Feb. 20, 1945. C. R. NEESON 2,369,841

VARIABLE CAPACITY COMPRESSOR

Filed March 27, 1942 3 Sheets-Sheet 1

FIG. 1.

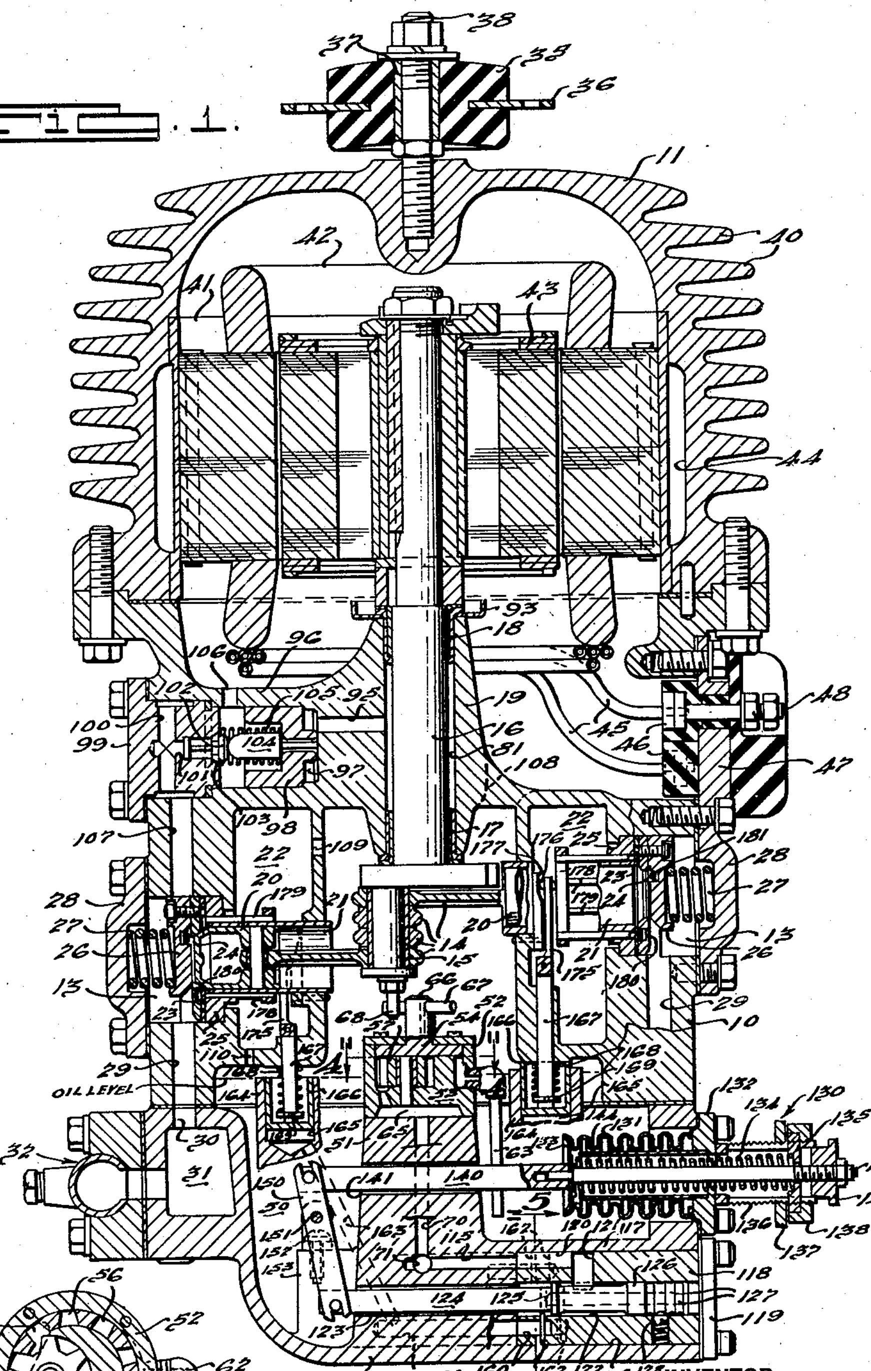
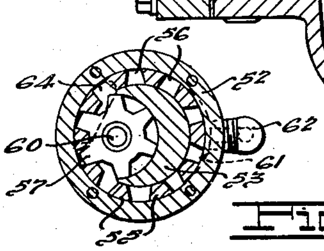


FIG. 4.



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VARIABLE CAPACITY COMPRESSOR

