United States Patent

Schnear

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[54] FLUID COMPRESSOR APPARATUS

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[52] **U.S. Cl.** **417/360**, 417/273, 91/491, 417/266

[51] **Int. Cl.**.....**F04b 17/00**, F04b 35/00, F01b 1/06, F01b 13/06

[58] **Field of Search**.....417/427, 567, 360, 508, 273, 417/266; 91/491, 494, 495; 123/55 VS

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[57] **ABSTRACT**

Fluid pumping apparatus, particularly for compressing fluid refrigerants, with a plurality of cylinder piston units mounted in diverging angular relationship, the pistons being connected to a single crankjournal on the crankshaft by one-piece connecting rods with antifriction bearings in the crank connected ends.

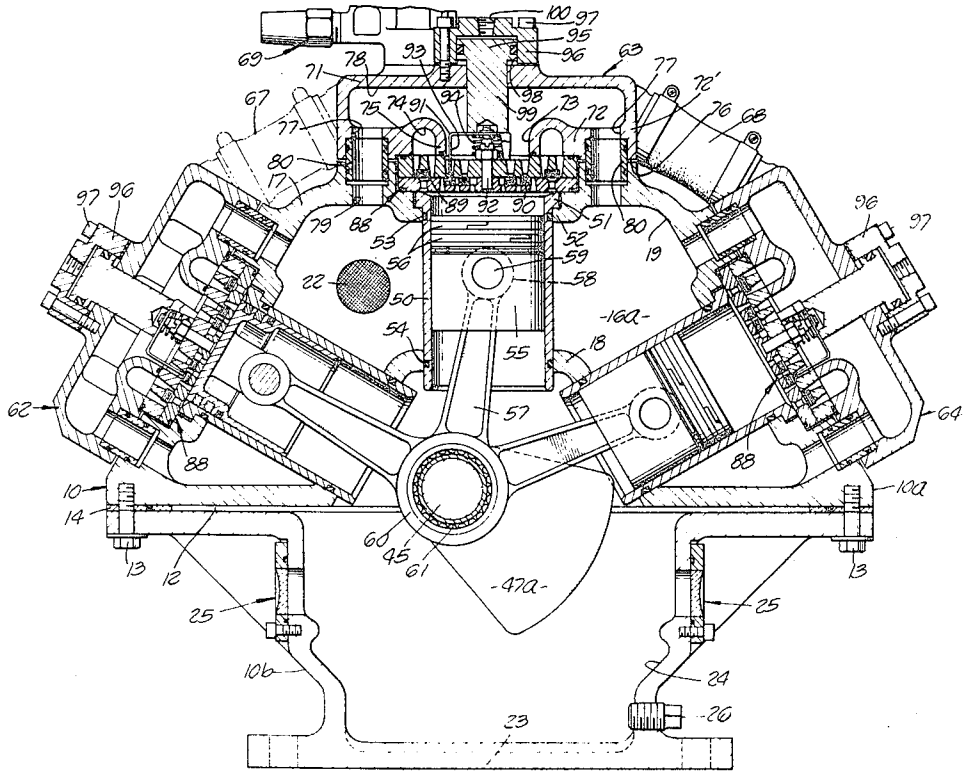
The crankshaft is of two-piece construction and releasably connected at the crank journal to facilitate assembly and disassembly of the connecting rods.

The compressor frame is of hollow sectionalized construction and arranged with a crank case which is split at the axis of the crankshaft to facilitate assembly and disassembly of the shaft, the shaft supporting bearings, and the pistons.

Each cylinder is closed at its outer end by a cavitated head cap with an inlet compartment and outlet exhaust compartment, the inlet compartment being connected to a common fluid inlet cavity formed in the hollow frame, and from which fluid is fed to all of the pumping cylinders.

Provision is made for valve unloading which permits selective incremental control of the output capacity level of the compressor.

6 Claims, 8 Drawing Figures



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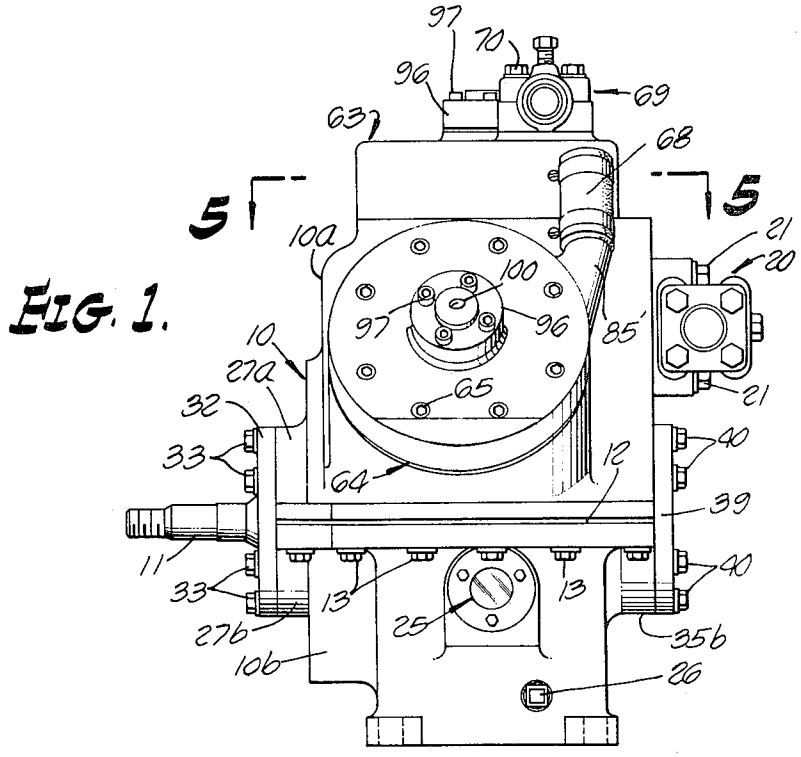


FIG. 1.

