Feb. 2, 1954 L. H. BROWNE 2,668,004

COMPRESSOR

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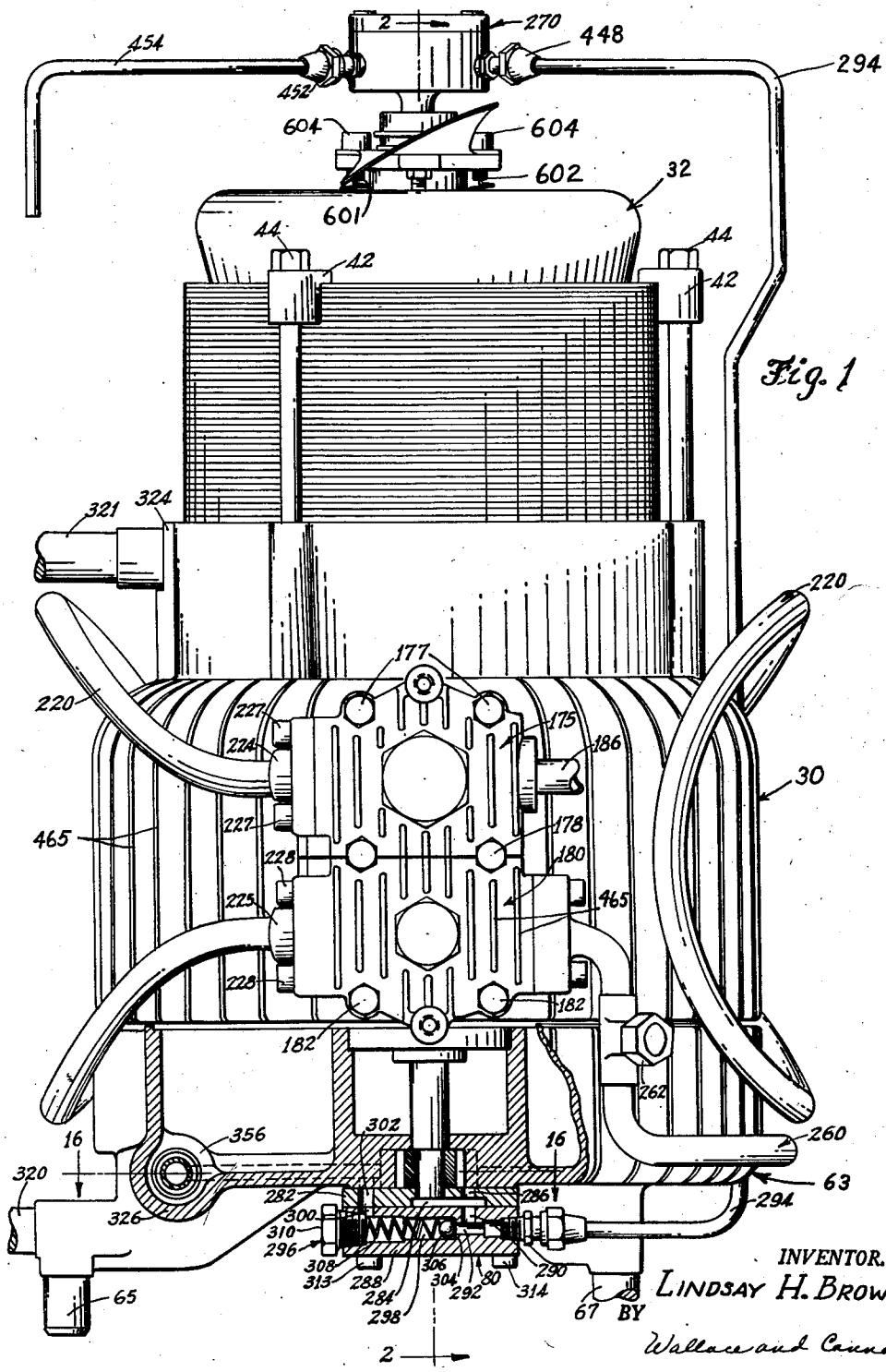


Fig. 1

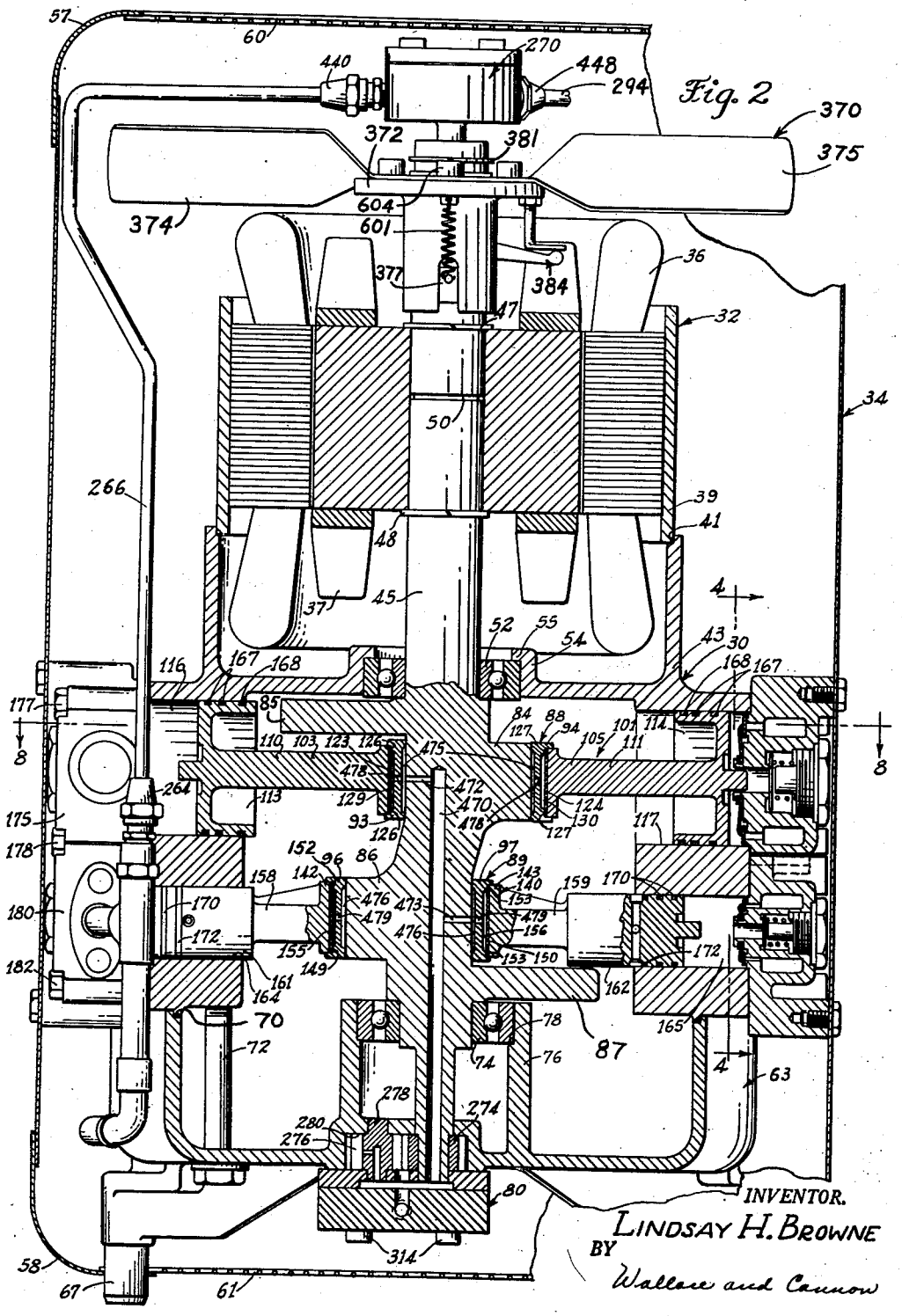
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COMPRESSOR