Filed March 27, 1942 3 Sheets-Sheet 2

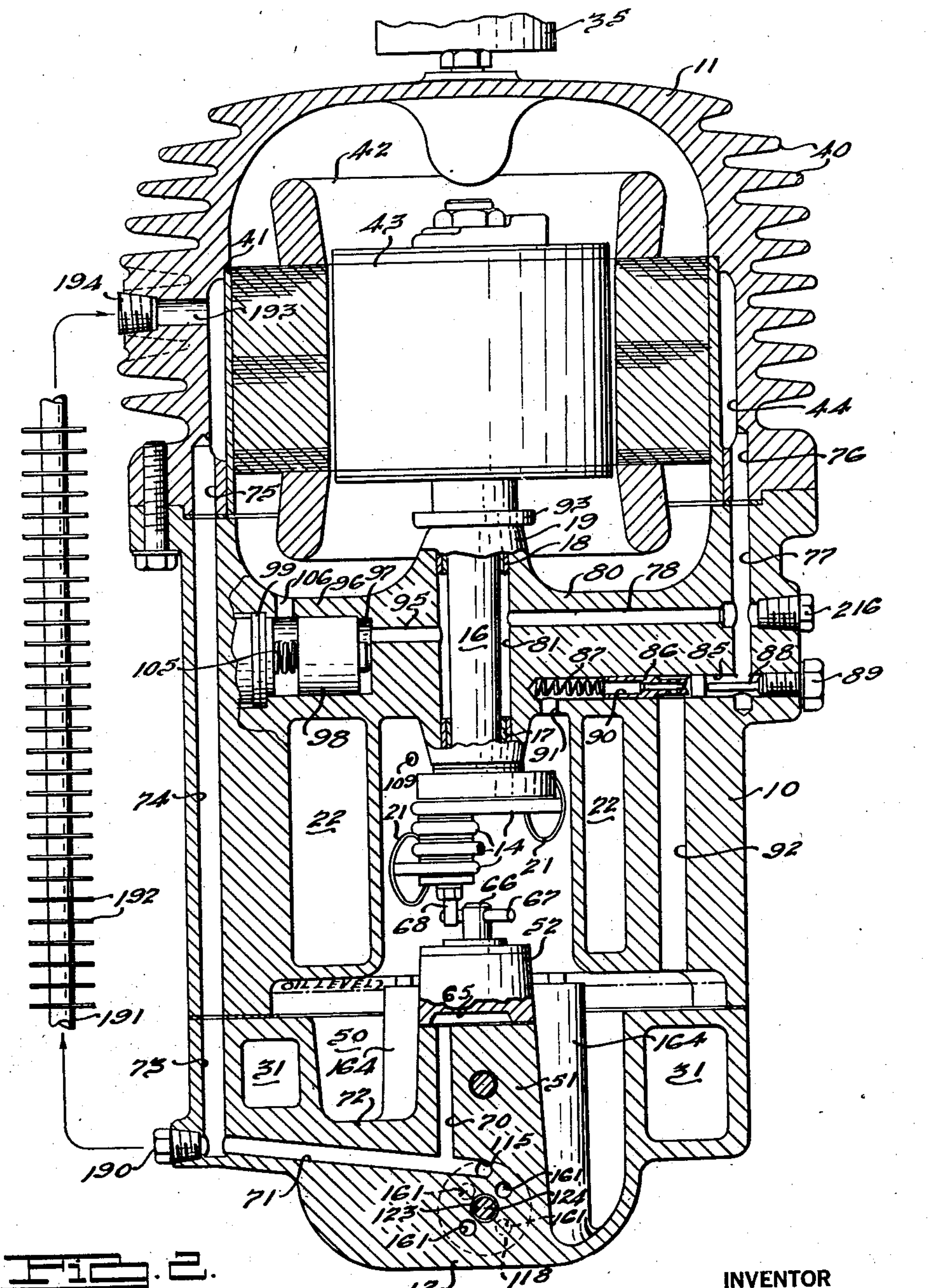

FIG. 2.

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VARIABLE CAPACITY COMPRESSOR

Filed March 27, 1942 3 Sheets-Sheet 3

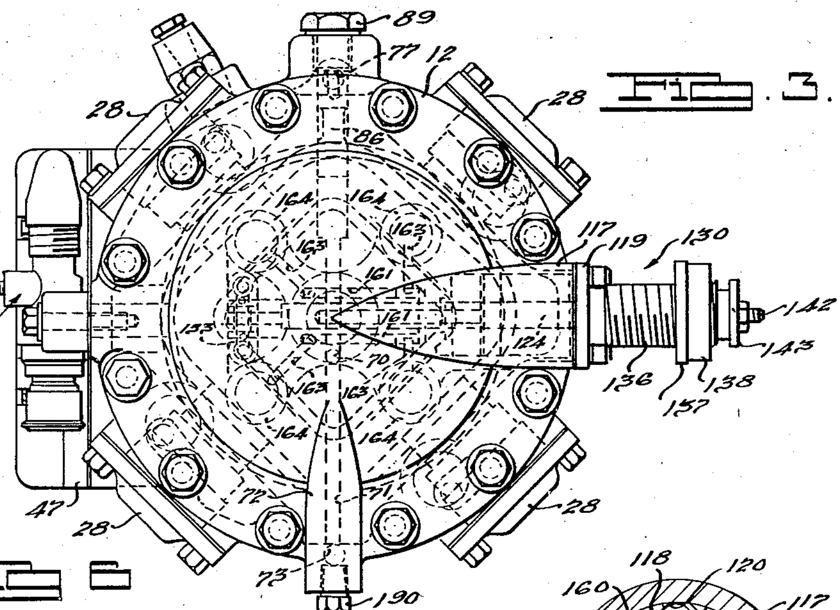
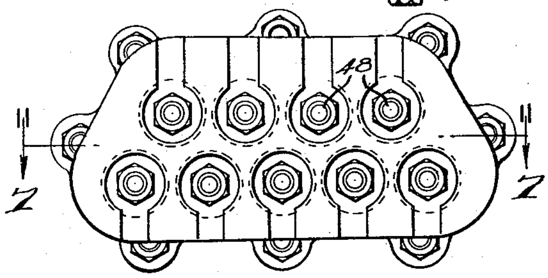


FIG. 3.

FIG. 6



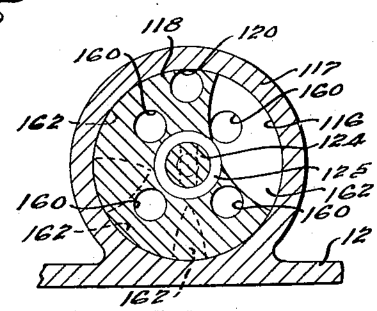


FIG. 5.

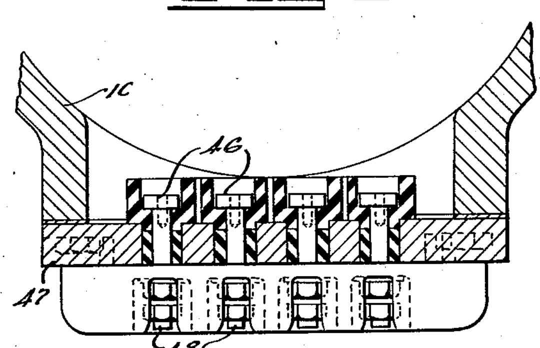


FIG. 7.

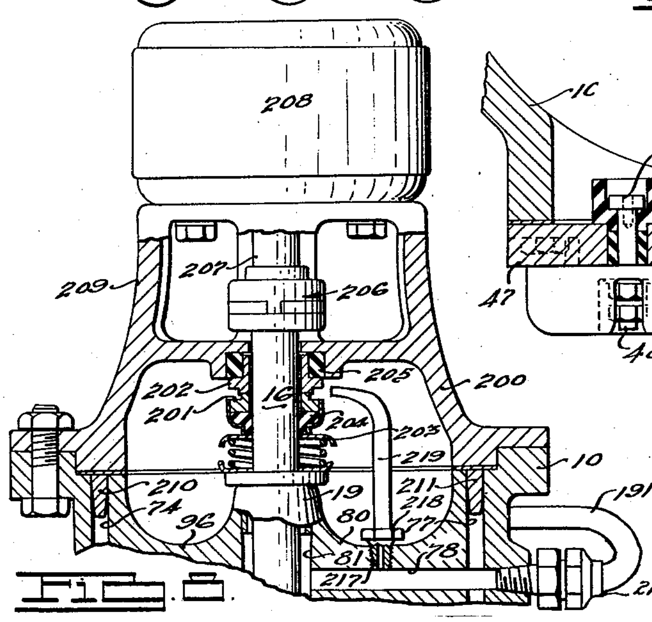


FIG. 8.

