

June 28, 1966

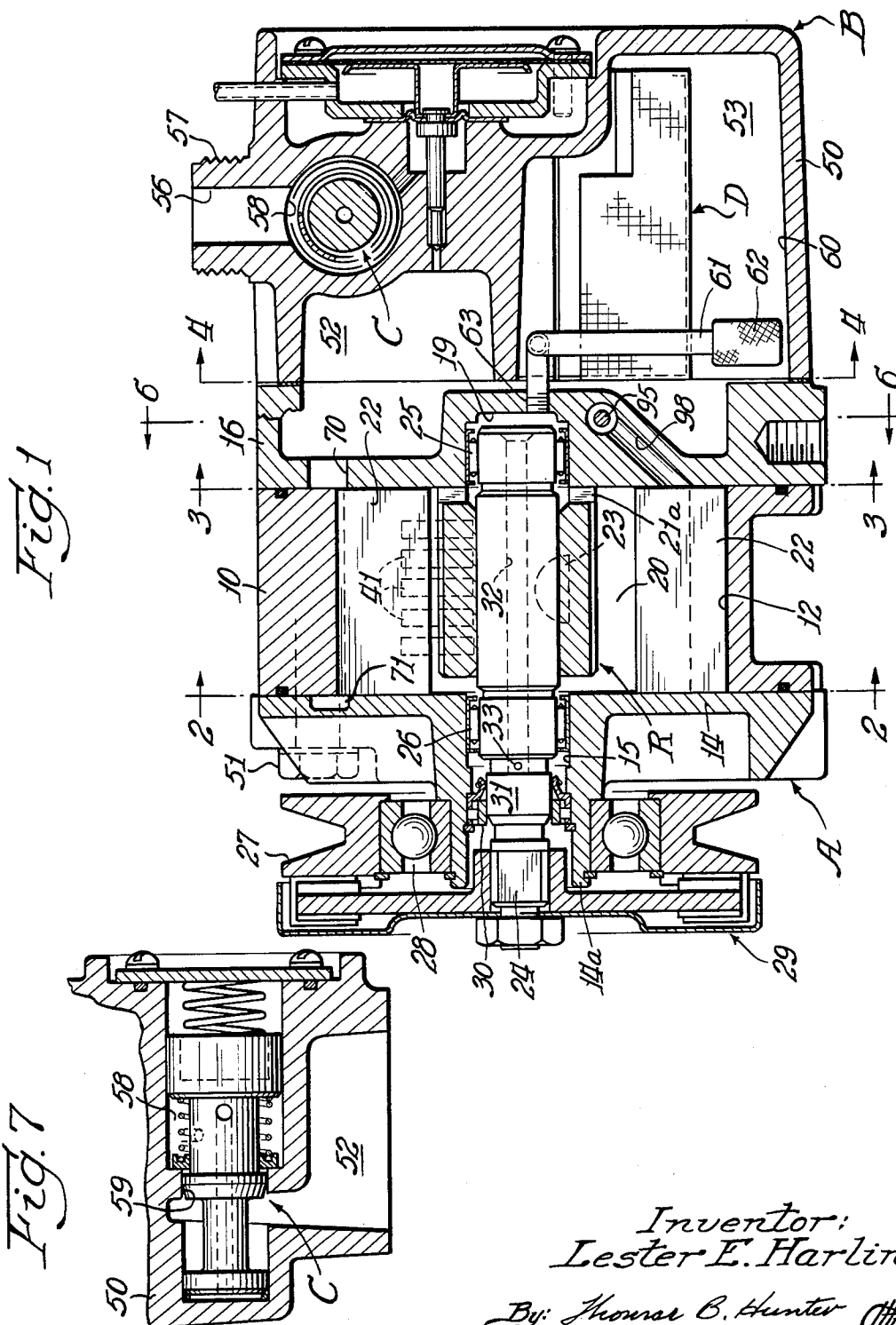
L. E. HARLIN

3,258,198

ROTARY COMPRESSOR

Filed June 4, 1964

3 Sheets-Sheet 1