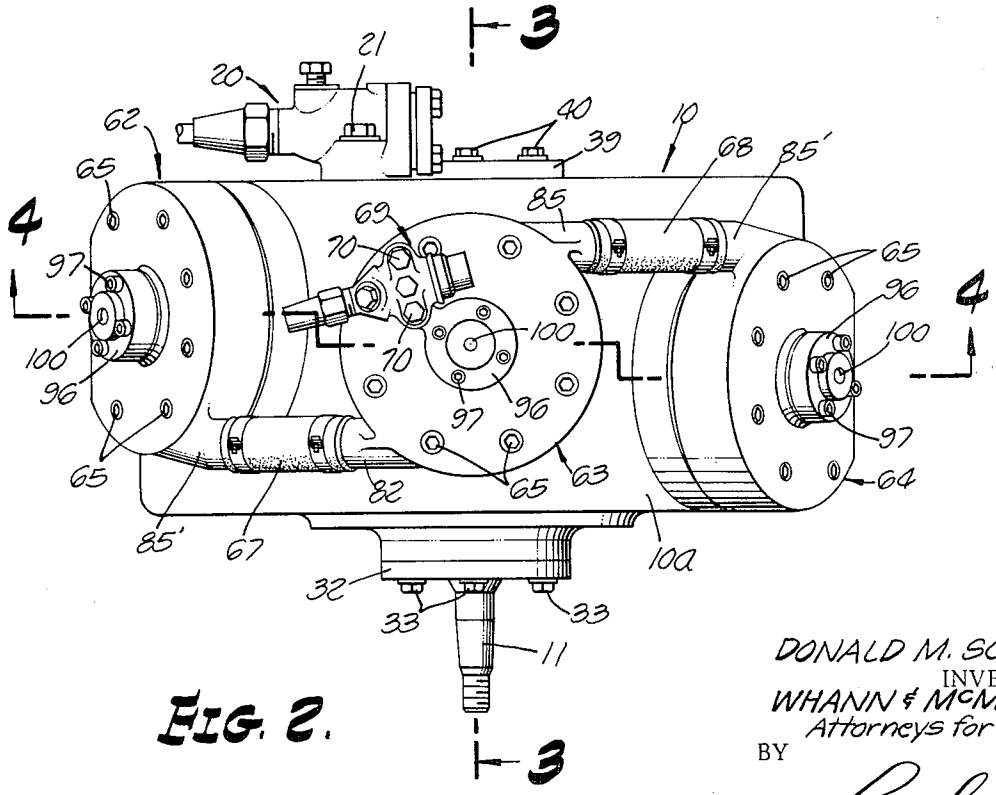


FIG. 2.

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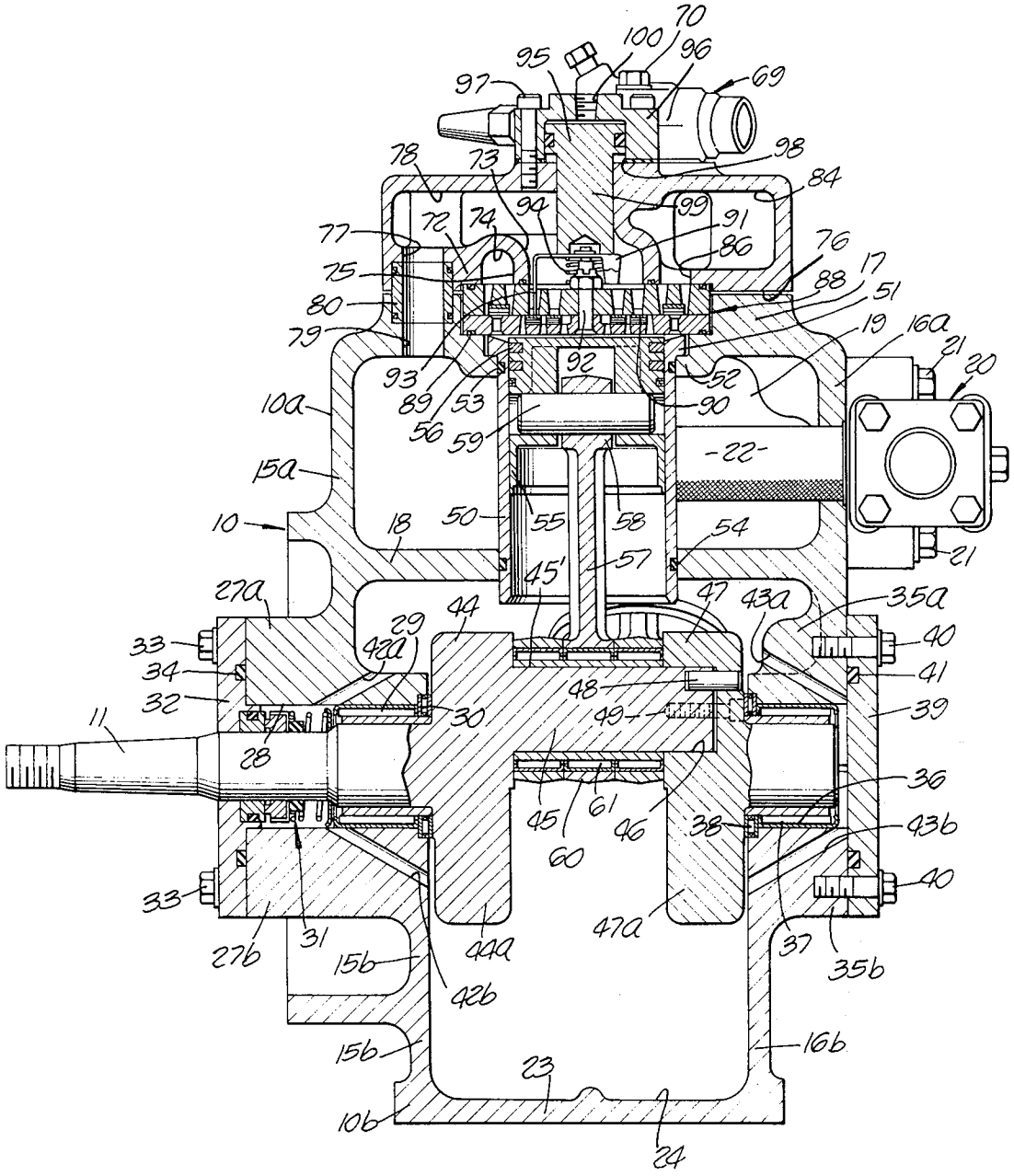


