

A series of four radially extending passages 85 are provided in rotor 21 to fluidly couple axial bore 55 to the bottom ends of slots 22. With this construction, the high pressure oil exiting from the oil pump is delivered to the slots behind vanes 23 thereby to impel the vanes toward and in sealed engagement with cylindrical wall 12. The magnitude of the oil pressure is set so that during start-up the pressurized oil alone will be a sufficient to cause the vanes to move out of their slots and establish fluid-tight connections with the cylindrical wall. Preferably, the pressure level will be just adequate to make the required sealed contact between the vane tips and cylindrical wall, but yet will not cause undue strain on the vanes and needless wear.

Since the oil pump is driven by drive shaft 26, the oil pressure fed to slots 22 would normally tend to increase linearly as the rotor speed increases. In the illustrated compressor, the rate at which the oil pressure increases with RPM is reduced so that the pressure tends to level off to a constant magnitude. This is desirable inasmuch as centrifugal force, which also acts to push each of the vanes against wall 12, increases with RPM. By effectively limiting the extent to which the oil pressure increases from start-up to maximum rotor speed, the total force (as contributed by both the oil pressure and by centrifugal action) holding each of the vanes against the cylindrical wall may be maintained within a relatively narrow acceptable range and will never be excessive. The upper limit of the range, which prevails at maximum speed, will be less than that which would cause undue strain, friction and wear on the vanes.

The rate, at which the oil pressure would otherwise increase as speed increases, is reduced by decreasing the efficiency of oil pump 54 with RPM. This is achieved by sizing or dimensioning the passageway extending between oil sump 44 and the pump inlet in order to cause cavitation, the amount of which increases with rotor speed. In other words, during high speed operation oil cannot flow into the pump fast enough, thus effecting a vacuum or void in the pump which gives rise to a reduction in the rate of oil pressure increase as speed increases. The faster the operation, the greater will be the vacuum created and the smaller will be the rate of pressure increase.

As a variation, a bypass line controlled by a series-connected pressure relief valve may be coupled from the oil pump's outlet back to its inlet. The valve would be adjusted to block the bypass line during start-up and at low speeds, while at high speeds the resulting pressure would be sufficient to open the valve and bypass

or short circuit at least some of the output oil flow directly back to the pump inlet. In this way, the maximum oil pressure on the vanes is reduced even further.

The invention provides, therefore, a unique compact rotary sliding vane compressor that is rugged but low cost in construction, dependable and quiet in operation and at the same time producing very low vibration and torque pulsation, and combines maximum operating efficiency and capacity with minimum space requirements.

Certain features described in the present application are disclosed and claimed in copending application Ser. No. 160,694, filed concurrently herewith in the name of Lester E. Harlin and assigned to the present assignee.

While a particular embodiment of the invention has been shown and described, modifications may be made, and it is intended in the appended claims to cover all such modifications as may fall within the true spirit and scope of the invention.

We claim:

1. A compact rotary sliding vane compressor for an automotive air-conditioning system comprising:

a casing including front and rear bearing plates separated by a cylinder structure and defining a closed cavity having a cylindrical wall, provided by and formed in said cylinder structure, and a pair of spaced parallel end walls provided by said bearing plates;

a slotted rotor eccentrically positioned within said cavity to define with said cylindrical wall and said end walls a crescent-shaped compression chamber; suction and discharge ports communicating with said compression chamber;

a drive shaft for said rotor journaled in said bearing plates and having one of its ends projecting outwardly of said front bearing plate to facilitate driving of said shaft, while its other end projects outwardly of said rear bearing plate;

a plurality of vanes slidably mounted in the slots of said rotor and engaging the cylindrical wall of said cavity, when said drive shaft is driven, to compress refrigerant gas introduced through said suction port and to discharge that gas through said discharge port at a higher pressure;

a shell, attached to said casing and extending from said rear bearing plate, having a generally cylindrical peripheral wall and an end wall spaced from said rear bearing plate, said shell containing a reservoir of lubricating oil;

an oil separator within said shell and including a gas permeable, oil separating filter screen mounted generally parallel to said rear bearing plate and defining a first chamber between said rear bearing plate and said filter screen and a second chamber between said screen and the shell's end wall;

a lubricating system for lubricating said rotor, vanes and drive shaft, for sealing the high and low pressure sides of said compressor from each other, and for supplying pressurized oil into said slots behind said vanes to urge said vanes toward the cylindrical wall of said cavity, and including said oil reservoir and a gear-type oil pump mounted to said rear bearing plate in parallel relationship and directly coupled to said other end of said drive shaft so as to be driven thereby,

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said lubricating system having an axially extending bore in said drive shaft and a plurality of radially extending passages in said rotor for fluidly connecting said bore to said slots, the outlet of said oil pump communicating with said axially extending bore in said drive shaft for conveying high pressure oil to said slots,

lubricating oil flowing into said compression chamber and entraining into the refrigerant gas during compression, as a result of which the high pressure gas is heavily oil laden as it flows through said discharge port;

a discharge outlet in the cylindrical peripheral wall of

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said shell and communicating with said first chamber;

and means for delivering the high pressure, oil-laden gas from said discharge port into said second chamber from which it then flows through said oil separating filter screen to said first chamber and then out through said discharge outlet, said oil separator removing the entrained oil from the high pressure refrigerant gas to produce oil-free gas at said discharge outlet, the separated oil flowing into said reservoir from which it is supplied to the inlet of said oil pump.

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