

May 8, 1951

O. S. MORE
COMPRESSOR

2,551,623

Filed April 29, 1944

3 Sheets-Sheet 1

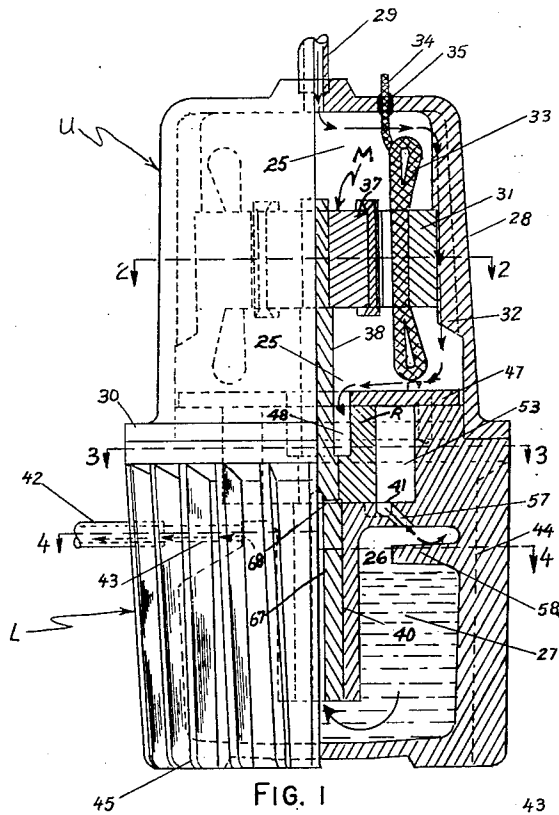


FIG. 1

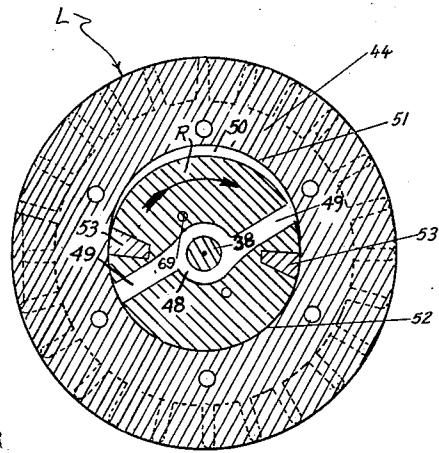


FIG. 3

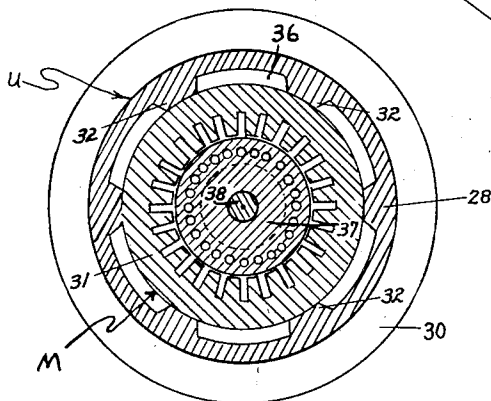


FIG. 2

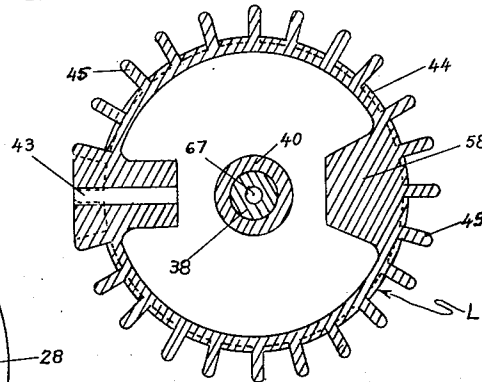


FIG. 4

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May 8, 1951

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2,551,623

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3 Sheets-Sheet 2

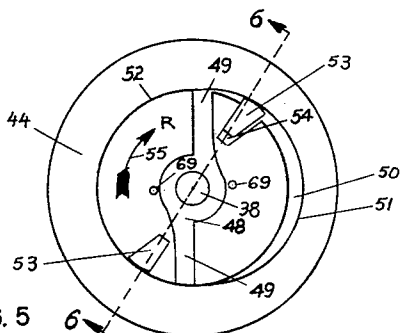


FIG. 5

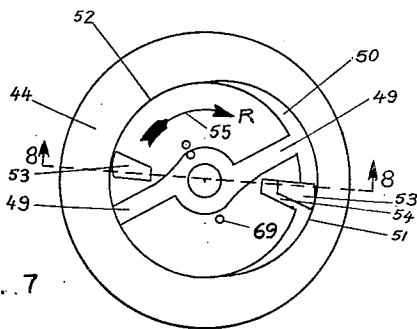


FIG. 7

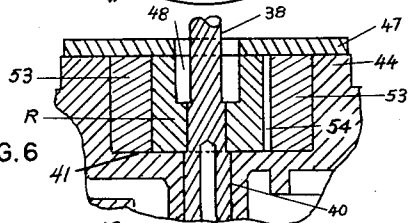


FIG. 6

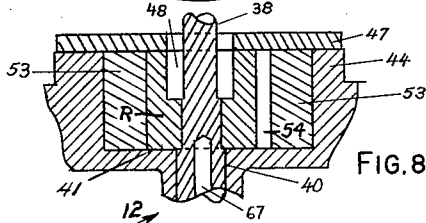


FIG. 8

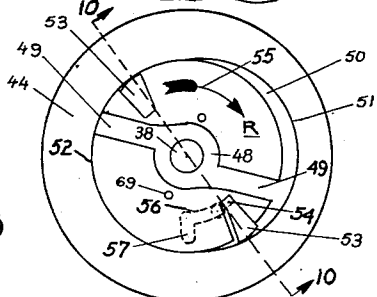


FIG. 9

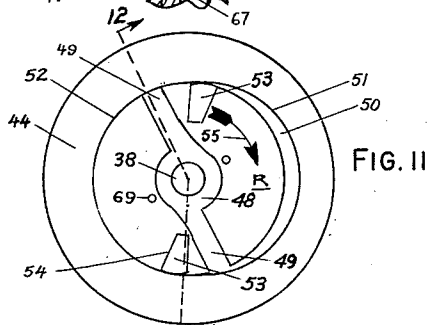


FIG. 11

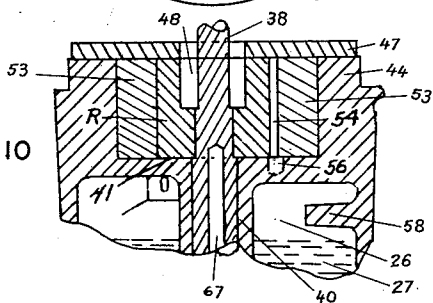


FIG. 10

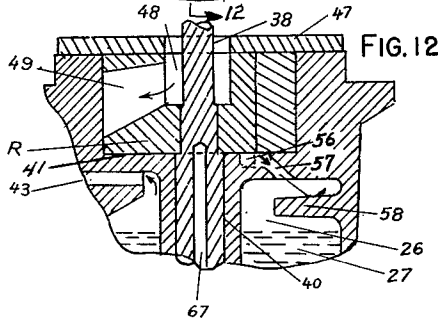


FIG. 12