FIG. 3.

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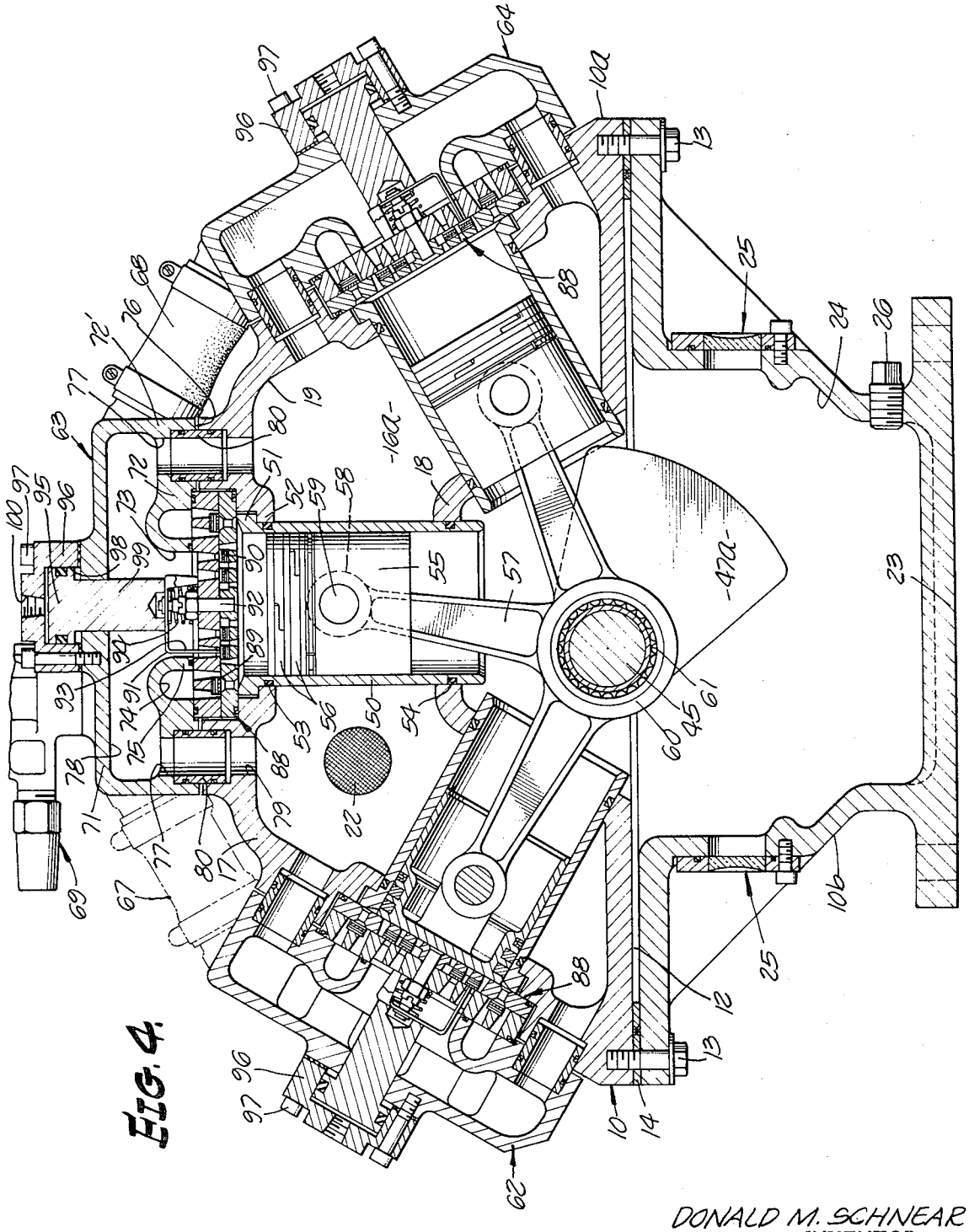


FIG. 4.