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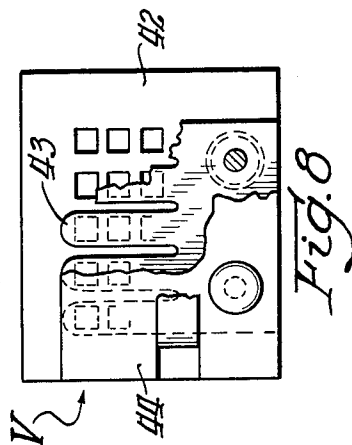
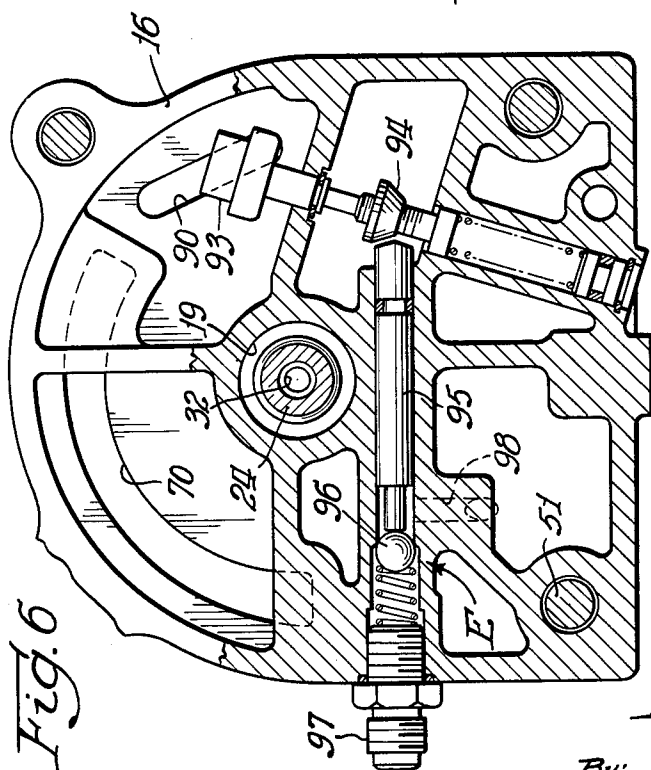
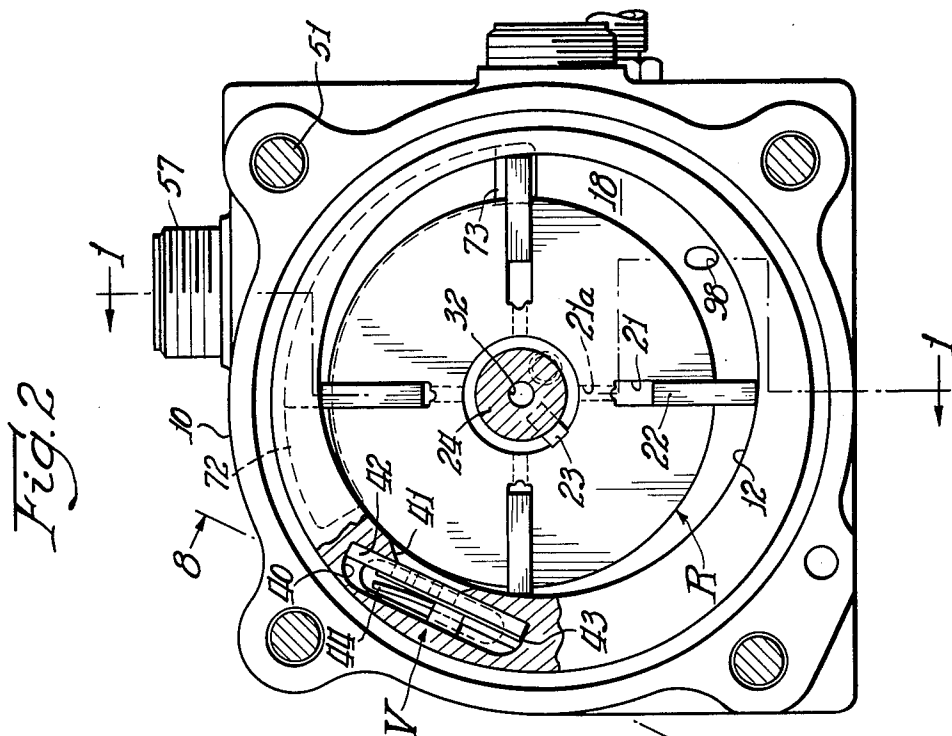