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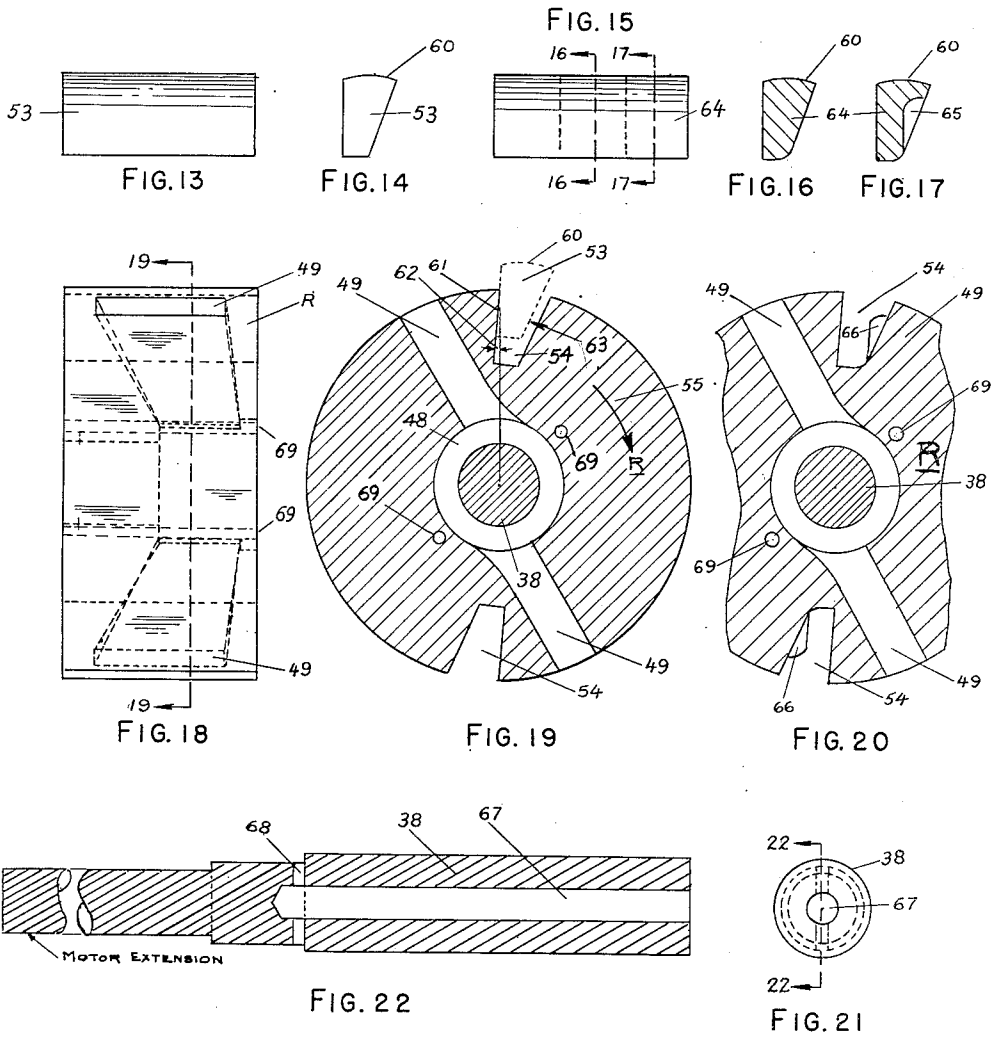
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,551,623

COMPRESSOR

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Application April 29, 1944, Serial No. 533,273

4 Claims. (Cl. 230—139)

1

This invention relates to compressors, and more particularly to totally enclosed rotary compressors, such as the sliding vane type.

Among the objects of the invention are to provide a compressor, such as driven by an electric motor, in which the motor and compressed gas are adequately cooled; to provide a totally enclosed compressor which is compact and simple in structure; to provide such a compressor in which the electrical portion thereof is easily insulated and includes no slip rings or brushes; to provide a rotary compressor which has a low starting torque; to provide such a compressor in which adequate oiling and lubrication of moving parts are assured; to provide a rotary compressor which has high volumetric and mechanical efficiencies; to provide a rotary, vane type compressor which has a novel vane construction; to provide a rotary compressor in which intake and exhaust ports of a novel type are provided, and in connection with which check valves may be unnecessary; to provide a rotary, vane type compressor in which gas is fed to the compression space in a novel manner; to provide a rotary, vane type compressor in which the vanes are maintained in position in a novel manner; to provide a rotary compressor in which there are no springs and substantially all rotating parts are cylindrical, with all eccentric rotating parts being few in number and relatively light in weight; to provide a compressor in which the compressing unit and a high pressure gas chamber are formed as a unit; and to provide a compressor which includes a novel lubricant reservoir.