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Fig. 2



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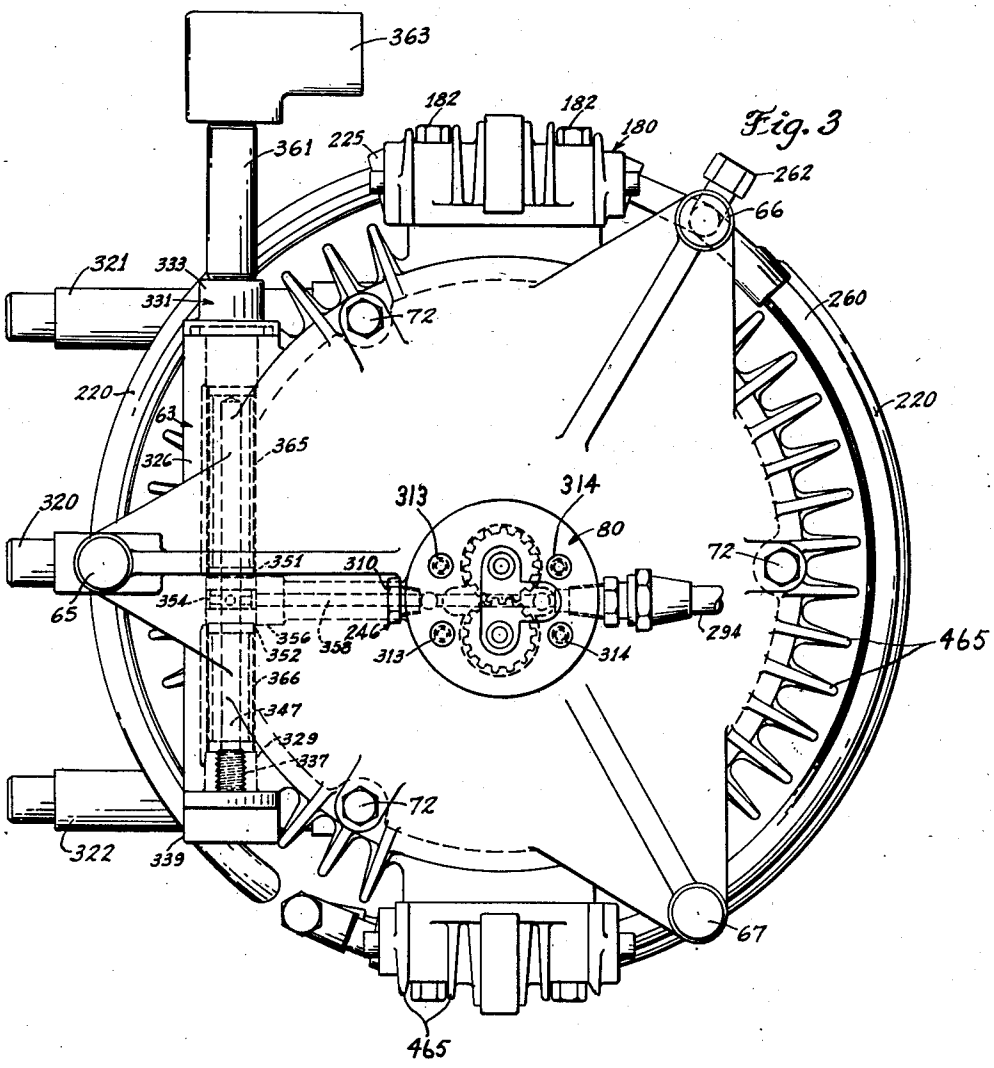


Fig. 3

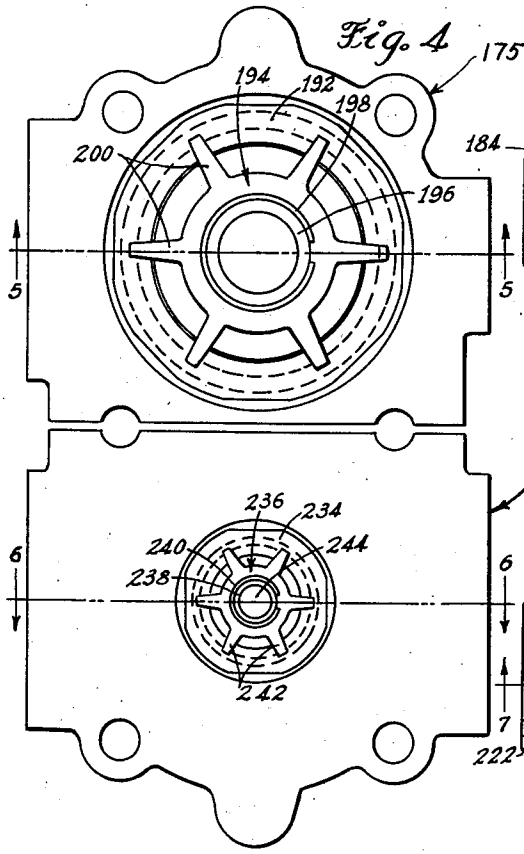
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Fig. 4