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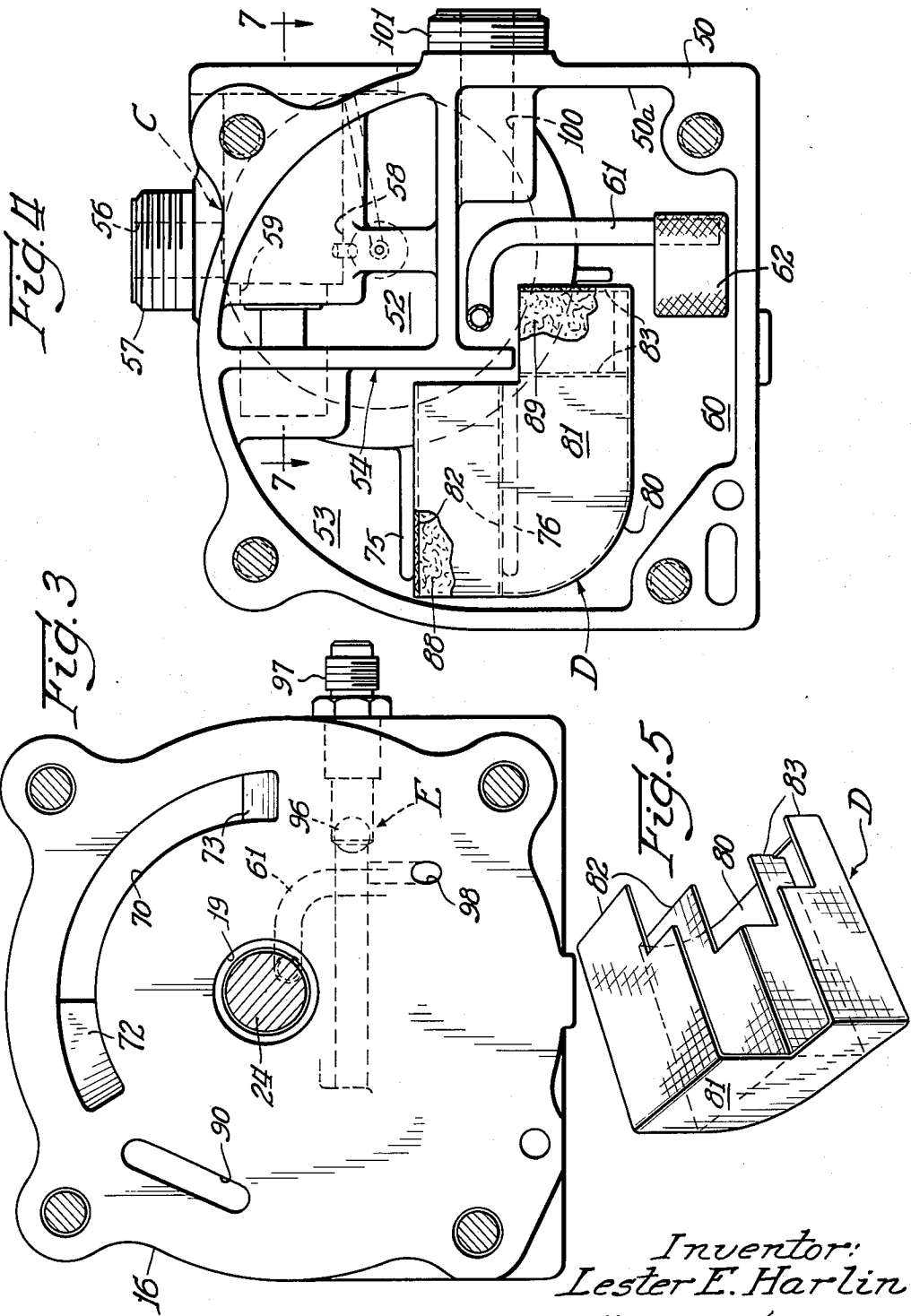
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3,258,198