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2,369,841

UNITED STATES PATENT OFFICE

2,369,841

VARIABLE CAPACITY COMPRESSOR

Charles R. Neeson, Dayton, Ohio, assignor to Chrysler Corporation, Detroit, Mich., a corporation of Delaware

Application March 27, 1942, Serial No. 436,520

15 Claims. (Cl. 230—24)

The present invention relates to compressors particularly adapted for use in refrigeration systems. The present invention comprises an improvement upon the inventions disclosed in my prior patents, No. 2,137,965, No. 2,185,473, No. 2,204,510, No. 2,225,228 and No. 2,247,449, with particular reference to Patents No. 2,185,473, entitled "Compressor unloading means," and No. 2,247,449, entitled "Compressor control."

As disclosed in my prior patents, I have invented a compressor having functions whereby considerable economy in operation and great flexibility of use are achieved, these functions particularly including means whereby the number of cylinders of a multiple cylinder compressor operating at any given instant, varies in proportion to the suction pressure of the refrigerant which, in turn, is a measure of the load upon the refrigerating system to which the compressor is connected. The loading or unloading of a cylinder, as disclosed in Patent No. 2,185,473, is accomplished by control of the suction valves through which refrigerant gas is permitted to enter the cylinders, the valves associated with certain cylinders being held in open position when the load is lightest and being permitted to open and close in regular compressing manner when the load increases.

In the years of commercial operation of the inventions disclosed in the aforesaid patents, the value thereof has been demonstrated time and again and certain unforeseen values have come to light. The primary object of the development of the prior inventions was to provide an air conditioning system which would maintain a practically constant temperature by variably supplying the air conditioning surface with refrigerant, as distinguished from the prior practice of permitting a compressor of constant capacity to cycle on and off to create alternate waves of extremely cold air and warm air. This primary purpose has not only been demonstrated in a multitude of installations as being of extreme advantage, but also other uses have come to light particularly in commercial installations of refrigeration, such as, for example, in photograph developing where a constant temperature must be maintained, in greenhouses and cut flower boxes where plants and flowers will die or wilt under fluctuations in temperatures, and in food or meat storage rooms where bacteria sometimes increase to a dangerous extent if the room is permitted to warm at any time to a temperature above the desired point. With the use of my compressor, permitting continuous operation of the system to maintain a substantially constant temperature, waste is materially prevented. Accordingly, the demand for adaptation of all of the advantages disclosed in my prior patents, particularly in Patent No. 2,185,473, to smaller capacities of refrigerating systems, such as for fractional horsepower air conditioning units, household refrigerators, household meat or milk coolers, mobile photograph development units, and numerous other applications, has increased to a tremendous extent. Accordingly, the primary object of my present invention is to provide variable capacity unloading means in a compressor of fractional horsepower or of relatively small maximum capacity.

A further object of the present invention is to provide variable capacity unloading means in a compressor, the unloading means being of such a nature as to be more easily manufactured and assembled than the type disclosed in my prior patents.

A further object of my present invention is to provide a compressor lubricating and cooling system, and associated variable capacity unloading means, in a compressor which by the substitution of a few simple parts may be of the type having a motor hermetically sealed within a casing enclosing the compression apparatus or of the type having an externally driving means such as a motor with its shaft connected to the shaft of the compression apparatus through a shaft seal.

A further object of the present invention is to provide a variable capacity compressor unloading means involving a minimum of sturdy, easily manufactured and assembled parts.

These and other objects and advantages of the present invention may be more readily understood by reference to the following specification and accompanying drawings wherein like numerals refer to like parts throughout.

In the drawings,

Fig. 1 is a vertical, longitudinal section through the preferred form of the present invention;

Fig. 2 is a vertical, longitudinal section through the preferred form of the invention taken substantially at right angles to the plane of Fig. 1;

Fig. 3 is a bottom view of the preferred form of the invention;

Fig. 4 is a horizontal section through a portion of the apparatus taken substantially along line 4—4 of Fig. 1;

Fig. 5 is a vertical sectional view of a portion of the apparatus taken substantially along line 5—5 of Fig. 1:

Fig. 6 is a vertical view of a portion of the apparatus disclosed in Fig. 1;

Fig. 7 is a horizontal sectional view taken substantially along line 7—7 of Fig. 6; and

Fig. 8 is a partial sectional view taken in the same plane as that of Fig. 2, showing a modification of the present invention.

The compressor preferably includes three main castings comprising a body casting 10, a top casting 11, and a bottom casting 12, the three castings being joined by suitable bolts and gaskets to form a hermetically sealed housing.

The body casting 10 is provided with a plurality of cylinder seating openings 13, the number of which may vary from one to as many as can be permitted by the relative diameters of the cylinder seating openings and the main body casting. The cylinder seating openings are placed radially about the main casting and are vertically offset to permit the attachment of a plurality of connecting rods 14 to the crankpin 15 of a crankshaft 16 which is mounted in bearings 17 and 18 at the ends of a journal 19 cast integrally with the main casting 10. Each connecting rod 14 is connected to and operates a piston 20 which reciprocates within cylinder sleeves 21 supported in the cylinder seating openings 13. The sleeves 21 extend through an annular suction chamber 22 having provision for connection (not shown) with the suction pipe extending from the refrigerating system to which the compressor may be connected.

Expanded refrigerant is drawn into the cylinder sleeve 21 from the suction chamber 22 through an annular suction valve 23 when the piston is retracted, and the compressed refrigerant is discharged through a discharge valve 24 when the piston is extended. The suction valve 23 is seated adjacent its inner diameter on the end of the cylinder sleeve 21 and adjacent its outer diameter on a valve seating ring 25 positioned within the cylinder receiving space 13. The gas may enter the cylinder space through a series of openings (not shown) extending through the ring 25. The gas may be discharged from the cylinder sleeve through a series of openings (not shown) in a discharge valve retaining member 26 which is held in position by a safety spring 27 having its outer end seated against a cylinder cap 28 which is bolted to the main casting. The gas discharged under compression travels downward through discharge passage 29 in the main casting which connects with discharge passage 30 aligned therewith in the bottom casting 12 and which opens into an annular discharge chamber 31 substantially surrounding the bottom casting 12. The chamber 31 opens into a discharge valve 32 which is adapted to be connected to the discharge pipe (not shown) leading to the refrigerating system to which the compressor may be connected. Complete details of a piston and valve assembly of the type having the operating characteristics of the valve assembly disclosed herein may be found in my prior Patent No. 2,137,965.