Other objects and novel features of this invention will become apparent from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a front elevation, partially in section, of a compressor constructed in accordance with this invention;

Fig. 2 is a horizontal section taken along line 2—2 of Fig. 1;

Fig. 3 is a horizontal section taken along line 3—3 of Fig. 1;

Fig. 4 is a horizontal section taken along line 4—4 of Fig. 1;

Fig. 5 is a top and partially diagrammatic view of a compressor unit, forming a portion of the compressor of Fig. 1, illustrating the action of the parts thereof;

Fig. 6 is a partial vertical section taken along line 6—6 of Fig. 5;

2

Fig. 7 is a view similar to Fig. 5, with the compressor rotor in a different position;

Fig. 8 is a partial vertical section taken along line 8—8 of Fig. 7;

Fig. 9 is a view similar to Fig. 5, with the compressor rotor in still a different position;

Fig. 10 is a partial vertical section taken along line 10—10 of Fig. 9;

Fig. 11 is a view similar to Fig. 5, with the compressor rotor in still another different position;

Fig. 12 is a partial vertical section taken along line 12—12 of Fig. 11;

Fig. 13 is a rear view of a sliding vane forming a part of the compressor unit of the compressor of Fig. 1;

Fig. 14 is an end view of the sliding vane of Fig. 13;

Fig. 15 is a rear view of an alternative type of sliding vane;

Fig. 16 is a cross section of the vane taken along line 16—16 of Fig. 15;

Fig. 17 is a cross section of the vane taken at another position, along line 17—17 of Fig. 15;

Fig. 18 is a side view of the rotor of the compressor unit;

Fig. 19 is a cross section taken along line 19—19 of Fig. 18, of a rotor adapted to carry the sliding vane of Fig. 13;

Fig. 20 is a similar cross section of an alternative compressor rotor construction, adapted to carry the vane of Fig. 15;

Fig. 21 is an end view of the main shaft of the compressor; and

Fig. 22 is a longitudinal section of the compressor shaft, taken along line 22—22 of Fig. 21.

A compressor constructed in accordance with this invention is particularly adapted to form a portion of a refrigeration cycle, in which a suitable refrigerant is compressed, cooled, condensed, passed through an expansion valve into an evaporator or the like, and led back at a lower pressure to the compressor. As in Fig. 1, the compressor may consist of a lower unit L, in which a compressor unit having a rotor R is housed, and an upper unit U, which contains an electric driving motor M. Preferably, the upper unit U encloses a low pressure or inlet gas chamber 25, while the lower unit L encloses a high pressure chamber 26. The lower portion of the high pressure chamber is preferably adapted to act as a reservoir in which may be stored a body 27 of lubricant, normally oil, which may occupy a greater or lesser portion of the high pressure chamber, as desired. The compressor unit is constructed in a novel manner, as described in detail

later, and is provided with a central inlet from which gas is fed by centrifugal force into a compression space, there compressed, and then discharged to the high pressure chamber. The lubricant contained in the lower portion of the high pressure chamber is forced upwardly, through suitable passages, to lubricate the rotating parts and a portion of the lubricant may find its way to the low pressure chamber 25, so that the incoming gas to the compressor unit may contain a certain amount of lubricant. As the compressed gas is discharged into the high pressure chamber, the lubricant or oil is separated therefrom in a novel manner, as described later, and the oil so separated falls into the body 27 of lubricant in the high pressure chamber.