ROTARY COMPRESSOR

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11 Claims. (Cl. 230-207)

This invention relates to improvements in gas compressors and more particularly to a rotary compressor especially adapted for use in refrigerating systems and similar applications.

Commercial success of refrigerating system compressors, particularly those used for automotive air-conditioning applications, depends to a large extent on how well they meet certain performance standards. At the very minimum, such compressors must be rugged in construction, dependable and quiet in operation, and combine maximum operating efficiency with minimum space requirements.

The space available inside an automotive engine compartment is limited, particularly in the more recent designs which feature larger engines, a considerable amount of auxiliary equipment and lower hood profiles. Consequently, reduction of size is a major consideration in the design of air-conditioning system components.

Most of the compressors now used in automotive vehicle installations are positive displacement compressors which are either of the rotary or of the reciprocating type, and mostly the latter. With regard to the rotary designs, there are several basic forms which are well known to those skilled in the art; so for the purposes of this description, the term "rotary" is meant to embrace dynamic-type compressors using rotating vanes or impellers to impart velocity and pressure to the fluid.

Rotary compressors offer several advantages over reciprocating compressors, particularly with respect to noise, vibration, and torque pulsations. Since a rotary compressor does not require mechanism for changing rotary to reciprocating motion, they are considerably quieter in operation. Moreover, the moving parts of the rotary compressor are subjected to less mechanical stress so that metal fatigue and failure of such parts is minimized.

On the other hand, rotary compressors present some problems which are not present in reciprocating compressors to any significant degree. For example, in a rotary compressor, a considerable amount of oil, which is used to lubricate the bearings and seal the clearances between the rotor and the walls of the compression cavity, is entrained in the refrigerant discharge gas. While small amounts of oil can be tolerated in the system, the typical rotary compressor ejects such a large quantity of oil into the discharge gas that it is unable to operate efficiently. A small amount of oil will often bypass the piston in a reciprocating compressor, but such quantities are so insignificant that extraordinary precautions for preventing the entrainment of oil in the refrigerant are unnecessary.

Quite often, an externally arranged oil separator is used in combination with rotary compressors; such means are disclosed, for example, in U.S. Patent 2,846,138. However, the space occupied by these external oil separating devices make such units impractical for automotive applications. To solve the aforementioned problem, several attempts have been made to incorporate a trap or other such means for separating the oil from the discharge gas within the compressor. Examples of the prior art which show arrangements for this purpose are U.S. Patents 2,785,851 and 2,634,904.

The condition of the oil as it is passed through the discharge port presents serious difficulties in trapping the oil and separating it from the refrigerant gas. As the discharge gas passes out of the compression cavity at

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high velocity, the oil is in the form of an extremely fine mist. Unless some means are provided for coalescing this mist to produce droplets which are of sufficient mass to facilitates separation from the gas stream, the major portion of the oil will be passed into the hot gas line and carried through the system. This oil will lessen system efficiency and capacity; also, oil may be trapped in the system in sufficient quantity to starve the compressor of proper lubrication.

The basic principles which contribute to the improved operation of the compressor described herein may best be understood by analyzing the flow of refrigerant through a series of discrete steps. First of all, the velocity of the discharge gas is reduced by expanding it through the discharge port into a relatively large chamber. The gas then passes through a first coalescing medium which, in a preferred embodiment, comprises a body of porous material providing a large effective surface area within a very small volume; this material is sufficiently porous so as to minimize the pressure drop across the medium. The oil mist tends to collect on the surfaces of the material of first coalescing medium to form small droplets which are swept off by the moving gas stream. These droplets are carried along in the gaseous stream which then flows through a second coalescing medium of substantially the same type as that described above. The droplets collected on the second coalescing medium tend to aggregate until much larger droplets are formed. Again, these larger droplets are blown off or stripped from the surface of the material and re-entrained in the discharge gas. At this stage, the oil droplets are large enough to be easily separated by centrifugal or gravitational means. In the present invention, the difference in mass is relied on to effect separation by rapidly changing the direction of the gas stream so that the momentum of the oil droplets causes them to pass into a zone which is remote from the exit point for the refrigerant gas.

It is therefore a principal object of the present invention to provide an improved rotary compressor which incorporates means for effectively separating oil from the discharge gas.

Another object of the invention is to provide an improved compressor in accordance with the foregoing object which will coalesce the oil mist carried in the discharge gas to facilitate the separation therefrom.