In the preferred form of the invention the compressor is adapted to be suspended from a resilient biscuit 35 carrying a mounting member 36 as disclosed in my prior Patent No. 2,204,510. The biscuit 35 is bonded to a sleeve 37 through which may be slipped a bolt 38 adapted to be threaded into a boss in the top casting 11. The biscuit 35 may thus sustain the weight of the compressor when the mounting member 36 is attached to a suitable supporting framework. The compressor may thus oscillate in all directions and the biscuit will eliminate vibration and noise transmission. The top casting 11 is preferably provided with a plurality of annular fins 40 which increase the heat transmission factor of the casing to aid in the elimination of the heat of friction and compression.

The top casting 11 is so shaped as to provide means to receive an annular sleeve 41 supporting the stator 42 of the driving motor. The rotor 43 of the motor is attached to the end of the shaft 16 extending above the journal 19. Convenience of assembly is thus provided since the stator may be mounted in the detached top casting 11 and the assembly slipped into place over the rotor assembled on the crankshaft. The casting 11 and the sleeve 41 are preferably shaped to provide an annular oil receiving space 44 through which a stream of oil may be passed to carry away the heat generated by the motor. The windings of the stator are connected through leads 45 to slip connectors 46 mounted in a connector plate 47 fastened over an opening in the main casting 10. The slip connectors are fastened to bolts 48 extending through the plate 47 and to the outer ends of which the power lines may be fastened. It is contemplated that a plurality of bolts 48 and slip connectors 46 will be provided in a standard connector plate 47. In the example illustrated, I have shown nine such members so that any known type of motor may be used by connecting leads in certain manners to the power lines as is well-known to the skilled electrician.

The bottom casting 12 is provided with a space 50 providing an oil sump, the oil contained therein forming a reservoir from which lubricating and cooling oil may be drawn. The oil level preferably extends above the bottom of the associated main casting 10 to the point indicated in Fig. 1, although the level may fluctuate within wide limits without affecting the operation of the compressor. A central standard 51 is cast integrally with the casting 12 and provides a base for a pump housing 52 which has cast integrally therein an upstanding crescent shaped land 53. A runner gear 54 surrounds the land 53 and is provided with vertical teeth 55 (Fig. 4) between which are oil receiving pockets 56. The teeth 55 are adapted to mesh with the teeth of an idler gear 57 mounted upon a post 60 supported in the pump housing 52. The housing 52 is provided at one side with an elongated suction pocket 61 to which is connected an elbow 62 carrying a suction tube 63 extending well below the oil level. At the opposite side the bottom of the pump housing 52 is provided with an elongated discharge pocket 64 having a drain opening extending into a discharge cavity 65 provided by the solid rim of the housing 52, the bottom surface of the housing 52, and the top surface of the pump standard 51. The runner gear 54 is connected to a drive shaft 66 through which extends a horizontal driving bar 67 adapted to be engaged by a vertical driving pin 68 extending from the end of the crank pin 15.

When the motor drives the crankshaft the runner gear 54 is rotated and the gear pockets 56 are successively brought adjacent the suction pocket 61. Oil which is thus placed in the pockets 56 is carried around between the outer wall of the crescent 53 and the inner wall of the pump housing 52 until it is deposited in the discharge pocket 64 by the compressing action of the teeth of the idler gear 57. When the gear pockets 56 commence to open up again they have passed beyond the limits of the discharge pocket 64 and are thus placed under suction so that when they again reach the suction pocket 61 oil will be drawn from the sump. The oil is discharged into the space 65 under considerable pressure and in greater quantity than needed for lubrication.

The oil leaves the discharge space 65 through a passage 70 drilled vertically through the standard 51, and which connects with a substantially horizontal passage 71 drilled through a boss 72 (Fig. 2) connecting the base of the standard to the outer wall of the bottom casting 12. Passage 71 communicates with a vertical passage 73 in the outer wall of the casting 12. Passage 73 communicates with an aligned passage 74 in the outer wall of the main casting 10 and an aligned passage 75 in the outer wall of the top casting 11. Passage 75 communicates with the annular oil receiving space 44 surrounding the stator of the motor. The opposite side of the space 44 communicates with a downwardly extending passage 76 which communicates with an aligned passage 77 in the main casting 10. A horizontal passage 78 drilled through an arm 80 supporting the journal 19 intersects vertical passage 77 and transmits oil into an annular space 81 surrounding the shaft 16 between the inner ends of the bearings 17 and 18. Oil is also transmitted through openings drilled through the shaft 16 (not shown) to the spaces between the connecting rods 14 as disclosed in my prior Patent No. 2,247,449.

Passage 77 also communicates with a horizontal passage 85 in arm 80 within which is mounted a pressure relief valve 86 operating against a spring 87 in the inner end of the passage and an abutment provided by the narrow elongated end 88 of the plug 89 closing the outer end of the passage. The pressure relief valve 86 is provided with an opening 90 through which any oil may drain and flow through a drainage opening 91 so as to prevent leakage from trapping the piston against operation. The strength of the spring 87 is designed to maintain a desirable pressure, such as 40 pound to 50 pounds, in the lubricating system. When the spring 87 has been compressed due to the application of the desired pressure, the outer head of the valve 86 uncovers a vertical passage 92 drilled through the wall of the main casting 10 to a point closely adjacent the oil level line, the oil escaping therefrom being thus deposited in the sump without undue agitation and foaming. Oil which escapes from between the connecting rods and through the drainage opening 91 likewise flows down into the sump. Oil escaping from above the bearing 18 drains into the sump from a collector cup 93.

The annular space 81 communicates with a horizontal passage 95 drilled into a second arm 96 supporting the journal 19. This arm 96 is of large diameter and is provided with a cylindrical pocket 97 within which is slidably guided a sarting unloader piston 98. The outer end of the cylinder pocket 97 is capped by a plug 99 through which extends a passage 100 communicating with a longitudinal passage 101, in which is placed a starting unloader valve 102. The valve is provided with a triangular stem which provides three longitudinal passages between its sides and the cylindrical wall of the passage 101. The inner end of the valve 102 is provided with a conical head adapted to seat in a conical valve seat 103 in the inner end of passage 101. Inward movement of the valve 102 is limited by an abutment member 104 supported in the starting unloader piston 98. A spring 105 surrounds the abutment member 104 and tends to keep the piston 98 retracted, as shown in Fig. 1.