The upper unit U has a casing 28 to which a gas inlet 29 may be attached above the motor, and is preferably separable from the lower unit L, as at a flange 30, but after assembly and test these units may be sealed by welding, brazing or other means. The incoming gas, as from the evaporating coils of a refrigeration system, cools stator 31 of motor M, which is held stationary in the upper unit, as by inwardly extending flanges 32 of Figs. 1 and 2. The incoming gas also cools motor windings 33 which are connected with a suitable source of electricity by leads 34, which are sealed at the point of passage through the casing in a suitable manner, as by packing 35. Suitable gas passages and baffles are provided, including passages 36 between flanges 32, as in Fig. 2, to insure that the motor will be adequately cooled by the incoming cold gas. A rotor 37 of the motor, preferably a squirrel-cage induction motor, is mounted on the outboard end of a main shaft 38, and is cooled by gas contacting its upper and lower ends.

Main shaft 38 extends vertically within the unit, and rotor R of the compressor unit is mounted substantially on the mid-portion of the main shaft. Almost the entire lower half of the main shaft extends within a bearing 40, the length of the bearing area overcoming the tendency for the overhang of the motor rotor 37 to produce a whipping effect. It is unnecessary to provide a thrust bearing, because rotor R of the compressor unit bears directly against surface 41 which supports it at its lower end. Rotor R also provides a seal for the high pressure chamber, in a manner explained in greater detail later, thus eliminating a discharge check valve which is normally used.

Since the upper unit U can be removed bodily from the lower unit without disturbing the relationship of any of the parts, access to the compressor unit is relatively easy. Also, the lower unit may be utilized as a container for the refrigerant gas, as by providing a suitable valve in an outlet line 42 connected to outlet passage 43 in casing 44 of the lower unit, the outlet passage being in direct connection with the high pressure chamber, as in Fig. 4. To insure that the gas and lubricant within the high pressure chamber are adequately cooled, or pre-cooled, the periphery of casing 44 may be provided with cooling fins 45, which may be cast integrally with the casing or attached thereto by welding or brazing, or in any other suitable manner.

The compressor unit occupies the upper portion of the lower unit, and rotor R, which is cylindrical in shape, is disposed within a suitable housing, which may be formed by casing 44 and a cover plate 47 attached to the casing in a suitable manner, as by bolts as shown. The

upper end of the rotor is provided with a well 48, surrounding shaft 38 and extending downwardly about half the thickness of the rotor. A pair of oppositely disposed intake ports 49 extend outwardly from the well and discharge incoming gas by centrifugal force into a compression space 50, taking advantage of natural physical forces to produce precompression of gas prior to entering compression space 50. As in Figs. 12 and 18, the intake ports 49 may diverge outwardly, so as to discharge the gas centrally of the compression space. The compression space may be formed between the rotor and an off-set or eccentric section 51 of the housing wall surrounding the rotor, the remaining section 52 of the housing wall being concentric with the shaft and substantially coincident with the periphery of the rotor R. The eccentric wall section 51 may be in the form of any desired curve, such as a circular arc having the same radius as section 52, but having a center offset from the axis of shaft 38. The concentric and eccentric sections may join together in tangential connections which ordinarily, but not necessarily, form straight vertical lines. Thus, the eccentric and concentric sections may join along a slanting line, or area, if desired.

Preferably, the eccentric and concentric sections are so formed and merged that uninterrupted and uniformly smooth surfaces are produced for contact with vanes 53, which, as in Figs. 5 to 12, inclusive, are adapted to compress the gas in space 50. Each vane slides inwardly and outwardly in a slot 54, and is preferably substantially trapezoidal in cross section and extends from surface 41 to the underside of cover plate 47. It will be evident that any desired number of vanes may be used, other than two, with intake ports to correspond, and also that more than one compression space may be provided, such as three vanes and three compression spaces for dynamic balancing purposes.