It is another object of the invention to provide a compact compressor design which does not require a separate unit for removing the entrained oil from the discharge gas.

Additional objects and advantages will be apparent from a reading of the following detailed description taken in conjunction with the drawings wherein:

FIGURE 1 is a cross-sectional view of a rotary compressor constructed in accordance with the principles of the present invention, said view taken along the plane of line 1-1 of FIGURE 2;

FIGURE 2 is a cross-sectional view taken along the plane of line 2-2 of FIGURE 1;

FIGURE 3 is a cross-sectional view taken along the plane of line 3-3 of FIGURE 1;

FIGURE 4 is a cross-sectional view taken along the plane of line 4-4 of FIGURE 1;

FIGURE 5 is a detailed isometric view of the coalescing medium retainer;

FIGURE 6 is a cross-sectional view taken along the plane of line 6-6 of FIGURE 1;

FIGURE 7 is a cross-sectional view taken along the plane of line 7-7 of FIGURE 4; and

FIGURE 8 is a partial cross-sectional view taken along the plane of line 8-8 of FIGURE 2.

Referring now to the drawings, and more specifically to FIGURES 1 and 2, the improved compressor forming

the subject matter of the present invention comprises a housing which is divided into a first section A and a second section B. For convenience, sections A and B will be referred to herein as the compressor section and the gas chamber section respectively.

Compressor section A includes a casing or body member 10 having a cylindrical bore 12 extending therethrough, a front bearing plate 14, a rear bearing plate 16, and a rotor assembly, designated generally by reference character R, the latter being received within the casing bore 12. The rotor assembly R includes a slotted rotor element 20 which carries a plurality of substantially radially extending and reciprocating vanes 22. The axis of rotor element 20 is offset or eccentrically arranged with respect to the axis of the bore 12 so that the bore, the front bearing plate 14, the rear bearing plate 16, and the rotor element 20 cooperate to provide a crescent-shaped compression chamber or cavity 18. Rotor element 20 is keyed at 23 to a drive shaft 24 which is journaled in an anti-friction bearing 25 supported by the rear bearing plate 16 in recessed portion 19 and an anti-friction bearing 26 supported within a counterbore 15 in the front bearing plate 14.

Inasmuch as the preferred embodiment is especially adapted for automotive use, the compressor rotor is driven by a V-belt pulley 27 rotatably journaled on a bearing 28, the inner race of which is carried on an axial extension 14a of the front bearing plate 14 and arranged for driving connection with the engine fan belt (not shown). Pulley 27 is connected to the rotor drive shaft 24 through a vibration dampener 29 of any suitable construction. The front bearing plate extension 14a is provided with a lip-type seal 30 engaging a boss 31 on the drive shaft to prevent loss of refrigerant and lubricant through the front bearing plate journal bearing plate journal bearing. The drive shaft 24 is further provided with an axially extending bore 32 intersecting a transverse bore 33. These two bores fluidly interconnect the recessed portion 19 in the rear bearing plate and the space between the seal and the front bearing to assist in balancing the rotor assembly and provide a flow path for lubricating oil.

Attention is now directed to FIGURE 2 which is a cross-sectional view showing the details of the rotor assembly R and illustrating the manner in which the rotor assembly cooperates with the compression cavity. The rotor assembly R, as previously noted, includes a cylindrical rotor element 20 which is furnished with a plurality of radially extending slots 21, each of which are adapted to receive a vane member 22 reciprocatively slidable therein. The vane members, preferably fabricated from a graphite compound, are arranged so that their radially outermost or tip portions extend transversely across the compression cavity and are in constant engagement with the inside diameter of the bore 12. Oil for lubricating and sealing purposes is supplied to the space underneath each vane by means of slots 21a cut in the front face of the rotor element 20. The oil pressure also serves to hold the vanes outwardly against the surface of the cavity.

The casing or body member 10 is provided with an elongated gas discharge passage 40 which is spaced radially outwardly from the internal surface of cylindrical bore 12 adjacent to the point where the rotor and casing bore are almost contiguous. Passage 40, extends the full length of casing 10 and communicates with a discharge gas compartment in the gas chamber section B in a manner which will be more fully described below. Fluid passage means to fluidly interconnect the compression cavity 18 and gas discharge passage 40 are provided in the form of a plurality of slots 41 through the thin partition separating passage 40 from the compression cavity 18.