When oil pressure is applied to the inner end of piston 98 the spring may be compressed, and the abutment 104 may cause the head of valve 102 to seat in the conical seat 103 thus blocking communication between the passage 100 and the space surrounding the abutment 104, which space communicates with the interior of the casing through a gas return opening 106. The passage 100 is in communication with a passage 107 extending to one of the openings 13 which is in communication with the discharge chamber 31, so that when the valve 102 is open the compressed gas will be released through the gas return opening 106 and the gas will expand back into the interior of the casing. The gas escapes from the portion of the casing enclosing the motor through openings 108 between the arms 80 and 96 (Fig. 1) and is returned to the suction chamber 22 through openings such as opening 109 adjacent the lower bearing 17 and oil drain 110 in the bottom of the suction chamber. Thus, as long as the valve 102 is open the compressor will do substantially no work since the gas will be discharged against the suction pressure existing in the suction chamber 22, instead of against the discharge pressure established by the resistance of the refrigeration system. The valve 102 will be closed as soon as the pump has established sufficient oil pressure to move the piston 98 toward the valve 102. In this manner it is made possible to use low starting torque motors which are economical in power consumption and low in peak load, as well as less bulky than high starting torque motors, since the oil pressure will not be built up until sufficient revolutions of the rotor have been made to permit the flywheel effect of the rotor and associated mechanism to overcome the load of compression and inertia.

The inner end of the passage 71 extending through the boss 72 connects at right angles to a horizontal passage 115 extending into a cylindrical pocket 116 bored through a boss 117 connecting the base of the pump standard 51 and the wall of the bottom casting 12 opposite the discharge valve 32. The pocket 116 seats a cylindrical master valve body 118 which is held in place by sealing cap 119. The master valve body has a recess 120 therein in communication with a passage 121 leading to a central bore 122 extending through the valve body 118. The central bore 122 is in communication with a bore 123 extending through the base of the pump standard 51 into the oil sump 50. The central bore 122 supports and guides a longitudinally movable master valve rod 124 which is provided with a land 125 shutting off normal communication between the passage 121 and the bore 123, and a second land 126 shutting off normal communication between the passage 121 and the bore 122 between the end of the valve rod 124 and the sealing cap 119. Adjacent the land 126 the valve rod is provided with a plurality of grooves 127 which are adapted to receive a spring urged ball 128. The master valve rod 124 is adapted to be moved longitudinally of the bore 122, and the purpose of the grooves 127 and spring urged ball 128 is to provide resistance causing the valve rod to move quickly by short steps rather than slowly by uneven amounts.

Movement of the valve rod 124 is accomplished by a master valve operator 130 including a flexible metallic bellows 131 projecting into the space 50 within the bottom casting 12 and retained in position by a sealing cap 132. The end plate 133 seals the interior of the bellows 131 from the interior of the casing and provides a surface against which the gas in the interior of the crankcase presses on one side and the atmosphere presses on the opposite side. A spring 134 also bears against the outside surface of the end plate 133 and is adjustably compressed by an adjusting member 135 slidable longitudinally in slots through the wall of a threaded member 136 extending from the cap 132. The member 135 is retained in position by a nut 137 and lock nut 138. The inner end of the bellows 131 is fastened to a plunger 140 which is slidably guided in a bore 141 through the pump standard 51. A locking rod 142 is also fastened to the plunger 140 and is threaded at its exterior end, which projects through the member 136, to receive a locking nut 143 which is adapted to bear against the end of member 136 when the rod 140 is locked against movement by drawing the end plate 133 tightly up against the end of a sleeve 144 disposed within the bellows 131.

When the locking nut 143 is loosened, as shown in Fig. 1, the end plate 133 is free to move inwardly from the inner end of a spacer sleeve 144 as permitted by the balance of pressures between the suction pressure existing within the crankcase on one side and the combined effect of the atmospheric pressure and the expanding strength of spring 134 on the other side. As the suction pressure decreases, inward movement of the rod 140 is accomplished to an extent such as to cause the force of the spring 134, lessened due to its expansion, practically to balance the outward thrust. As the suction pressure increases, the spring 134 is compressed until the end plate 133 strikes the inner end of sleeve 144. Movement of the bellows may be accomplished within different ranges of suction pressures by adjustment of the spring adjusting member 135 longitudinally of the member 136.

Further details of the master valve operator may be ascertained from my prior Patent No. 2,185,473.

The plunger 140 is pivotally connected to a pair of rocking levers 150 mounted upon a rockshaft 151 supported in trunnions 152 carried by a pedestal 153 cast integrally with the pump base 51. The lower arms of the levers 150 are longer than the upper arms and are pivotally connected to the inner extremity of the master valve rod 124 so that movement of the bellows 131 is transmitted to a multiplied extent to the master valve rod 124. Movement of the bellows 131 would normally be gradual but the action of the grooves 127 and ball 128 causes movement of the bellows and of the master valve rod in spaced steps equal to the extent of one of the grooves 127.

As seen more clearly in Figs. 1 and 5, the master valve body 118 is provided with a plurality of longitudinal bores 160 corresponding to the number of cylinders carried by the compressor and the number of grooves 127 in the master valve rod. The bores 160 are adapted to be aligned with a plurality of bores 161 drilled partially through the pump base 51. Each of the bores 160 communicates with the bore 122 in the master valve body through a slot 162 cut through the master valve body 118. The slots 162 are spaced longitudinally of the master valve body a distance substantially equal to the width of the land 125 or the distance between centers of the grooves 127 so that movement of the master valve rod 124 from one position to another places one or more of the slots 162 in communication with the space 65 into which oil is discharged by the pressure pump.

Each of the bores 161 is in communication with a connecting bore 163 extending upwardly through a vertical boss 164 cast integrally with the bottom casting 12 and rising toward the top of the casting, there being a plurality of such bosses equal in number to the number of cylinders of the compressor, and each of such bosses being associated with one of the cylinders. The upper end of each boss 164 is provided with an open ended cylindrical bore 165 in which is loosely mounted a piston 166. The piston is adapted to bear against the lower end of an individual cylinder unloading plunger 167 extending through a vertical bore drilled through the wall of the suction space 22 beneath the centerline of the cylinder. A spring 168 surrounding the plunger 167 tends to urge the piston 166 toward the bottom of the bore 165, the lower end of the spring being held by a snap ring 169 mounted on the lower end of the plunger 167. Oil pressure transmitted to the cylindrical bore 165 through the action of the master valve rod 124 causes compression of the spring and vertical movement of the plunger 167. In Fig. 1 the first of the slots 162 has been connected to the pump so that the piston 166 at the right side of the view has been raised by oil pressure. The other three slots 162 are still beyond the land 125 so that the piston 166 at the left side of the view has been lowered by expansion of spring 168.