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FIG. 5.

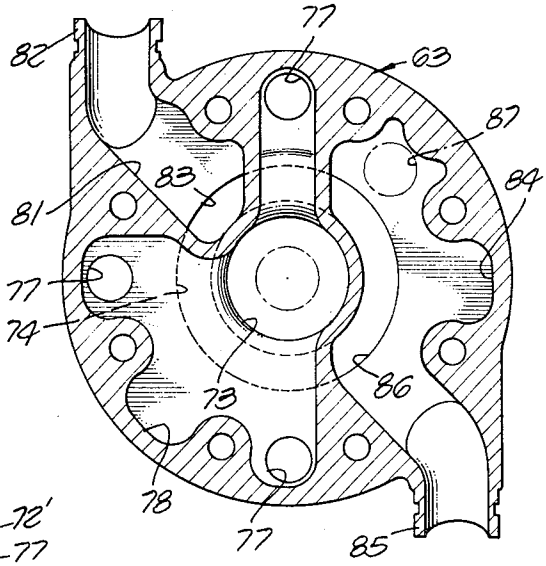


FIG. 7.

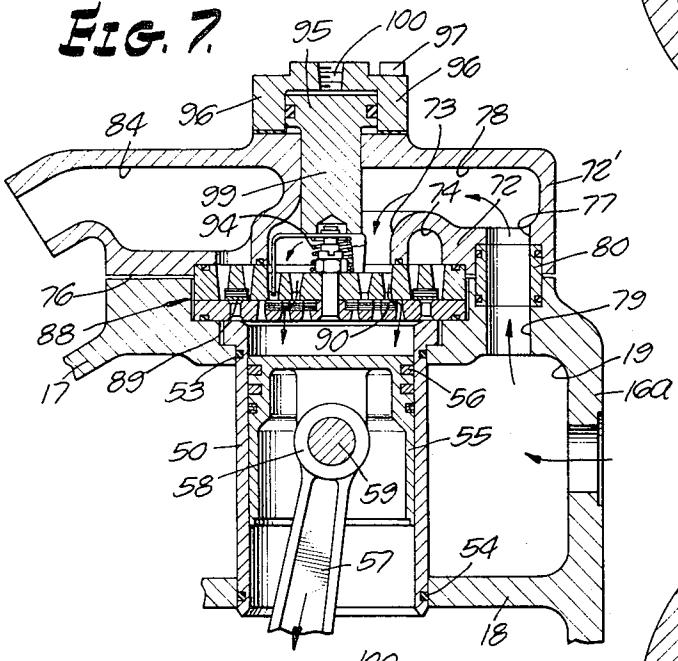


FIG. 6.

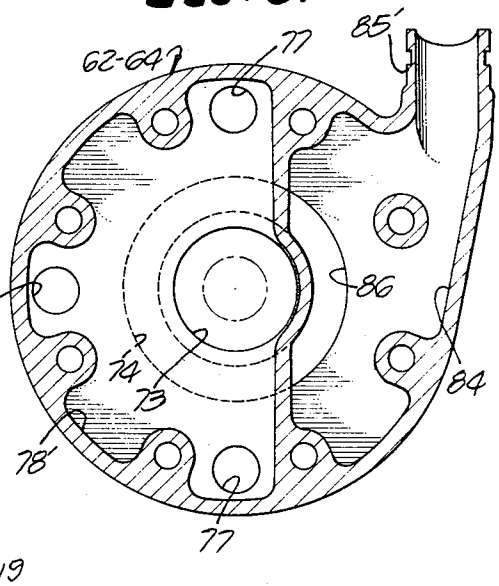
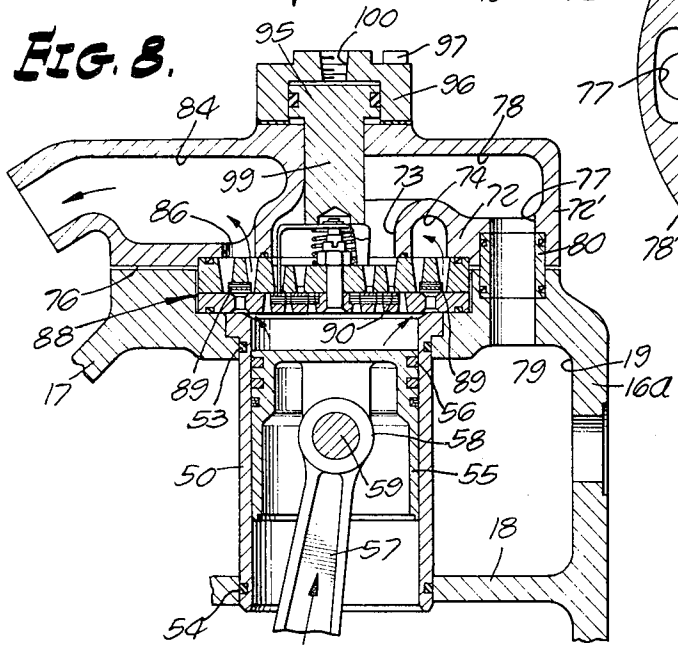


FIG. 8.