A valve assembly, designated generally by reference character V is disposed within the gas discharge passage

40, said assembly including a perforated valve plate 42, a plurality of flexible, reed-type valve elements 43 normally overlying the perforations in the valve plate and a resilient backing plate 44 which resiliently biases the valve elements in position against the valve plate.

As best illustrated in FIGURES 1 and 4, the gas chamber section B comprises a casing 50, preferably in the form of an integral casting, which is connected to the compressor section A by means of a plurality of elongated cap screws 51 located around the periphery thereof. The cap screws extend through registered holes (not shown) in the front bearing plate 14, the casing 10, and the rear bearing plate 16 and are adapted to be threaded into a series of tapped holes (not shown) in the gas chamber casing 50. The volume enclosed by casing 50 is divided into an inlet compartment 52 and a discharge compartment 53 by an integral, L-shaped partition 54. The inlet compartment 53, located in the upper right-hand quadrant of the gas chamber (as seen in FIGURE 4), is in fluid communication with a gas inlet passage 56 to which the suction gas line is connected at nipple 57.

Flow of the suction gas from the inlet passage 56 into the inlet compartment 52 is controlled by a capacity control valve, designated generally at C. As shown in FIGURE 7, suction gas is admitted into the annular space 58 from the inlet passage 56. As the valve shifts toward the right (as viewed in FIGURE 7) to its open position, gas passes through the throat 59 into the inlet compartment 52. The construction of the capacity control system, which is the subject matter described and claimed in co-pending application Serial No. 372,614, filed June 4, 1964, forms no part of the present application as such. A general reference is made herein to merely facilitate the understanding of the overall construction of the compressor assembly.

The gas discharge compartment 53 which is defined in part by partition 54 and in part by a portion of the casing 50 has a generally L-shaped configuration (FIGURE 4). The lower portion of the gas discharge compartment provides a sump 60 for the oil separated from the discharge gas, said oil being conducted back into the rotor assembly for lubrication and sealing. Means for this purpose include an oil return tube 61 having one end depending downwardly into the sump portion below the normal operating level of oil therein and provided with a filter screen element 62. The other end of the oil return tube is received within a threaded aperture 63 in the bearing supporting recess 19 of rear bearing plate 16 and is consequently in communication with the rear bearing and also with the front bearing through the oil passages 32, 33 in the rotor shaft.

The inlet compartment 52 in the gas chamber section B is in fluid communication with the inlet portion of the compression cavity 18 through an arcuate inlet port 70 in the rear bearing plate 16 (see FIGURES 1, 2, 3, and 6). The front bearing plate (FIGURE 1) is also provided with an arcuate groove or slot 71 which is symmetrically arranged with respect to the inlet port in the front bearing plate. It can be seen from an inspection and a comparison of FIGURES 3 and 6 that the back side of inlet port 70 (i.e., the side facing the gas chamber section B) communicates solely with the inlet compartment 52 in the gas chamber. The sharply chamfered end edges 72, 73, of the inlet port 60 permit the opening of said inlet port into the compression cavity to be of greater arcuate length (approximately 110° of arc) than the area on the back side of the bearing plate 16 which opens into the inlet compartment 52.

An important aspect of the present invention concerns the arrangement of oil separation means within the discharge compartment to effect a coalescing and separation of oil entrained in the discharge gas. It will be noted from FIGURE 4 that the gas chamber casing includes a pair of integral ribs 75, 76, for supporting a generally L-shaped coalescing element designated at D. This ele-

ment comprises a metal retainer or frame, the details of which are shown in FIGURE 5, including a sheet metal member having a curved bottom portion 80 and an up-standing side wall 81. A pair of coalescing medium support members 82, 83 are brazed or otherwise secured to the curved, bottom portion 80 of said frame, said support members being formed of coarse-mesh wire screening. Each of the support members comprises a pair of spaced parallel panels which are adapted to receive the coalescing medium therebetween. Support member 82 is arranged horizontally across the path of the discharge gas while support member 83 is arranged vertically at substantially a right angle with respect to member 82.