The plunger 167 is pivotally connected to a yoke 175 having its arms embracing the cylinder sleeve 21 in which the piston 20 operates. Each arm of the yoke carries a floating pin 176, one end of which rests upon a ramp 177 and the other end of which engages an unloader ring 178 surrounding sleeve 21. The unloader ring 178 carries a plurality of pins 179 extending longitudinally of the outer surface of the cylinder sleeve 21 and the outer ends of which are adapted to engage the suction valve 23, as illustrated in the cylinder at the left side of Fig. 1, when the yoke has been retracted by expansion of spring 168. When the yoke 175 is advanced, as shown in the cylinder at the right side of Fig. 1, the pin 176 has slid down the ramp 177 thereby permitting the normal operation of the suction valve 23. The ring 178 and the pins 179 may float in this position or may be held in retracted position by any suitable spring device (not shown). Such a spring device is illustrated in my aforesaid Patent No. 2,185,473.

When the suction valve 23 of a single cylinder is held in open position, no work will be accomplished by that piston since the gas will enter the cylindrical space through the suction valve on the retraction stroke of the piston and then be forced back into the suction space 22 through the open suction valve 23 on the extension stroke of the piston. When the yoke 175 is extended, normal operation of the suction valve 23 permits that cylinder to accomplish the work of compression. The cycle then is as follows: On the retraction stroke of the piston, suction will be established within the cylinder sleeve 21 until the pressure within the suction space 22 is greater than the pressure within the cylinder sleeve 21 thereby causing the suction valve to open and permitting gas to fill the cylinder sleeve.

On the extension stroke of the piston the valve 23 will close, partially due to the increased internal pressure and partially due to the actions of springs such as spring 180. As soon as the gas is compressed to an extent sufficient to overcome the pressure existing within discharge space 31, the discharge valve 24 will open permitting discharge of the compressed gas. As soon as the piston starts to retract, the discharge valve 24 will close, partially due to the difference in pressures thus established and partially due to the operation of springs such as spring 181.

As the pressure in the suction space 22 tends to vary, the number of cylinders in operation may vary so that the compressor tends to run constantly and thus maintain a supply of refrigerant sufficient to balance the load on the refrigerating system, rather than to cycle on and off causing wide fluctuations in temperature.

In a compressor put to air conditioning use, the spring 134 of the master valve operator may be set to start moving the master valve rod when the suction pressure drops to 42 pounds. In the example illustrated in Fig. 1, this would cause sufficient movement to cause unloading of the individual cylinder at the right of the view. The force of the spring may be such that, as soon as the suction pressure drops another two pounds, a second cylinder would be unloaded and all cylinders would be momentarily unloaded when the suction pressure dropped to 36 pounds. However, the suction pressure would immediately rise, causing one or more cylinders to begin operating again. Selection of refrigerating systems substantially balanced against the capacity of the compressor would thus permit practically constant operation of the refrigerating system tending to maintain a constantly proper output of conditioned air.

In other applications, such as the storage of meat, a weaker spring may be used or the same spring with proper adjustment of the member 135 may permit operation of the master valve within ranges of, for example, 10° above zero to 10° below zero in increments of 5° for each cylinder. A wide range of applications is thus made possible with but a simple adjustment and a wide range of uses can be accommodated by the same type of apparatus. Likewise, a wide range of variance in the calculations of the installation engineer may be accommodated since the compressor will always attempt to balance against the refrigeration system; whereas, in prior practices if the refrigerating system were of too small capacity the compressor would only run intermittently for short periods of time.

A further advantage of the present invention resides in the fact that a single multiple cylinder compressor may be used in installations where a plurality of separate compressors were formerly employed. Such would be the case in meat, fruit, vegetable or fur storage rooms where a large increase in load might be suddenly applied in a refrigerating system as by the introduction of a large supply of fresh meat into the refrigerator box. If the refrigerating system were supplied with refrigerant by a plurality of compressors connected in tandem and each controlled by a thermostat, the sudden increase in load would cause all of the compressors to operate until the suction pressure had been drawn down to such a point as to cause the usually supplied suction pressure safety cutout to operate on one machine. This would cause the one machine to stop with a resulting sudden increase in suction pressure since the other machine could not carry the doubled load. The machine which had thus been cut off from operation would be required to start operating. Installations have been observed where the cycling of such a machine would occur every ten, fifteen, or perhaps thirty seconds. The strain on the compressor, and particularly upon the driving motor, commonly results in failure of the mechanism which would leave an insufficient number of compressors in operation to draw down the temperature, with the resulting loss of the commodity intended to be refrigerated. A single compressor employing my invention will overcome all these difficulties since the compressor would be selected to be capable of balancing a refrigerating system having a capacity great enough to take care of the maximum load which would be imposed, and the single compressor would draw down the temperature on a continuous smooth curve until a point might be reached where a single cylinder would be sufficient to maintain the normal heat leakage. An advantage flowing from this is that the power consumption would be substantially proportioned to the number of cylinders in operation which is materially less than the power consumption required by a standard compressor cycling on and off to maintain the desired conditions.

The starting unloader piston 98 cooperates with the individual cylinder unloading mechanism as follows: When a compressor has come to rest, for example, due to the fact that a single cylinder is capable of carrying more than the normal heat loss, the oil pressure is released and the passage 106 permits escape of the discharge gas. A rise in temperature in the refrigerated or air conditioned space causes the motor to start operating with the result that oil pressure is rapidly built up resulting in rapid closing of the unloader valve 102. While the compressor was at rest the pressure existing in the interior of the crankcase rose because of the release into the interior of the crankcase through escape passage 106 of a large amount of gas at high pressure thus causing compression of the bellows 131 and connection of all the slots 162 to the space 65 before the compressor started operating. Therefore, as soon as oil pressure is supplied all of the yokes 175 will be extended to permit normal operation of the suction valves 23. Immediately all of the cylinders would commence drawing down the suction pressure until one or more of the cylinders would be unloaded by operation of the master valve. The compressor would continue operating under control of the master valve 130 until such time as the thermostat in the space caused the motor to stop. It can be seen from the above that the controls required for an air conditioning or refrigerating system are reduced to the bare minimum of a single thermostat, or a single humidostat, or conceivably in accordance with known practices in the art a thermostat and humidostat so arranged as to cause one or the other instrument to take precedence. The starting unloader piston assures normal starting torque against a low discharge pressure while the individual cylinder unloading means assures constant balancing of the output against the load.

It is conceivable that the fins 40 on the top casting 11 would not be sufficient to dissipate the heat of the motor and friction of the bearings to a sufficient extent; hence, as shown in

Fig. 2, the end of passage 71 may be opened by removing the plug 190, and oil permitted to flow through a cooling device such as a tube 191 having fins 192. This cooled oil would enter the space 44 surrounding the stator through a passage 193 normally closed by a plug 194.