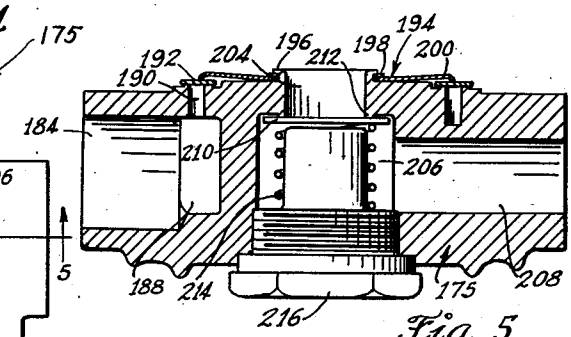
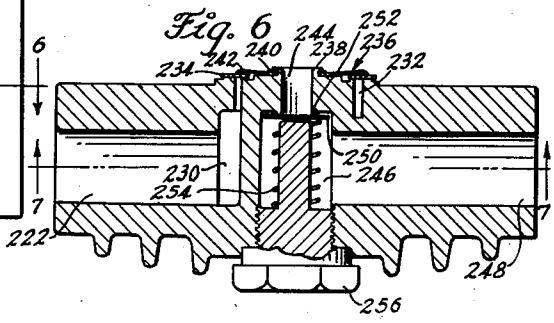


Fig. 5

Fig. 6



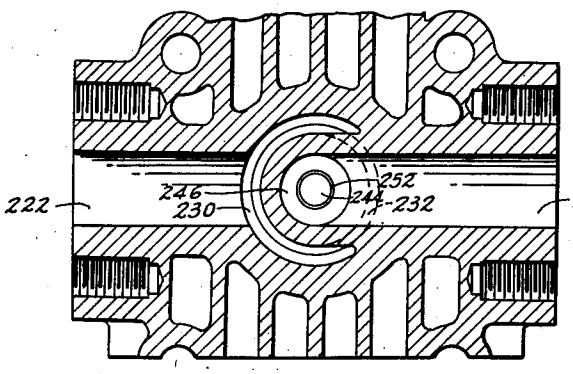


Fig. 7

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Fig. 8

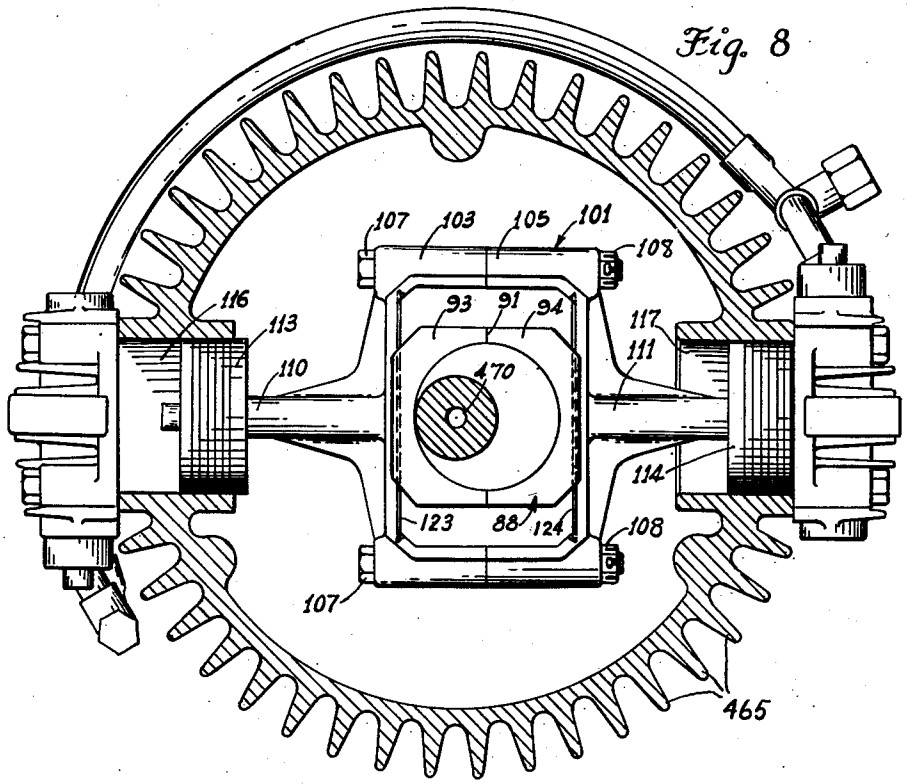
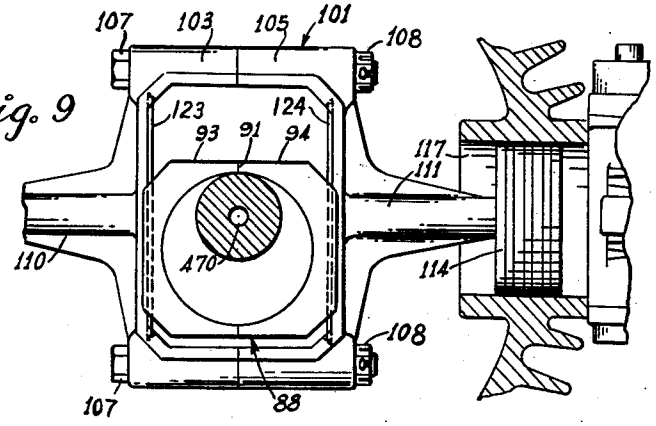