The coalescing medium, in a preferred embodiment, comprises a pair of generally rectangular pads 88, 89 of woven metal fibers or equivalent material. One medium which has been found to be particularly suitable is woven copper filament of the type commonly employed in scouring pads or the like. It is obvious, however, that other materials may be used, the only requirements being that the density of the materials should be such that the pressure drop across each pad is not too large and that the material have a relatively large surface area to volume ratio.

A discharge port 90 is provided through the rear bearing plate, said discharge port providing fluid passage means between the discharge gas passage 40 in the compressor casing 10 and the discharge compartment 53 of the gas chamber section. This discharge port 90 registers with the discharge passage 40 and terminates in the upper left-hand portion of the discharge compartment as viewed in FIGURE 4.

The compressor is further provided with means for injecting liquid refrigerant into the compression chamber 18 in response to the temperature of the discharge gas exiting the compression cavity through discharge port 90. Such means include a temperature responsive element 93 located in the path of the discharge gas and valve means designated generally at E controlled by said temperature responsive element. When the latter indicates that the compressor is running too hot, the cam element 94 is moved downwardly against a movable pin 95 to unseat a ball valve element 96 permitting liquid refrigerant from a line connected to external nipple 97 to pass into the compression cavity 18 through a fluid passage means 98. The specific details of this system and the operation thereof form no part of the present application as such. This system is described with more particularity and claimed in copending application Ser. No. 372,615, filed June 4, 1964. A general reference is made herein merely to complete the present disclosure.

Operation

In order to facilitate an understanding of the present invention, the overall operation thereof will now be described. Low pressure refrigerant gas from the evaporator passes through the inlet passage 56 into the space 58 (FIGURE 7) on the upstream side of the capacity control valve element C. Assuming that the system is calling for cooling and that the valve C is open, gas passes through the valve into the inlet compartment 52 of the gas chamber. From there, it is expanded into the compression cavity through inlet port 70.

As the rotor assembly R is driven, the vane elements trap a small volume of the gas and force it through the compression chamber, the volume of which decreases in a direction toward the outlet. At a point in the compression cavity 18 adjacent to the valve element V, the maximum pressure of said gas is achieved. The gas passes through the perforated valve plate 42 against the biasing pressure of reed valve elements 43 into the discharge gas passage 40 in the casing 10. From there, it flows transversely into and through the discharge port 90 in the rear bearing plate and into the discharge compartment of the gas chamber section B. Referring to

FIGURE 4, it will be noted that the discharge port opens into the space in the upper left-hand quadrant of the discharge compartment. The gas then flows downwardly through the first coalescing medium 88 and is directed through an angle of approximately 90° through the second coalescing pad into the zone in the lower right-hand quadrant (FIGURE 4) of the gas chamber. At this stage, as mentioned in the preliminary remarks, the oil mist is coalesced to form droplets of sufficient mass to separate from the gas stream by using centrifugal or gravitational effects. It will be noted that the discharge passage 100 to which the hot gas line (not shown) is connected at external nipple 101 extends inwardly of the zone previously identified as located in the lower right-hand quadrant of the discharge compartment. The wall portion 50a of casing 50 directly in line with the path of gas exiting from the second coalescing medium is thus spaced a greater distance away than the mouth of the discharge gas passage 100. Consequently, the gas stream is constrained to alter its direction and follow a tortuous path before passing into the discharge passage 100. This change in direction forces the oil droplets to be separated from the discharge gas stream, after which they impinge on the portion of the housing 50a which is directly in their path of travel, and run down into the sump 60.

The L-shaped configuration of the discharge compartment has been found to be particularly desirable, not only because it enhances the efficiency of the two-stage coalescing, but also because it permits a more compact design. The gas enters the upper portion of the vertical leg, passes through the first coalescing medium, and is guided by the bottom wall 80 of the retainer through the second coalescing medium located in the horizontal leg.

It should be understood that such terms as "vertical," "horizontal," "upper," "lower," etc., as used in the specification and claims merely refer to the relative positions of the elements and components. They are not to be construed in any absolute sense unless this is specifically stated. Moreover, while the invention has been described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation; and the scope of this invention is defined solely by the appended claims which should be construed as broadly as the prior art will permit.