The present invention permits the use of either a motor sealed in the casing as shown in Figs. 1 and 2, or of an external motor (or other driving means) as shown in Fig. 8. It is dangerous, if not impossible, to use a direct current motor sealed into the casing since some refrigerants break down under the arcing of a direct current motor, or slow operation through gears or belts may be desired. Hence, as shown in Fig. 8 the top casting 11 may be replaced by a casting 200 having a shaft opening therethrough through which the shaft 16 projects. The shaft opening may be sealed by any convenient sealing means, that illustrated being the type of seal disclosed and claimed in the patent to Christman et a.. No. 2,200,413. This seal comprises a running seal member 201 having frictional engagement with a fixed seal member 202. The member 201 is rotated with the shaft by the force of a spring 203 transmitted through a sealing gasket 204. The fixed sealing member 202 rests upon a fixed sealing gasket 205. The projecting end of the shaft may be fastened through a coupling device 206 of any suitable character to the shaft 207 of a motor 208 mounted upon a bracket 209 extending from the end of the casting 200. In this form of the invention the upper ends of the oil passage 74 and the oil passage 77 are preferably blocked by plugs 210 and 211, respectively, although a solid gasket in place of the perforated gasket normally used may be sufficient. In this case the normal flow of oil would be maintained by bringing the end of the oil cooler tube 191 into a fitting 215 occupying the place of the plug 216 (Fig. 2) normally used to block the end of passage 78.

A further change found desirable would be the provision of a threaded bore 217 through the arm 80 into the passage 78 into which would be screwed a fitting 218 carrying a short length of tubing 219 having its upper extremity flattened and bent over to direct a stream of oil into contact with the frictional surfaces of the shaft seal. The oil thus released to cool the seal would flow back into the oil sump 50 through the opening 108 (Fig. 1). All other parts and the functioning of each part of the compressor would be the same as explained in connection with the sealed compressor of Fig. 1.

Having described and illustrated preferred embodiments of my invention, it should be apparent to those skilled in the art that the same permits of various modifications in arrangement and detail. All such modifications as come within the scope of the following claims are considered a part of my invention.

I claim:

1. A refrigerant compressor comprising a plurality of sets of compressing pistons and cylinders, suction valve means and discharge valve means associated with each of said sets, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through one of said suction valve means respectively and a common discharge chamber adapted to be connected with each of said cylinders through one of said discharge valve means respectively during the compression cycle, starting unloader means operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement, means for disestablishing the connection through said starting unloader means soon after commencement of movement of said pistons, and individual cylinder unloading means responsive to lessening of pressure in said suction chamber below desired limits to render individual sets of pistons and cylinders and the valves associated therewith ineffective to discharge compressed gas into said discharge chamber even though said crankshaft continues to reciprocate all of said pistons.

2. A refrigerant compressor comprising a plurality of sets of compressing pistons and cylinders, suction valve means and discharge valve means associated with each of said sets, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through one of said suction valve means respectively and a common discharge chamber adapted to be connected with each of said cylinders through one of said discharge valve means respectively during the compression cycle, starting unloader means operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement, means for disestablishing the connection through said starting unloader means soon after commencement of movement of said pistons, and individual cylinder unloading means associated with each of said sets of pistons and cylinders responsive to lessening of pressure in said suction chamber to successive predetermined pressures to render individual sets of pistons and cylinders successively ineffective to discharge compressed gas into said discharge chamber even though said crankshaft continues to reciprocate all of said pistons.

3. A refrigerant compressor comprising a plurality of sets of compressing pistons and cylinders, suction valve means and discharge valve means associated with each of said sets, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through one of said suction valve means respectively and a common discharge chamber adapted to be connected with each of said cylinders through one of said discharge valve means respectively during the compression cycle, starting unloader means operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement, means for disestablishing the connection through said starting unloader means soon after commencement of movement of said pistons, and individual cylinder unloading means associated with each of said sets of pistons and cylinders responsive to lessening of pressure in said suction chamber to successive predetermined pressures to render individual suction valve means ineffective to operate in normal compression cycle fashion whereby individual pistons and cylinders become unable to compress refrigerant even though said crankshaft continues to reciprocate all of said pistons.

4. A refrigerant compressor comprising a plurality of sets of compressing pistons and cylin-

ders, suction valve means and discharge valve means associated with each of said sets, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through one of said suction valve means respectively and a common discharge chamber adapted to be connected with each of said cylinders through one of said discharge valve means respectively during the compression cycle, starting unloader means operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement, means for disestablishing the connection through said starting unloader means soon after commencement of movement of said pistons, and individual cylinder unloading means associated with each of said sets of pistons and cylinders responsive to lessening of pressure in said suction chamber to successive predetermined pressures to render individual suction valve means ineffective to operate in normal compression cycle fashion whereby individual pistons and cylinders become unable to compress refrigerant even though said crankshaft continues to reciprocate all of said pistons, such action being accomplished successively with respect to each set of cylinders and pistons as the suction pressure arrives at successively lower predetermined points.

5. A refrigerant compressor comprising a plurality of sets of compressing pistons and cylinders, suction valve means and discharge valve means associated with each of said sets, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through one of said suction valve means respectively and a common discharge chamber adapted to be connected with each of said cylinders through one of said discharge valve means respectively during the compression cycle, starting unloader means operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement, means for disestablishing the connection through said starting unloader means soon after commencement of movement of said pistons, and individual cylinder unloading means including an element responsive to lessening of pressure in said suction chamber below desired limits to render individual sets of pistons and cylinders and the valves associated therewith ineffective to discharge compressed gas into said discharge chamber even though said crankshaft continues to reciprocate all of said pistons, said pressure responsive element being responsive to an increase of pressure in said suction chamber resulting from connection of the latter with said discharge chamber by said action of said starting unloader means for presetting said individual cylinder unloading means in readiness to render said individual sets of pistons and cylinders and valves effective upon commencement of crankshaft movement.

6. A compressor comprising a single crankshaft and a plurality of compressing elements driven thereby, a housing comprising two separable castings, one of which carries said compressing elements, and unloading means associated with each of said compressing elements, each of said means comprising actuated parts shiftably carried by the casting carrying said compressing elements and actuating parts shiftably carried by the other of said castings in such positions that cooperative relationship of the actuating and actuated parts of all of said individual unloading means is established upon assembly of said castings.

7. A compressor comprising a single crankshaft and a plurality of compressing elements driven thereby, a housing comprising two separable castings, one of which carries said compressing elements, and unloading means associated with each of said compressing elements, each of said means comprising a suction valve lifting mechanism shiftably carried by the casting carrying said compressing elements and a suction valve lifting mechanism actuating piston shiftably carried by the other of said castings in such positions that cooperative relationship of the suction valve lifting mechanisms and the actuating pistons therefor of all of said individual cylinder unloading means is established upon assembly of said castings.