As illustrated more clearly in Figs. 5 to 12, inclusive, the rotor R, when rotating in the direction of arrow 55, causes vanes 53 to be thrown outwardly by centrifugal force against the wall sections of the housing. As the rotor moves from the position of Fig. 5 to the position of Fig. 7, and then to the position of Fig. 9, the space adapted to be occupied by the gas will become increasingly smaller, so that the gas is thereby compressed. As soon as a vane and slot reach a point adjacent the merging of eccentric wall section 51 with concentric section 52, the compressed gas will begin to enter a trough 56 extending into the housing from surface 41 and extending circumferentially for a sufficient distance so that the compressed gas will be collected in the trough and discharged through an outlet 57 extending downwardly, and also relatively outwardly as in Figs. 9 and 12, to cause the compressed gas to impinge against a baffle 58. The outward velocity component of the discharged gas, and also the impingement thereof on baffle 58, tend to cause any lubricant in the gas to separate out and fall into the body 27 of lubricant.

The vanes 53 are constructed, and held in position, in a novel manner. The vanes may be substantially trapezoidal in cross section, as mentioned previously, but preferably are provided with an outer rounded surface 60 which has a radius of curvature less than the radius of curvature of any portion of the housing wall. Also, as in Fig. 19, trailing edge 61 of slot 54 is inclined inwardly and also rearwardly, with respect to the

direction of rotation, at an angle 62 between the trailing edge of the slot and a radius of the rotor R. This trailing angle causes the vane to be thrown not only outwardly in the slot by centrifugal force, but also forwardly to counteract the tendency for the pressure of gas in the compression space, which acts tangentially against the vane, as in the direction of arrow 63 of Fig. 19, to twist the vane in the slot. The resultant of these forces maintains the vane in the desired position in the slot, i. e. in contact with trailing edge 61 over a substantial area, and also holds the vane against the wall of the compression space. Due to this utilization of centrifugal force and gas pressure in the compression space to hold the vane in position, springs or other resilient elements, normally utilized in sliding vane compressors, are unnecessary. Particularly when the rotor is rotating at relatively high speeds, the vanes will be held at all times outwardly against the wall of the compression space, and no difficulty will be encountered. When the compressor is to be rotated at a relatively lower speed, it may prove advisable to provide, as in Figs. 15 to 17, inclusive, a vane 64 having a guiding slot 65 extending outwardly therein, and adapted to fit over a lug 66 provided on rotor R, within slot 54, as in Fig. 20.

As will be evident, the elimination of springs or other devices for pressing the vanes outwardly against the wall of the compression space reduces the amount of friction, thus minimizing the initial starting torque. Also, the pressure of the vanes against the side walls of the compression space is directly in proportion to the speed of the rotor. Furthermore, the centrifugal feed of incoming gas to the compression space through ports 49 eliminates inlet check valves and the like, which increases the mechanical efficiency, and ports 49 also pre-compress the gas, which increases the volumetric efficiency. The use of the bottom of the rotor to cover the exhaust trough 56 and outlet port 57, except when a slot 54 is thereover, eliminates exhaust check valves and further increases the mechanical and volumetric efficiencies. As shown in Figs. 12 and 18, the terminus of intake ports 49 is spaced from surface 41 and also from the underside of cover plate 47, so that there is little possibility of leakage of gas through the intake ports, either back to the low pressure chamber, or from the high pressure chamber to the intake ports. As in Fig. 9, the eccentric wall section 51, as the concentric wall section 52 is approached, causes each vane 53 to force the gas into the center of the vane slot, for readier pickup by the collecting trough 56. Also, as the vane approaches the concentric wall section, compressed gas outside the periphery of the rotor is forced back between the leading edge of slot 54 and the leading edge of the vane, so that there is an inward compressing effect as the vane moves in, to enhance the flow of gas to the exhaust trough and port. Of course, as soon as slot 54 is completely within the concentric wall section, the vane fills the slot, except for a small outer space due to the curvature of the outside of the vane.