Fig. 9



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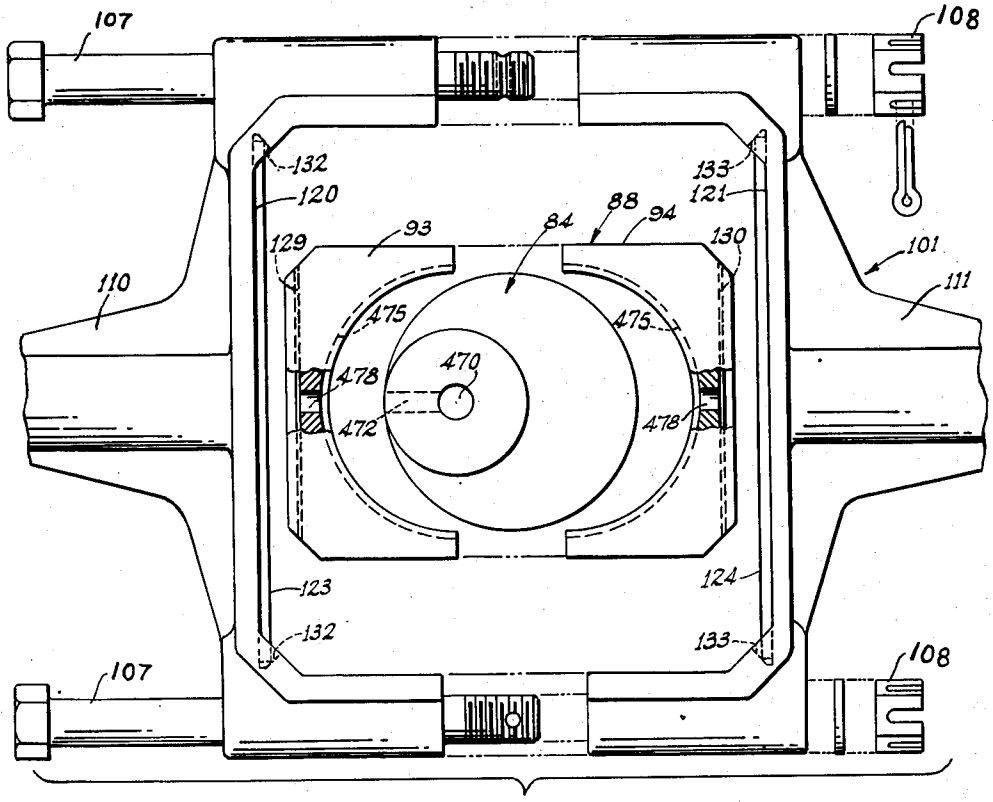


Fig. 10

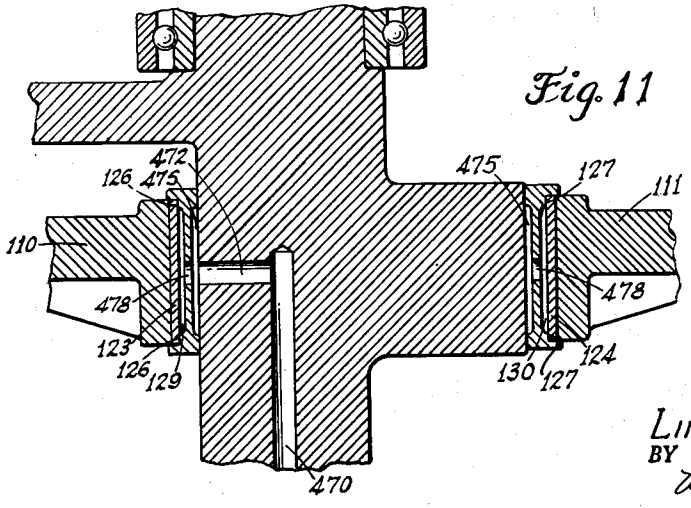


Fig. 11

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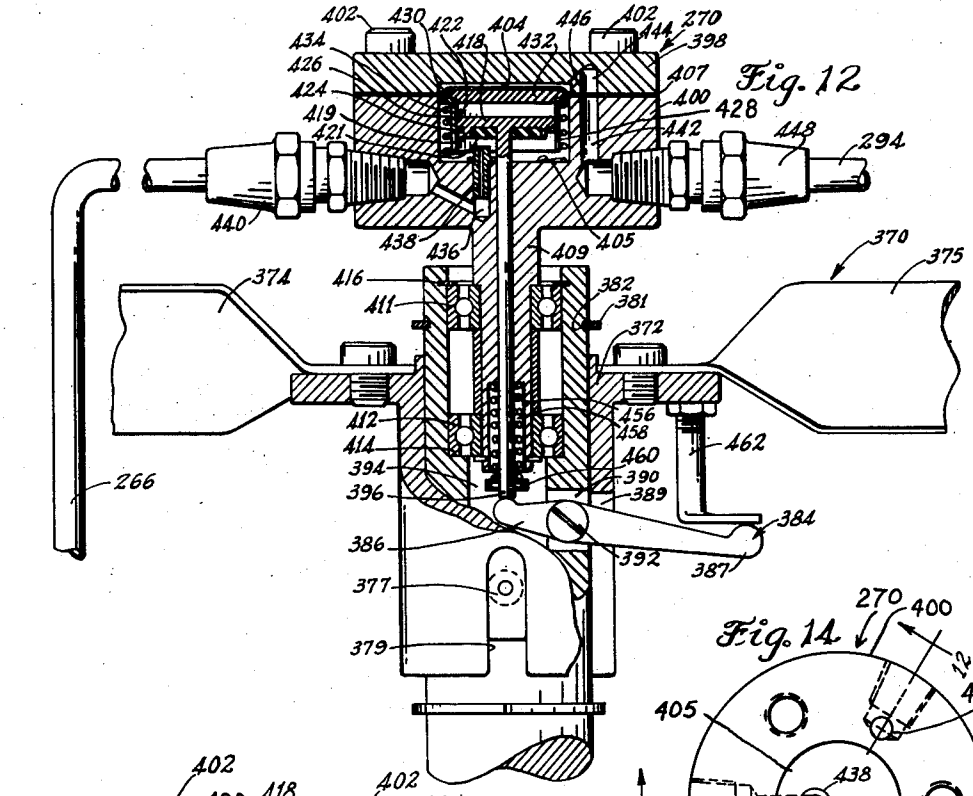