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FLUID COMPRESSOR APPARATUS

BACKGROUND OF THE INVENTION

The invention relates to the field of fluid pumping apparatus.

Heretofore, fluid compressing apparatus such as utilized in the field of refrigeration has become largely stereotyped as to the design of the apparatus and its operation. From an analysis of conventional apparatus, it is apparent that in a number of respects the apparatus could be improved to provide a more efficient and better operating machine which could be more economically manufactured, assembled and, after installation, be maintained.

Conventional compressor design utilizes a hollow frame structure with removably mounted end bells or large cover plates which serve also as bearing supports for the crankshaft, the size of the cover being usually determined by the amount of space required to install the crankshaft into the frame. The use of this construction is a potential source of trouble and problems which can arise due to main bearing misalignment. Frames of this general design cannot be economically produced since they are difficult and expensive to cast, machine, and in general to manufacture.

In the compressor constructed according to the present invention, the frame or crankcase is of two piece design with the two pieces interfacing at an extended diametral plane through the crankshaft axis and being separated by a combination metal and elastomer seal which permits metal-to-metal dimensional control of manufacturing tolerances. The interfacing frames of the casing are also utilized at the opposite ends of the crankshaft to form split bearing supports so that it is possible to utilize anti-friction bearings for supporting the shaft. Thus, the frame design of the present invention provides a materially improved concept which enables easy and rapid assembly and disassembly of the compressor during manufacture and for maintenance.

Moreover, conventional compressors utilize piston connecting rods which are constructed at their crank connection end with a split bearing support in which a retaining cap is fastened by bolts to retain a split sleeve type bearing in operative position on the crank journal.

In the present invention, the manner of connecting the crankshaft journal and connecting rods of the several pistons has been improved by providing a two-piece crankshaft which is separable at the crank so that anti-friction bearings may be inserted endwise over the crank journal. It is therefore not necessary to utilize connecting rods having a split bearing support, but the rods can be made at their crank connection end with a one-piece construction in which a cylindrical bore receives the anti-friction bearing endwise therein. This improved arrangement results in more facile assembly and disassembly, and has the manufacturing advantage of requiring less parts and providing greater accuracy.

From the foregoing, it will thus be seen that the present invention has advantageously improved the conventional design by utilizing an arrangement which permits the use of anti-friction bearings instead of the type in which the bearing surfaces are in friction sliding engagement. Bearing life is one of the inherent problems with conventional rotating machinery due to lubrication problems and operational loads causing friction and wear. In the present invention by utilizing

anti-friction type bearings, bearing wear is reduced and the compressor permitted to function with design tolerances instead of deteriorating to a looseness which is beyond practical limits. Moreover, in the use of anti-friction bearings such as roller bearings, it is unnecessary to utilize the conventional oil pumping equipment with its pump, filter, and piping to carry the lubricant to the sliding friction bearing surfaces. Instead, a simple splash system may be utilized, as in the present invention.

Another area in which the present invention has materially improved the conventional compressor design, resides in the construction of the compressor frame. In the conventional design, two chambers are utilized, one for suction or inlet gas, and the other for discharge or outlet gas. These two chambers are separated in the frame housing or casing by a wall structure which allows a relatively high order of heat transfer from one chamber to the other due to the discharge gas temperature being in the order of three to four times greater than the temperature of the suction gas.

In the present invention, this disadvantage is overcome by utilizing a frame construction in which inlet gas only is brought into a single chamber in the frame, and from there is conducted to the cylinder head caps for induction into the pumping cylinders. The exhaust gas is carried directly to delivery means independent of the frame interior. Thus, the high temperature pressurized gas is kept substantially isolated from the lower temperatured inlet gas. Greater efficiency is thus obtained.

The present invention has further improved the conventional compressor apparatus in providing selectively operable unloaders for opening the suction valves to the pumping cylinders, thus permitting incremental control of the pumping output level. For example, in the illustrated compressor having three cylinders, three different levels of capacity control are possible in substantially 33 percent increments from a condition of zero unloading with 100 percent capacity output, to 100 percent unloading with zero capacity output.

SUMMARY OF THE INVENTION

The present invention relates generally to fluid pumping means, and is more particularly concerned with improvements in compressor apparatus of the reciprocating piston type such as used in the field of refrigeration.

One object of the herein described invention is to provide a compressor having a plurality of cylinder-piston pumping units positioned in diverging angular relation on one side of a diameter through the axis of a common drive shaft, and in a which the frame or a crankcase comprises interconnected sections interfacing at the axis of the drive shaft.

A further object is to provide an improved compressor having a plurality of pumping pistons connected to a single actuating crank, and wherein the shaft is split at the crank to facilitate disconnection of the pistons from the crank and disassembly of the pistons and their associated cylinders.

A further object is to provide in a compressor a pumping piston structure which utilizes a unique piston rod of one-piece construction, and which enables use of roller bearings at the crank connected end.

A still further object is to provide in a compressor of the reciprocating piston type, a structural organization which permits use of anti-friction bearings instead of the conventional sleeve bearings with frictionally engaged surfaces, thus enabling the use of a simple splash type lubricating system instead of the conventional oil pump, filtering means and pressure piping.