For positive lubrication, a hole 67 extends centrally up shaft 33 to the upper end of the bearing area, as in Figs. 1, 21 and 22, and two or more branches 68 extend to the outside of the shaft at the lower end of the rotor R. Bearing 40 is lubricated by oil forced upwardly between the bearing and the shaft surfaces from the body of lubricant, and also by oil flowing downwardly

from branches 68. The major portion of the oil from branches 68 flows outwardly along between the bottom of the rotor and surface 41 and then upwardly between the rotor and the eccentric and concentric sections 51 and 52. Since the vanes tend to sweep oil off the concentric and eccentric surfaces, and some of the oil also passes directly to the compression space and is returned to the high pressure chamber, with a small portion of the oil flowing inwardly between the top of the rotor and the underside of plate 47, vertical holes 69 are provided in the rotor, as in Figs. 3, 18 and 19, to carry oil from surface 41 to the upper end of the rotor, inside the radius of slots 54. Holes 69 are preferably spaced with respect to intake ports 49, and the greater portion of the oil from holes 69 passes ultimately to slots 54, compression space 59 or the intake well 48, and thence is returned to the high pressure chamber. It will be apparent that there is no necessity for lubricating anything above the rotor R, since the motor rotor is maintained on the outboard end of the shaft.

The clearances between the rotor R and the surfaces surrounding the same, as well as the clearances between the ends of vanes 53 and the bearing surface 41 and the underside of cover plate 47, are preferably such that a film of oil may extend between the surfaces, to prevent undue wear thereon, but the parts are preferably made sufficiently accurately so that the clearance will not be sufficient to permit the loss of efficiency through leakage of high pressure gas from the compression space, or from the high pressure chamber. Of course, the weight of rotor R and the motor rotor 37 holds the bottom of the rotor against the bearing surface 41, without, however, creating undue friction. The presence of the lubricant reservoir in the lower portion of the high pressure chamber assures an adequate supply of lubricant at all times, thus preventing the compressor from running dry and its efficiency thereby becoming impaired, or parts becoming unduly worn.

It will be evident that the rotating parts which are not concentric with shaft 33, comprising only vanes 53, are very light in weight. Also, the pressure of the gas being compressed causes the vanes to be held against the trailing edge of slot 54, so that there is little chance of leakage around the rear of the vanes and into the portion of the compression space behind the vane. After the vane is pushed into the slot, during contact with the concentric housing wall section 52, any small amount of compressed gas which may remain in the slot, upon failure to pass into trough 56 or outlet 57, will tend to thrust the vane outwardly against the eccentric wall section 51, when the same is reached by the vane.

It will be evident that the force with which the vanes are pressed against the housing wall increases with an increase in the rate of rotation of the rotor, or with an increase in the pressure of gas in the compression space. Thus, at starting, the pressure of the vanes is slight, as is also the amount of gas compressed, since the initial pressure in the compression space is low due to the lesser amount of compression in intake ports 49. Thus, only a very low torque is necessary at the start. This low starting torque is a feature of considerable importance, since it permits a much simpler and cheaper type of motor to be utilized, and also reduces the high current normally drawn by an induction motor on starting.

It will be evident that a compressor constructed in accordance with this invention has a high me-

chanical and a high volumetric efficiency. The absence of check valves for both intake and exhaust ports increases the mechanical efficiency, and the pre-compression of the gas by the centrifugal compression in intake ports 49 increases the volumetric efficiency. In addition, the assurance of positive lubrication, and the presence of only one bearing and the elimination of a bearing above the motor, further increase the mechanical efficiency. The lubricant reservoir, which always assures a supply of lubricant positively fed to the surfaces needing lubricant, decreases the possibility of wear and repair or replacement of parts.