Fig. 12

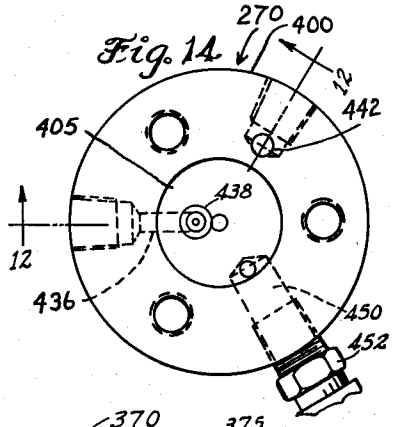


Fig. 14

Fig. 13

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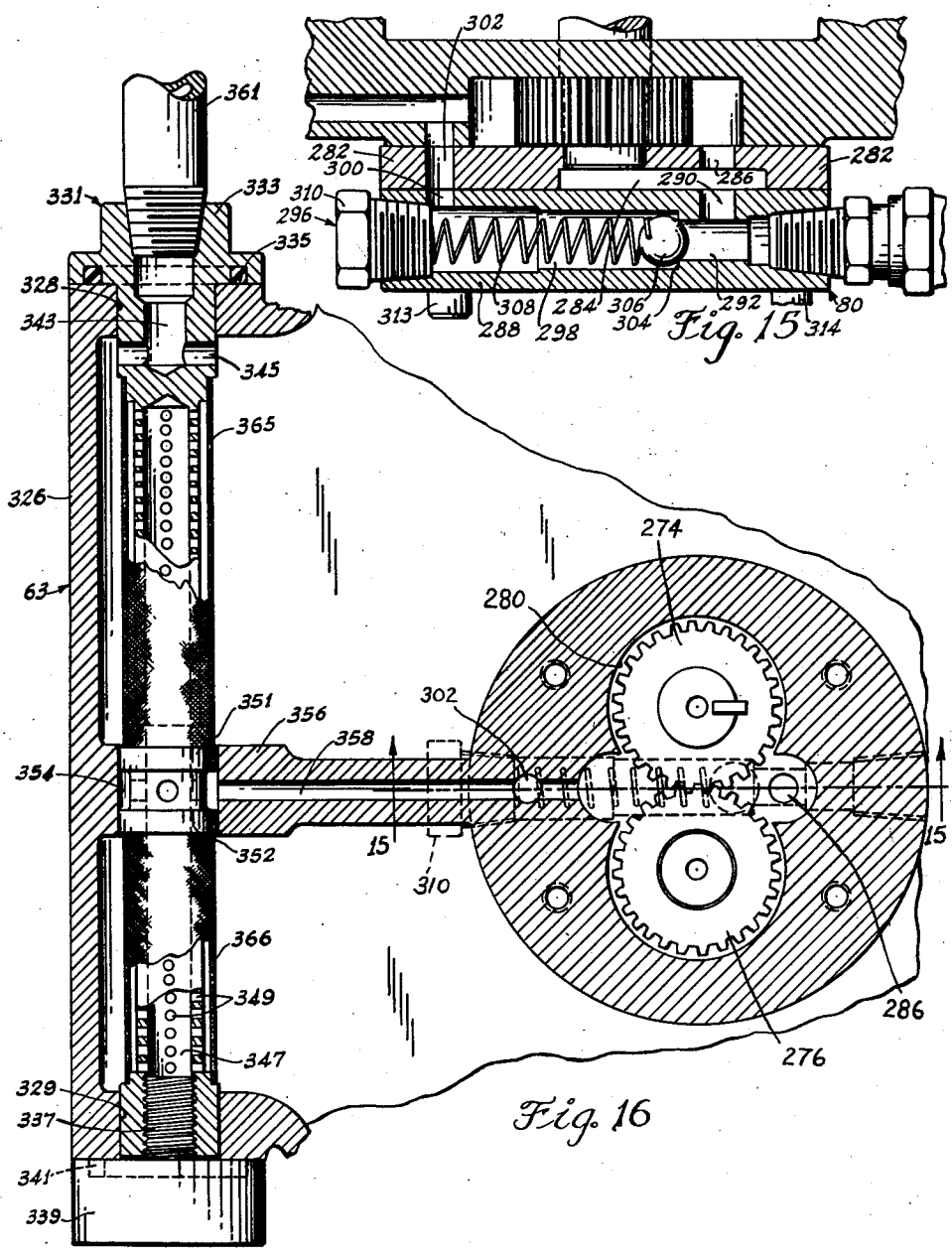


Fig. 15

Fig. 16

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Patented Feb. 2, 1954

2,668,004

UNITED STATES PATENT OFFICE

2,668,004

COMPRESSOR

Lindsay H. Browne, Weston, Conn., assignor to American Brake Shoe Company, Wilmington, Del., a corporation of Delaware

Application March 2, 1948, Serial No. 12,610

4 Claims. (Cl. 230—26)

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This invention relates to compressors and more particularly to directly driven compressors of the type which are especially well adapted to compress working fluid, such as air or the like, to relatively high pressures.

Compressors are at the present time used for many purposes, such as, for example, in automobile service stations for supplying compressed air for inflating tires, and with paint spraying equipment for supplying compressed air to the spray gun. Because of the variation in demand on compressors used for the different purposes, compressors of different capacities are preferably provided so that the compressors may normally operate at an optimum efficiency. Manufacturers are, therefore, faced with the practical necessity of providing compressors of various sizes and capacities, which multiplies the problem of supplying parts therefor. It is a primary object of my invention to alleviate this problem by enabling novel direct-drive compressors of various capacities to be constructed wherein the parts thereof are relatively widely interchangeable.

An object ancillary to the foregoing is to enable compressors of various capacities to be constructed having a relatively small number of variable and total parts.

Another object of my invention is to construct a novel compressor which comprises a compact unit of relatively high efficiency, and which may be run in either a vertical or horizontal position.

Another object of my invention is to provide a reciprocating-piston type of compressor having two banks of cylinders, both of which banks are embodied in a single housing.

A further object of my invention is to enable the construction of a novel compressor of the aforesaid reciprocating-piston type having a plurality of high pressure and low pressure cylinders embodied in the same housing.

An object ancillary to the foregoing is to construct a novel compressor of the aforementioned type having diametrically opposed cylinders of substantially the same bore so that machining of the cylinder bores may be readily and economically effected in the manufacture of the compressor.

Yet another object of my invention is to construct a compressor of the reciprocating-piston type comprising a novel yoke mechanism for driving the pistons from a drive shaft.

A further object is to enable a novel compressor of the aforementioned type to be constructed which embodies a drive shaft which may be cast

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of suitable materials and wherein the drive shaft has substantially true dynamic balance.

Another object is to construct a novel compressor in such a manner that strips of suitable material such as steel may be utilized in a novel manner to afford the bearing surfaces for the yokes of the compressor and to provide ready adjustment of the fit of the yokes relative to the movable parts to which they are connected.

Yet another object of my invention is to construct a novel compressor of the reciprocating-piston type wherein, during operation thereof, the side thrust on the pistons is relatively small.

A further object is to afford a novel compressor wherein the compression chamber is maintained in relatively free communication with the atmosphere in a novel and expeditious manner until the compressor has reached a predetermined speed of operation, and the oil pressure of the lubricating system thereof has also reached a predetermined amount.