Another object is to provide in a compressor an improved and unique gas inlet and gas exhaust system wherein the heat exchange flow path between the hot exhaust or discharge gas and the cooler inlet or suction gas is materially reduced by providing substantially isolated flow paths thus allowing the gas compression to be performed at a sufficiently low enough temperature as to provide a higher refrigeration efficiency.

Still another object is to provide in connection with the above noted feature, a unique head cap construction for each cylinder having cored flow passages for the inlet and exhaust gas, the limits which are interconnectable to conduct the exhaust gas from the respective pumping cylinders to a common exhaust line.

It is also an object to provide in a compressor of the herein described type, unique selective unloading means for each pumping cylinder, which allows incremental control of capacity level between the limits of zero unloading with full capacity, and full unloading with zero capacity.

Further objects and advantages of the invention will be brought out in the following part of the specification, wherein detailed description is for the purpose of fully disclosing the invention without placing limitations thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the accompanying drawings, which are for illustrative purposes only:

FIG. 1 is a side elevational view of a compressor embodying the features of the present invention,

FIG. 2 is a plan view of the same;

FIG. 3 is a longitudinal section, taken substantially on line 3—3 of FIG. 2;

FIG. 4 is a transverse sectional view taken substantially on line 4—4 of FIG. 2;

FIG. 5 is a sectional view through a cylinder head cap as used with the central cylinder of the unit, taken substantially on line 5—5 of FIG. 1; and

FIG. 6 is a similar view on the cap of the cylinder in the foreground as seen in FIG. 1; and

FIGS. 7 and 8 are fragmentary sectional views in a head portion of a pumping cylinder and head cap for diagrammatically illustrating suction and exhaust operations.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more specifically to the drawings, for illustrative purposes, there is shown in FIG. 1 a compressor constructed according to and in the main embodying features of the present invention. Basically, the compressor is of the W block configuration and in this case comprises a hollow frame structure **10** mounting three cylinder-piston pumping units. These pumping units extend in angular radially spaced directions on one side of an extended diametral plane through the longitudinal axis of a crankshaft **11**. The frame structure **10** is formed in two sections, shown in FIG. 1 as comprising an upper section **10*a*** and lower section **10*b***, these sections being interfaced on the diametral plane as indicated at **12** and being secured together by peripheral stud bolts **13**, a peripheral combination metal and elastomer seal strip **14** being interposed between the interfacing frame sections, (FIG. 4).

As best shown in FIG. 3, the upper section of the hollow frame structure comprises spaced end walls **15*a*** and **16*a***, these end walls being interconnected by an outer generally arcuate wall structure **17** and a radially inwardly spaced generally arcuate inner wall structure **18**. These walls coact to form a fluid inlet cavity **19** for receiving the fluid which is to be compressed, this fluid being supplied from a suitable external source to a suction stop valve device **20** of well known construction, which is secured to the end wall **16*a*** as by cap screws **21** (FIG. 3). From the stop device, the fluid enters the cavity **19** through a connected filter **22**.

The lower section **10*b*** of the frame structure is correspondingly provided with end walls **15*b*** and **16*b*** between which there extends a generally U-shaped connecting wall **23** which provides a supporting base for the compressor and coacts with inner wall structure **18** to form a crankcase cavity **24** on the opposite side of the crankshaft **11** from that of the inlet fluid cavity **19**. The crankcase wall is provided with one or more window sight gauges as generally indicated at **25**, and a usual drain plug **26** for a drain opening, which may be used for the mounting of a heating unit in the crankcase if desired.

At the opposite ends of the crankshaft **11**, the end walls adjacent the shaft are fabricated to provide hub portions for supporting the shaft bearings. At one end of the shaft, as shown in FIG. 3, the end walls **15*a*** and **15*b*** are formed with bearing supporting hub portions **27*a*** and **27*b*** having a cooperably formed axial bore **28** arranged at its innermost end to receive therein an anti-friction main bearing **29** and thrust bearing **30**. Outwardly of the bearing **29**, there is provided a conventional spring urged shaft seal assembly as generally indicated at **31**. The outermost end of the axial bore **28** is closed by an end plate **32**, this plate being retained in mounted position by cap screws **33**, a seal **34** being interposed between the end plate and adjacent hub portion, and interfacing with seal strip **14**.

At the opposite end of the shaft, the end wall sections are formed to provide hub forming portions **35*a*** and **35*b***, these portions having an axial bore **36** for receiving an anti-friction shaft bearing **37** and thrust bearing **38**. The outer end of the bore **36** is a similarly closed by an end plate **39** which is retained by cap screws **40**, a seal **41** being interposed between the end plate and hub portions. Oil flow passages **42a** and **42b** are provided in the hub portion for the circulation of lubricating oil to the outer end of the bearing **29**. Similarly oil flow passages **43*a*** and **43*b*** are provided in the hub portions at the other end of the shaft to provide oil circulation to the outer end of the bearing **37**.