What is claimed is:

1. In refrigeration apparatus of the character described, an oil lubricated compressor having suction and discharge ports; a gas chamber communicating with said discharge port and having an outlet, said gas chamber having a generally L-shaped configuration including a vertical leg portion and a horizontal leg portion; a first body of porous material positioned so that it extends generally transversely across said vertical leg portion; a second body of porous material positioned so that it extends generally transversely across said horizontal leg portion; and means for changing the direction of gas flow through said chamber to induce the separation of oil from said gas stream, said first and second bodies effecting a two-stage coalescing of said oil.

2. Apparatus as defined in claim 1 wherein said gas chamber outlet is located with respect to the horizontal leg of said chamber such that the gas is constrained to follow a tortuous path as it flows from said second porous body to said outlet.

3. In refrigeration apparatus of the character described, an oil lubricated compressor having suction and discharge ports; a housing associated with said compressor, said housing defining a gas chamber having separate inlet and discharge compartments communicating with said suction and discharge ports respectively; means defining a gas inlet in said inlet compartment adapted to be connected to a suction line; means defining an outlet in said discharge compartment, said outlet being arranged so that gas flows from said discharge port through said dis-

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charge compartment to said outlet; a first coalescing medium in said discharge compartment arranged downstream in the direction of gas flow from said discharge port; a second coalescing medium in said discharge compartment spaced from, and downstream from said first coalescing medium, said first and second coalescing mediums being arranged in the path of gas as it passes through said discharge compartment to said outlet, said outlet being located so that the gas, after passing through said second coalescing medium, is constrained to follow a tortuous path as it flows to said outlet, whereby the separation of coalesced oil droplets from said gas stream is effected.

4. Apparatus as defined in claim 3 including a means defining a sump in said discharge compartment, said sump being arranged to collect the oil separated from the gas stream; and means for conducting oil in said sump back to said compressor.

5. Apparatus as defined in claim 3 wherein said discharge compartment has a generally L-shaped configuration and includes a vertical leg portion and a horizontal leg portion, said first coalescing medium being disposed in said vertical leg portion, said second coalescing medium being disposed in said horizontal leg portion.

6. Apparatus as defined in claim 3 wherein said coalescing mediums comprise bodies of porous material having a relatively large surface area to volume ratio.

7. Apparatus as defined in claim 6 wherein said bodies of porous material are formed from interwoven metallic fibers.

8. In refrigeration apparatus of the character described, a housing forming a gas chamber; means for mounting said housing onto a compressor; means dividing said gas chamber into an inlet compartment and a discharge compartment, said inlet compartment communicating with the suction side of said compressor, said discharge compartment communicating with the discharge side of said compressor; first oil coalescing means located immediately downstream from the entrance to said discharge compartment; second oil coalescing means located downstream from said first coalescing means; and discharge passage means downstream from said second coalescing means, the entrance of said discharge passage means being disposed such that the discharge gas is constrained to follow a tortuous path prior to entering said discharge passage means, whereby oil droplets entrained in the gas

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stream are separated and prevented from passing out of said gas chamber with said discharge gas.

9. In refrigeration apparatus of the character described, a housing having a compression cavity; suction and discharge ports opening into said compression cavity; a rotor in said compression cavity adapted to impart pressure and velocity to gas admitted at said suction port; means for introducing lubricant into said compression cavity; a gas chamber mounted on said housing, said gas chamber having partition means dividing said chamber into an inlet compartment communicating with said suction port and a discharge compartment communicating with said discharge port, said discharge compartment having a generally L-shaped configuration including vertical and horizontal legs, said discharge port opening into the upper portion of said vertical leg; oil separation means in said discharge compartment including a first body of porous material extending transversely across the vertical leg downstream from said discharge port and a second body of porous material extending transversely across said horizontal leg; means defining an outlet for gas from said discharge compartment in said gas chamber, said outlet having an entrance portion disposed relative to said horizontal leg such that gas must follow a tortuous path before entering said entrance portion, whereby lubricant entrained in the discharge gas is induced to fall out of said stream prior to passing out through said discharge gas outlet.

10. Apparatus as defined in claim 9 including a lubricant sump in said discharge compartment for collecting lubricant separated from the discharge gas.

11. Apparatus as defined in claim 10 including conduit means for passing lubricant from said sump in lubricating relation with said rotor.

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