An object ancillary to the foregoing is to provide a compressor of the aforementioned type with a novel unloader mechanism which is responsive in a novel and expeditious manner to both the speed of operation of the compressor and the pressure of the oil in the lubricating system.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show preferred embodiments and the principles thereof and what I now consider to be the best mode in which I have contemplated applying those principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is an elevational view of a compressor embodying the principles of my invention, with certain parts broken away and with the casing therefor removed;

Fig. 2 is a sectional view taken substantially on line 2—2 in Fig. 1, with the casing shown in place;

Fig. 3 is a bottom plan view of the compressor shown in Fig. 1;

Fig. 4 is a detail view of the valve mechanism of the compressor, taken substantially on the line 4—4 in Fig. 2;

Fig. 5 is a detail sectional view taken substantially on the line 5—5 in Fig. 4;

Fig. 6 is a detail sectional view taken substantially on the line 6—6 in Fig. 4;

Fig. 7 is a sectional view taken substantially on the line 7—7 in Fig. 6;

Fig. 8 is a sectional view taken substantially along the line 8—8 in Fig. 2;

Fig. 9 is a detail view similar to Fig. 8 but showing the piston in a different position;

Fig. 10 is an exploded view of the yoke and associated mechanism shown in Fig. 8;

Fig. 11 is an enlarged detail view of a portion of the cam shaft shown in Fig. 2;

Fig. 12 is a detail sectional view of the unloader mechanism taken substantially along the line 12—12 in Fig. 14;

Fig. 13 is a detail view similar to Fig. 12 but showing the valve in a different operating position;

Fig. 14 is a detail top plan view of the lower body member of the unloader shown in Fig. 2;

Fig. 15 is an enlarged detail view of the oil pump as shown in Fig. 1; and

Fig. 16 is an enlarged sectional view taken substantially along the line 16—16 in Fig. 1.

The compressor shown in the accompanying drawings, to illustrate the principle of my invention, comprises, in general, a compressing unit 30 connected to a motor 32 within a casing 34.

The motor 32 comprises a stator 36 and a rotor 37 mounted within a housing 39, and is mounted on the compressing unit 30 with the lower edge portion of the housing 39, as viewed in Fig. 2, mounted in a rabbet 41 formed in the top end portion of the housing 43 of the compressing unit 30, and is held in position thereon by suitable means such as clamps 42 mounted on hold-down bolts 44 mounted in the housing 43.

The rotor 37 is keyed onto one end portion of a drive shaft 45 and is secured against longitudinal movement with respect thereto by two snap-rings 47 and 48 mounted in suitable snap-ring grooves formed in the drive shaft 45. It will be noted that in Fig. 2 of the drawings another snap-ring groove 50 is shown which is not used with the rotor 37. This latter groove 50 is provided for use in other installations with motors of less horse-power rating than the motor shown in the drawings. In these other installations, the rotor of the smaller motor would be held on the drive shaft 45 by the snap-ring 47 and another snap-ring mounted in the groove 50. It will be apparent that, within the purview of my invention, snap rings can also be used at other positions on my drive shaft 45 to hold rotors of other sizes so that my drive shaft may be used with motors of various capacities.

The central portion of the drive shaft 45 is journaled in a ball-bearing 52 mounted in a sleeve 54 formed in the upper end portion of the housing 43 of the compressing unit 30. An inwardly extending flange 55 formed on the sleeve 54 restrains the bearing 52 from vertical upward movement, as viewed in Fig. 2.

The casing 34 is substantially cylindrical in shape, having two end caps 57 and 58 which have openings therethrough covered with suitable material such as wire screens 60 and 61, respectively. A base member 63, having three projecting legs 65, 66 and 67, Figs. 1 and 3, is mounted within the casing 34 with the legs 65, 66 and 67 projecting outwardly through the end cap 58 of the casing 34. The legs 65, 66 and 67 form supporting members for my compressor when the compressor is disposed in the vertical position shown in Fig. 2.

The housing 43 of the compressing unit 30 is mounted in a rabbet 70 formed in the upper end portion of the base 63, as viewed in Fig. 2, and is secured thereto by suitable means such as mounting bolts 72.

The end portion of the drive shaft 45 opposite to that on which the rotor 37 is mounted, extends through, and is journaled in, a ball bearing 74 mounted in a sleeve 76 projecting inwardly from the base 63. The ball bearing 74 is restrained from outward, or downward movement, as viewed in Fig. 2, by a shoulder 78 formed in the sleeve 76. The lower end portion of the drive shaft 45, as viewed in Fig. 2, extends downwardly from the bearing 74 and projects into an oil pump 80 mounted on the lower end portion of the base 63 for a purpose which will be discussed in greater detail presently.

Between the bearings 52 and 74, two substantially oppositely disposed crank cams 84 and 86, and two substantially oppositely disposed counter-weights 85 and 87, are formed on the drive shaft 45. Two cam blocks 88 and 89, made of a suitable material such as bronze, are mounted on the crank cams 84 and 86, respectively. Each of the cam blocks 88 and 89 are of two piece construction, the cam block 88 being split along a line 91, Fig. 8, into two halves 93 and 94, Figs. 2, 7 and 8, and the cam block 89 being split in a similar manner into two halves 96 and 97, Fig. 2.

A yoke, 101, Figs. 2, 8 and 9, comprising two separable end portions 103 and 105, is mounted on the cam block 88, the two end portions 103 and 105 of the yoke being held together by bolts 107 and nuts 108. The yoke 101 may be made of any suitable material such as, for example, cast aluminum, and the end portions 103 and 105 thereof include substantially rigid connecting rods, 110 and 111, respectively, having low-pressure pistons 113 and 114 formed on the outer end portions thereof, the pistons 113 and 114 being slidably mounted in diametrically opposed cylinders 116 and 117, respectively, in the housing 43 of the compressing unit 30. The drive shaft 45, by this connection between the crank cam 84 and the pistons 113 and 114, is effective, upon rotation, to reciprocate the pistons 113 and 114 in the cylinders 116 and 117, respectively, as will be discussed in greater detail hereinafter.

Two wear plates 123 and 124, made of a suitable material such as hardened and ground steel, are mounted on the inner faces 120 and 121 of the end portions 103 and 105, respectively, of the yoke 101 and project laterally therefrom into engagement with shoulders 126 and 127 disposed in recesses 129 and 130 formed in the outer edge portions of the two halves 93 and 94, respectively, of the cam block 88. The side member of the two end portions 103 and 105 of the yoke are under-cut to form lips 132 and 133 respectively, which are effective to normally retain the wear plates on the faces 120 and 121, the configuration of the lips 132 and 133 being such that they are adapted to effectively retain wear plates of various thicknesses on the faces. I have found that relatively thin wear plates, such as, for example, wear plates having a thickness of six-thousandths of an inch, are well adapted for normal use in my novel compressor. However, the wear plates used in my yoke have sufficient resiliency that during assembly, when the yoke 101 is in disassembled condition, they may be readily snapped into, and out from under, the

lips 132 and 133 by a mechanic so that wear plates having the proper thickness, as determined by the fitting of the yoke 101 onto the cam block 88, may be readily installed during the assembly of my novel compressor unit.