Intermediate its ends, the shaft **11** is constructed to provide a single actuating crank in which a crank arm **44** carries an integrally formed crank journal **45**, this journal at its outer end being arranged to seat within a recess **46** of a companion crank arm **47**. The crank arms are finitely spaced by a journal sleeve **45'** which also serves as a bearing surface. The crank arm and as-

sociated journal end are properly oriented by means of a dowel pin 48, the parts then being secured in operative position by suitable cap screws 49. With the connection just described, it will be appreciated that the driveshaft is thus constructed in two pieces which are separable at the crank journal, and thus facilitate assembly and disassembly of the piston connecting rods in a manner which will subsequently be explained. The offset crank journal is counter balanced by oppositely extending portions 44*a* and 47*a* of the crank arms to form in effect counterweights. These crank arms and counterweight extensions further serve to splash and distribute oil within the crank case for lubricating purposes.

Referring now to FIG. 4, it will be noted that there are three cylinder-piston pumping units which are contained within the upper frame section 10*a*, which are driven by the single crank journal 45. Since each of these pumping units is similarly constructed, it is believed that it will only be necessary to describe one unit.

As will be seen, the cylinders are supported in the outer wall structure 17 and inner wall structure 18 and extend through the inlet fluid cavity 19. The pumping cylinder as indicated at 50 comprises a tubular sleeve which may be cast or otherwise formed from suitable material. This sleeve at its outermost end is provided with an outwardly projecting end flange 51 adapted to abut and support the cylinder on an annular supporting flange 52 surrounding a cylinder receiving opening which is formed in a chordal portion of the outer wall. Peripherally the cylinder 50 contains appropriate end seals 53 and 54 by which the ends of the cylinder are sealed with respect to the outer and inner walls of the frame.

The cylinder has a piston 55 reciprocal therein, this piston at its outer end being fitted with bronze impregnated lap joint compression rings 56 rather than the conventionally used cast iron butt joint ring. An inherent problem with reciprocating compressors has always been "blow-by" or gas transfer from the compression chamber to the crankcase, whereby a great deal of refrigerant becomes intermixed with the lubricant. Such a condition is undesirable and has been known to cause considerable operation problems in a refrigerating system. By the use of the lap joint compression rings, this problem is greatly alleviated. Another advantage of the compression rings as mentioned above is that they can be operated without lubrication, and impurities will embed themselves in the ring material instead of becoming stuck between the ring and groove or ring and cylinder wall where unsatisfactory operating conditions could result.

The piston is connected with the crankshaft by means of a connecting rod 57. It is one of the important features of the present invention that this piston rod is of one-piece construction, an integrally formed cylindrical end 58 being provided at the outer end for receiving the piston connecting wrist pin 59, and at its crankconnected end with an integrally formed cylindrical end portion 60 for receiving endwise therein the crank journal and anti-friction connection bearing 61. This is made possible by utilizing a two-piece crankshaft which can be separated at one end of the crank journal as previously described. In FIG. 3 it will be observed that the connecting rods of the three pistons are mounted in end-to-end relation on the crank journal.

As shown in FIG. 2, the outer ends of the cylinders are provided with cylinder head caps as indicated at 62, 63 and 64, respectively, which are secured to the outer wall 17 by circumferentially spaced cap screws 65. Each of the cylinder head caps is internally cavitated to provide an inlet fluid compartment and outlet exhaust fluid compartment, as will hereinafter be described in detail. The exhaust fluid compartments of the respective cylinder head caps are interconnected, as shown in FIG. 2, by hoses 67 and 68, and thence to a conventional discharge stop valve device 69 secured to the top of cylinder head cap 63 as by cap screws 70, 70. This stop valve device is arranged for connection with a delivery means for the compressed fluid from the compressor.

The construction and operation of the cylinder head caps in conjunction with the valving means for controlling the inlet and exhaust of the pump fluid to the cylinders constitutes a very important feature of the present invention.

The construction of the cylinder head caps is basically the same, and for this reason the description will be primarily confined to the construction of the head cap 63, as utilized for the center cylinder. More specifically, the head cap is of generally circular configuration and contains an internal wall construction which provides compartments for separating the inlet fluid from the exhaust compressed fluid. As shown in FIG. 4, the cap is of generally hollow construction with an outer top wall 71 which peripherally connects with a depending circumferentially extending side wall 72', this side wall at its lower margin being connected with a circumferentially extending annular bottom connection flange 72 which surrounds a central opening 73. In concentric relation to the opening 73, the bottom flange is constructed to provide a concentric circular passage 74 which is separated from the opening 73 by an intervening wall portion 75. The passage 74 opens into the annular mounting face 76 of the cap. Outwardly of the passage 74 the flange 72 is provided with three port openings 77 (FIG. 5) which are in communication with an upper compartment 78, this compartment being in communication with the central opening 73. The compartment 78 is for receiving inlet suction fluid from the inlet fluid cavity 19 through the port openings 77. For such purpose, each port opening 77 is connected with a port opening 79 leading to the cavity 19 by means of a connection nipple 80, this nipple being peripherally sealed at its ends in the adjacent wall structures.

For the exhaust discharge fluid from the pumping cylinder, the cap 63 is internally formed in its upper portion with an upper compartment 81 which is in communication with an external hose connection nipple 82. Internally, the compartment 81 is connected through an opening 83 with the circular passage 74. In the same manner, a second upper compartment 84 communicates with an external hose connection nipple 85, and internally is connected through an opening 86 with the circular passage 74. It will further be apparent that the passage 74 interconnects the compartments 81 and 84 via the openings 83 and 86. A flow passage connection is also established between the upper compart-

ment 84 and the discharge stop valve device 69 through a port passage as indicated in phantom at 87 which is provided in the top wall 71 of the cap 63.