8. A compressor comprising a single crankshaft and a plurality of compressing elements driven thereby, a housing comprising two separable castings, one of which carries said compressing elements, unloading means associated with each of said compressing elements, each of said means comprising a suction valve lifting mechanism having a shiftable element carried by the casting carrying said compressing elements and a suction valve lifting mechanism actuating piston shiftably carried by the other of said castings in such positions that contacting cooperative relationship of the shiftable element of said suction valve lifting mechanisms and the actuating pistons therefor of all of said individual cylinder unloading means is established upon assembly of said castings, a fluid pump carried by said other casting, and master valve means within said housing for selectively directing fluid from said pump against one or more of said actuating pistons.

9. A compressor comprising a single crankshaft and a plurality of compressing elements driven thereby, a housing comprising two separable castings, one of which carries said compressing elements, unloading means associated with each of said compressing elements, each of said means comprising a suction valve lifting mechanism having a shiftable element carried by the casting carrying said compressing elements and a suction valve lifting mechanism actuating piston shiftably carried by the other of said castings in such positions that contacting cooperative relationship of the shiftable element of said suction valve lifting mechanisms and the actuating pistons therefor of all of said individual cylinder unloading means is established upon assembly of said castings, a fluid pump carried by said other casting, master valve means within said housing for selectively directing fluid from said pump against one or more of said actuating pistons, and a master valve operator comprising a pressure collapsible part subjected to the pressure existing in a portion of said housing and operatively associated with said master valve means.

10. A compressor comprising a single crankshaft and a plurality of compressing elements driven thereby, a housing comprising two separable castings, one of which carries said compressing elements, unloading means associated with each of said compressing elements, each of said means comprising a suction valve lifting

mechanism having a shiftable element carried by the casting carrying said compressing elements and a suction valve lifting mechanism actuating piston shiftably carried by the other of said castings in such positions that cooperative relationship of the shiftable element of said suction valve lifting mechanisms and the actuating pistons therefor of all of said individual cylinder unloading means is established upon assembly of said castings, a fluid pump carried by said other casting, master valve means within said housing for selectively directing fluid from said pump against one or more of said actuating pistons, and a master valve operator comprising a pressure collapsible part subjected to the pressure existing in a portion of said housing and operatively associated with said master valve means to move said master valve means in fluid connecting direction and adjustable spring means in opposition to said pressure collapsible part to move said master valve means in fluid disconnecting direction.

11. A compressor comprising a housing adapted to be sealed against the outside atmosphere, said housing comprising a separable main casting and a bell-shaped casting, compressing mechanism carried by said main casting and including a drive shaft having a free end projecting from the end of said main casting to which said end casting is attachable, drive shaft bearing means forming a integral assembly with said main casting, said main casting having its end surface lying substantially in the same plane as the outer end of said bearing means, an electromotive rotor mounted on said free end of the drive shaft, and an electromotive stator mounted on the inside surface of said bell-shaped end casting in position to surround said rotor when said castings are united to complete the housing.

12. A refrigerant compressor including a plurality of compressing units each comprising a piston, cylinder, suction valve means and discharge valve means, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through the suction valve means thereof, a common discharge chamber adapted to be connected with each of said cylinders through the discharge valve means thereof during the compression cycle, an individual cylinder unloading system including an element responsive to decreasing and increasing of the pressure in said suction chamber with respect to desired limits to render said individual compressing units ineffective and effective respectively to discharge compressed gas into said discharge chamber during continuous reciprocation of said pistons, and a starting unloader system operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement including means for disestablishing said connections after commencement of movement of said pistons.

13. A refrigerant compressor including a plurality of compressing units each comprising a piston, cylinder, suction valve means and discharge valve means, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through the suction valve means thereof, a common discharge chamber adapted to be connected with each of said cylinders through the discharge valve means thereof during the compression cycle, an individual cylinder unloading system including an element responsive to decreasing and increasing of the pressure in said suction chamber with respect to desired limits to render said individual compressing units ineffective and effective respectively to discharge compressed gas into said discharge chamber during continuous reciprocation of said pistons, and a starting unloader system operative upon cessation of movement of said crankshaft and pistons to connect said suction chamber with said discharge chamber whereby to cause reduction in the pressure against which said pistons operate upon starting movement including means for disestablishing said connections after commencement of movement of said pistons, said pressure responsive element of said individual cylinder unloading system being responsive to an increase in suction pressure resulting from said connection of the latter with said discharge chamber by said action of said starting unloader system for presetting said individual cylinder unloading system in readiness to render said compressing units effective upon commencement of crankshaft movement.

14. A refrigerant compressor including a pressure lubricating system and a plurality of compressing units each comprising a piston, cylinder, suction valve means and discharge valve means, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through the suction valve means thereof, a common discharge chamber adapted to be connected with each of said cylinders through the discharge valve means thereof during the compression cycle, mechanism associated with each of said compressing units and connected with said lubricating system and responsive to the pressure thereof for individually unloading and loading said units, shiftable valve means for controlling the application of pressure of said lubricating system on said mechanism, a member responsive to decreasing and increasing of the pressure in said suction chamber with respect to desired limits for setting said valve means to actuate said mechanism to its unloading and loading positions respectively, a starting unloader system including valve means for establishing and disestablishing a communicative connection between said suction and discharge chambers, and control mechanism for said starting unloader valve means including a member responsive to the pressure of said lubricating system for retaining said valve closed when said crankshaft is in motion and accommodating opening thereof when said crankshaft is at rest.

15. A refrigerant compressor including a plurality of compressor units each comprising a piston, cylinder, suction valve means and discharge valve means, a crankshaft drivingly connected to all of said pistons, a common suction chamber adapted to be connected with each of said cylinders through the suction valve means thereof, a common discharge chamber adapted to be connected with each of said cylinders through the discharge valve means thereof during the compression cycle, an auxiliary fluid pressure system including a pump drivingly connected with said crankshaft, mechanism associated with each of said compressing units and connected with said auxiliary fluid pressure system and responsive to the pressure thereof for individually unloading and loading said units, shiftable valve means for controlling the application of the pressure of said auxiliary system on said mechanism, a member responsive to decreasing and increasing of the

pressure in said suction chamber with respect to desired limits for setting said valve means to actuate said mechanism to unloading and loading positions respectively, a starting unloader system including valve means for establishing and dis-establishing a communicative connection between said chambers, and control mechanism for said starting unloader valve means including a member responsive to the pressure of said auxiliary fluid pressure system for retaining said unloader valve means closed when said crankshaft is in motion and accommodating opening thereof when said crankshaft is at rest.

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