Thus it will be seen that the wear plates 123 and 124 provide a good bearing surface between the cam block 88 and the yoke 101, so that it is unnecessary to machine finish the inner faces of the yoke 101 to the extent that would otherwise be required. Furthermore, it will be noted that the wear plates 123 and 124 provide an efficient and readily accomplished means for properly fitting the yoke 101 on the cam block 88 during assembly of my novel compressor unit, or during an overhaul thereof, it merely being necessary to mount wear plates having the proper thickness to give the desired fit on the faces 120 and 121 during such assembly.

A yoke 140, Fig. 2, similar to the yoke 101, and having two separable end portions 142 and 143 held together by bolts and nuts, similar to bolts 107 and nuts 108, is mounted on the cam block 89, the end portions 142 and 143 having wear plates 149 and 150, respectively, similar to wear plates 123 and 124, mounted thereon and engaged with shoulders 152 and 153 disposed in recesses 155 and 156 formed in the outer edge portion of the end portions 96 and 97, respectively, of the cam block 89.

The end portions 142 and 143 of the yoke 140 include substantially rigid connecting rods 158 and 159, respectively, having high-pressure pistons 161 and 162, Fig. 2, formed on the outer end portions thereof, the pistons 161 and 162 being reciprocably mounted in cylinders 164 and 165, respectively, in the housing 43 of the compressing unit 30.

As will be more apparent hereinafter, the construction of my novel compressing unit is such that the drive shaft 45 may readily be cast of any suitable material such as iron and is easily balanced so as to have substantially true dynamic balance.

As is best seen in Fig. 2, the low-pressure pistons 113 and 114 have suitable compression rings 167 and oil rings 168 mounted thereon, and the high-pressure pistons, likewise, have suitable compression rings 170 and oil rings 172 mounted thereon.

Low-pressure cylinder heads 175 are mounted on the housing 43 of the compressing unit 30 in alignment with the low-pressure cylinders 116 and 117, and are secured thereto by bolts 177 and 178. Likewise, high-pressure cylinder heads 180 are mounted on the housing 43 in alignment with the high-pressure cylinders 164 and 165 and are secured thereto by bolts 182 and the bolts 178.

The low-pressure cylinder heads 175 each have intake ports 184, Fig. 5, which are in communication with the atmosphere through an intake manifold 186, Fig. 1. The inner end portion of the intake port 184, in each of the cylinder heads 175 is in communication with a substantially semi-circular shaped chamber 188 which is in communication with an annular passageway 190 formed in the inner face of the cylinder head 175.

Intake valves 192, comprising substantially flat annular members made of suitable material such as spring steel, are yieldingly held against the inner face of each of the cylinder heads 175, in position to cover the passageways 190, by substantially annular-shaped valve springs 194 mounted on bosses 196 projecting inwardly from the cylinder heads 175, the valve springs being held on the bosses by suitable fastening means such as snap rings 198 and having resilient fingers 200, Figs. 4 and 5, engaged with the inner surface of the valves 192 and yieldingly holding the valves 192 in engagement with the inner face of the cylinder heads 175 in position over the annular passageways 190. The valve springs 194 are made of any suitable material such as spring steel, and are of such strength that when the low-pressure pistons 113 and 114 are stationary within the cylinders 116 and 117, or are moving outwardly in a compression stroke, they are effective to firmly seat the valves 192 against the inner face of the respective cylinder heads 175 to thereby positively close the passageways 190, but when the pistons 113 and 114 are moving inwardly they will permit the respective valves 192 to open to thereby permit air to be drawn from the atmosphere through the intake manifold 186, the intake port 184, the chamber 188 and the passageway 190 into the cylinders 116 and 117.

Substantially cylindrically shaped passageways 204 extend from the inner faces of the cylinder heads 175 axially through the bosses 196 into communication with enlarged passageways 206 which are in communication with exhaust ports 208 extending laterally through the respective cylinder heads 175. A valve 210, comprising a substantially circular shaped plate made of a suitable material such as spring steel, is mounted in each of the enlarged passageways 206 and is held in engagement with a shoulder or valve seat 212 therein by a compression spring 214 mounted on a plug 216 screwed into the respective cylinder head 175. The valve springs 214 are of such strength that, when the low-pressure pistons 113 and 114 are moving inwardly in an intake stroke, they are effective to firmly seat the valves 210 against the shoulders 212 to thereby close the passageways 204 in a positive manner, but when the pistons 113 and 114 are moving outwardly through the low-pressure cylinders 116 and 117 in a compression stroke they will permit the respective valves 210 to open and thereby permit air to be forced by the pistons 113 and 114 outwardly from the cylinders 116 and 117 through the passageways 204 and 206 and exhaust ports 208.

The exhaust port 208 of each of the low-pressure cylinder heads 175 is connected by a separate intercooler 220 to an intake port 222, Figs. 1, 6 and 7, of a respective, adjacently disposed, high-pressure cylinder head 180, the interconnection of the intercoolers 220 with the low-pressure cylinder heads 175 and the high-pressure cylinder heads 180 being effected by suitable coupling means such as plates 224 and 225, Fig. 1, mounted on opposite ends of the intercoolers and attached to the cylinder heads 175 and 180, respectively, by bolts 227 and 228. The intercoolers 220 are shown in the accompanying drawings as having smooth outer surfaces, but it will be understood by those skilled in the art that, if desired, the intercooler may have cooling fins formed thereon.

The intake port 222 in each of the high-pressure cylinder heads 180 is in communication with a substantially semi-circularly shaped chamber 230, Figs. 6 and 7, which opens into an annular shaped passageway 232 formed in the inner face of the cylinder head 180.

Intake valves 234, Figs. 4 and 6, similar to the valves 192, are yieldingly held against the inner faces of each of the cylinder heads 180, in position to cover and close the passageway 232, by

substantially annular-shaped valve springs 236 mounted on bosses 238 projecting from the cylinder heads 180, the springs 236 being held on the bosses by suitable fastening means such as snap rings 240 and having resilient fingers 242 engaged with the inner surface of the valves 234 for yieldingly holding the valves 234 in engagement with the inner face of the cylinder heads 180 in position over the annular passageway 232.