It will be understood that various changes may be made in the compressor of this invention. For instance, the direction of rotation may be the same or in the opposite direction to that indicated. Also, although the compressor has been described as mounted in a vertical position, it is quite practicable and may often be found desirable to mount the compressor in other than a vertical position, as long as an adequate supply of lubricant from the high pressure chamber is insured. For this purpose there may be supply passages for oil formed in bearing 49, or elsewhere in the housing, to insure an adequate supply thereof. Also, in case the compressor is to be placed in an inverted position, the outlet port 57 may be provided with an extension, and the high pressure chamber outlet passage 43 may be placed at the opposite end of the high pressure chamber. Again, the number of vanes and compression spaces may be varied as desired. For instance, for more complete dynamic balance, two oppositely disposed compression spaces may be utilized so that the radial position of the vanes is always the same. Also, three sets of vanes and three compression spaces may be provided for the same purpose. The number of intake ports, of course, should correspond to the number of compression spaces.

It will be understood that the compressor of this invention may be used in other than refrigeration cycles, and that it may be used in a continuous refrigeration or other cycle or in an intermittent cycle. In the latter case, suitable check valves may be provided in the high and low pressure lines, to be operable only during shutdown of the compressor. The size and shape of the compression spaces may be varied within rather wide limits, as well as the size and shape of the compression vanes.

It will be further understood that some of the features of this invention may be utilized in various types of compressors, without utilization of the remaining features thereof, and that one or more of the features may be incorporated in such compressors, where desired. As an example, a compressor unit of the type disclosed herein might be built without a direct-connected motor and without the enclosing low pressure chamber for use as an air compressor. Such a unit would be either belt or gear driven and could be mounted in either vertical or horizontal position.

It will be understood also that embodiments of this invention other than that described may exist, and variations of the parts other than those set forth and changes other than those specifically enumerated may be made, all without departing from the spirit and scope of this invention.

What is claimed is:

1. A compressor comprising a casing divided

into upper and lower sections, said upper section enclosing a low pressure chamber adapted to receive gas and said lower section enclosing a high pressure chamber adapted to receive compressed gas; a rotor within said casing having vane means for compressing gas and disposed between said chambers; an intake centrally of the rotor opening into said compressing means leading from said low pressure chamber; a discharge outlet from said compressing means leading to said high pressure chamber positioned adjacent the bottom of the rotor in the path of said vane means; and an electric motor for rotating said rotor and disposed in said low pressure chamber.

2. A compressor comprising a rotor, housing means enclosing said rotor and defining an eccentric compression space, means for supplying a lubricant to said rotor, compressing means mounted on the periphery of said rotor, trough-like means formed in said housing for collecting compressed gas, the housing having a passageway connected to said trough-like means for discharging the said gas outwardly, and a baffle wall below the passageway for sharply changing the direction of flow thereof to separate lubricant therefrom by causing the same to impinge against said baffle wall.

3. A compressor comprising a rotor having slots for compressing vanes; housing means enclosing said rotor and defining an eccentric compression space; and sliding vanes mounted in slots, said vanes and slots being approximately and correspondingly trapezoidal in cross-sectional shape, with the trailing wall of each slot beginning on the periphery of said rotor and extending inwardly toward the center of said rotor and rearwardly, opposite the direction of rotation of said rotor, the leading wall of each slot extending in the same general direction as the trailing wall and being inclined rearwardly at a greater angle than said trailing wall, and said vanes having curved outer edges with a smaller radius of curvature than said rotor.

4. A compressor comprising a rotor having slots for compressing vanes, housing means enclosing said rotor and defining an eccentric compression space, sliding vanes mounted in said slots, said vanes and slots being approximately and correspondingly trapezoidal in cross-sectional shape, with the trailing wall of each slot beginning on the periphery of said rotor and extending inwardly toward the center of said rotor and rearwardly, opposite the direction of rotation of said rotor, the leading wall of each slot extending in the same general direction as the trailing wall and being inclined rearwardly at a greater angle than said trailing wall, said vanes having curved outer edges with a smaller radius of curvature than said rotor, and a trough for collecting compressed gas formed in said housing means, said trough being disposed adjacent the terminus of said compression space.

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