The cylinder head caps 62 and 64 are basically constructed similarly to the cap 63, and perform the same functions. The primary difference is that the hose connection nipple 82 and the compartment 81 may be omitted, thus permitting enlargement of compartment 78 as indicated at 78' in FIG. 6. Also the location of the hose connection nipple 85 is reversed as indicated at 85' in FIG. 6.

For controlling suction and exhaust flows between the outer end of the cylinder and the cylinder head cap, there is provided a conventional valve assembly 88 of a type wherein the inlet and exhaust valves are in concentric relation with the inlet being positioned inwardly of the outlet. Such valves are well known in the industry and are generally referred to as the Hoerbiger Valve Company design and are available from this company. Basically, the valve embodies a spring loaded valve member 89 operable under exhaust compression to permit flow of compressed fluid from the top of the cylinder into the passage 74 of the head camp. Spring loaded inlet valves 90 are pressure actuated to control flow of inlet fluid from the compartment 78 through opening 73 into the upper end of the pumping cylinder, when the suction pressure is increased to the required value.

Selectively operable unloading means are provided for each of the cylinders. As shown in FIG. 4, the unloader comprises an actuator bracket 91 which is supported upon a central upwardly projecting bolt 92 of the valve assembly for limited raising and lowering movements to inactive and active positions respectively, this bracket having depending finger portions 93 adapted to engage with the inlet valves and move these valves to open position when the bracket member is moved to its active position. Normally the bracket is urged by a spring 94 to an inactive position. A fluid actuator is provided for moving the bracket to its active position, and is shown in FIG. 4 as comprising a piston 95 which is cooperatively associated with a cap member 96 which is secured by cap screws 97 to the top of the associated cylinder head cap. This cap member is provided with an internal cylinder bore 98 within which the piston is operatively reciprocable. A stem 99 carried by the piston is operatively associated at its outer end with the actuator bracket 91 so that upon the introduction of a low pressure fluid to the top of the cylinder bore by a port opening connection 100, the piston will be moved downwardly against the pressure of spring 34 so as to move the bracket 31 to its active position in which it will open the inlet suction valve and thus render the associated pumping unit ineffective to supply compressed fluid to the system. Since the unloaders are selectively operable, it will be evident that through the selective actuation of the unloaders, the output capacity of the compressor may be selectively maintained at three different output levels.

The operation of the compressor cylinder-piston pumping units will now be briefly described with reference to FIGS. 7 and 8, which diagrammatically illustrate the suction and compression strokes of the piston.

In FIG. 7, it will be observed that as the piston 55 is moved downwardly in the cylinder, a suction will be created which will open the inlet valves 90 of the valve assembly so as to permit inflow of inlet fluid centrally of the cylinder through opening 73. The fluid is supplied from the compartment 78 of the cylinder head cap into which the fluid is induced to flow from the inlet fluid cavity 19 of the frame structure through port opening 79, connection nipple 80 and port opening 77.

Referring now to FIG. 8, it will be seen that when the direction of movement of the piston is reversed and is moving upwardly, the fluid will be compressed and discharged through the outlet valve 89 into the circular passage 74 as well as through the opening 86 into the upper compartment 84 which is connected with an exhaust outlet.

It will be appreciated from the above that the inlet fluid and exhaust fluid are brought into heat exchange relation in the head cap structures and that the heat exchange barrier between the fluids has been reduced to an extremely low order, as compared to conventional structures wherein the inlet and exhaust fluids are brought into heat exchange relation in the frame structure where large heat exchange areas would exist.

From the foregoing description and drawings, it will be clearly evident that the delineated objects and features of the invention will be accomplished.

Various modifications may suggest themselves to those skilled in the art without departing from the spirit of my invention, and, hence, I do not wish to be restricted to the specific forms shown or uses mentioned.

I claim:

1. Fluid pumping apparatus having a plurality of cylinder-piston units positioned in diverging angular relation on one side of a diametral plane through the axis of a common rotatable drive shaft connected to the pistons, the improvement comprising:
   a. a crankcase including separate interconnected sections interfacing adjacent the drive shaft on an extended diametral plane through its axis, one of said crankcase sections providing a stationary support for the cylinders of said units;
   b. said sections at opposite ends of said shaft having cooperative portions forming a tubular support for a bearing; and
   c. a cylindrical anti-friction shaft bearing supported in each of said bearing supports, whereby said shaft is rotatably supported by said sections and upon disconnection and separation of said sections the shaft is free for disassembly.

2. Apparatus according to claim 1, wherein said shaft includes a single crank journal, and said pistons are actuated by piston rods respectively having a bearing connection on said crank journal.

3. Apparatus according to claim 2, wherein each of said piston rods at its journal connection end is of one-piece construction and includes a bearing receiving tubular bore.

4. Apparatus according to claim 3, including anti-friction bearing means receivable endwise into a mounted position in each piston rod tubular bore.

5. Apparatus according to claim 2, wherein said shaft is composed of releasably interconnected sections, said sections upon disconnection enabling disassembly of

said crank journal and the connected ends of said piston rods.

6. Apparatus according to claim 2, wherein said crank journal extends between spaced crank arms carried by said shaft, one end of said journal being integral with its associated crank arm, and the other end of said journal being releasably connected with its associated crank arm.

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