The valve springs 236 are made of any suitable material such as spring steel, and are of such strength that, when the high-pressure pistons 161 and 162 are moving outwardly in a compression stroke, the springs are effective to firmly seat the valves 234 against the inner face of the respective cylinder heads 180 to thereby positively close the passageways 232, but when the pistons 161 and 162 are moving inwardly they will permit the respective valves 234 to open to thereby permit air from the corresponding low pressure cylinder to flow from the connected intercooler 220 into the intake port 222, and through the chamber 230 and the passageway 232 into the respective one of the high pressure cylinders 164 and 165.

Substantially cylindrically shaped passageways 244, similar to the passageways 204 in the low pressure cylinder heads, extend from the inner faces of the cylinder heads 180 axially through the bosses 238 into communication with enlarged passageways 246 found in the cylinder heads 180. The enlarged passageways 246 are in communication with exhaust ports 248 extending transversely through the cylinder heads 180. A valve 250, similar to the valve 210, is mounted in each of the enlarged passageways 246 and is held in engagement with a shoulder or valve seat 252 therein by a compression spring 254 mounted on a plug 256 screwed into the respective cylinder head 180. The valve springs 254 are of such strength that they are effective to firmly seat the valves 250 against the shoulders 252 during inward strokes of the pistons 161 and 162, but permit the valves 250 to be unseated from the shoulders 252 during a compression, or outward, stroke of the pistons 161 and 162, to thereby permit air to be forced by the pistons 161 and 162 from the cylinders 164 and 165 outwardly through the passageways 244 and 246 into the exhaust ports 248 from which it flows into an aftercooler 260, Fig. 1, connected thereto.

The aftercooler 260 has an outlet connection 262, Fig. 1, by which it may be connected to a storage tank, or the like, not shown, and also has an outlet connection 264, Fig. 2, by which it may be connected through a pipe 266 to an unloader valve 270, in a manner and for a purpose to be discussed presently, so that compressed air flowing into the aftercooler 260 from the high-pressure cylinder 164 and 165 may flow to the storage tank and to the unloader 270.

The oil pump 80, Figs. 1, 2, 15 and 16, disposed at the lower end portion of the base 63, as viewed in Fig. 2, is of the type commonly known as a gear-type oil pump, and includes a gear 274, Fig. 2, keyed to the cam shaft 45 and in mesh with an idler gear 276 journaled on a bearing 278 carried by the base member 63. Both the gears 274 and 276 are mounted in a pocket 280 formed in the base member 63. A plate 282, having a recess 284 formed therein, is mounted on the base 63 and retains the gears 274 and 276 in the pocket 280. A passageway 286 extends upwardly from the recess 284 in the plate 282, as viewed in Fig. 2, into communication with the pocket 280 between the two gears 274 and 276 on the pressure side of the gears.

A cover plate 288, having a passageway 290 formed therein, is mounted on the outer face of the plate 282 with the upper end portion of the passageway 290, as viewed in Fig. 2, in communication with the recess 284 in the plate 282. The lower end portion of the passageway 290 connects with a discharge passage 292 connected at one end by a tube 294 to the unloader valve 270 in a manner, and for a purpose, which will be described in greater detail presently. The other end of the discharge passage 292 is connected to a pressure relief valve 296 embodied in the cover plate 288.

The relief valve 296 includes an enlarged chamber 298 in the cover plate 288, connecting at one end to the discharge passage 292 and connecting at the other end to a passage 300 extending through a portion of the cover plate 288 into communication with a passageway 302 which extends through the plate 282 and is in communication with the pocket 280 between the gears 274 and 276 on the inlet side of the gears. A shoulder 304 is formed at the interconnection of the enlarged passageway 298 and the discharge passage 292, and a ball valve member 306 is held in engagement therewith by a compression spring 308, one end of which is in engagement with the ball and the other end of which abuts a plug 310 screwed into the cover plate 288. The strength of the spring is such that during normal operation of the pump 80 the ball valve 306 is maintained seated against the shoulder 304 to thereby maintain the connection between the discharge passage 292 and the enlarged passageway 298 closed, but when the pressure of the lubricant pumped by the oil pump 80 exceeds a predetermined pressure, as determined by adjustment of the plug 310, the ball valve 306 is unseated from the shoulder 304 and lubricant is thereby permitted to circulate from the pressure side of the gears 274 and 276 through the passageways 286, 290, 298, 300 and 302 back to the pocket 280 on the inlet side of the gears 274 and 276.

The plate 282 and the cover plate 288, which comprise the lower end portion of the oil pump 80, as viewed in Fig. 1, are fastened to the lower portion of the base 63 by suitable means such as bolts 313 and 314.

In addition to the legs 65, 66 and 67 for supporting my novel compressor in the vertical position in which it is shown in Figs. 1 and 2, three other legs 320, 321 and 322, Figs. 1 and 3, are provided whereby the compressor may also be supported for operation in a horizontal position, that is, in a position wherein the entire compressor is rotated 90° in a counterclockwise direction from that shown in Fig. 1. The leg 320 forms a transverse projection from the leg 65, and the other two legs 321 and 322 project outwardly from a mounting plate 324 secured to the housing 43 of the compressing unit 39 by any suitable means such as welding.

The lower end portion of the housing base 63 forms the oil reservoir for the pump 80, and the base 63 is so constructed that, when the proper amount of oil is contained in the reservoir, the top of the oil is below the level of the cylinders 116, 117, 164 and 165 and below the path of travel of the yokes 101 and 149 when the compressor is in either the vertical or the horizontal position

in which it is adapted to run as previously discussed.

A recess or pocket 326 is formed in the base 63 and extends transversely thereacross, Figs. 1 and 3, and forms part of the oil reservoir for my compressor. The recess 326 is so positioned on the base 63 that, when the compressor is in either the previously discussed vertical or horizontal position, it extends somewhat below the interior of the other portions of the base 63, and, therefore, forms the lowest portion of the oil reservoir.

Two openings 328 and 329, Fig. 16, are formed in the base 63 at opposite ends of the recess 326, and a tube 331 extends therethrough. The end portions of the tube 331 fit snugly in the openings 328 and 329, and one end portion has a flange 333 thereon in which an annular sealing-ring 335 is mounted. The other end of the tube 331 has an opening 337 tapped therein, in which is screwed a plug 339, also having an annular sealing-ring 341 mounted therein. The sealing rings 335 and 341 may be made of any suitable material such as a chlorabutadiene polymer ("neoprene").

The end portion of the tube 331, embodying the flange 333, has an opening 343 extending longitudinally therethrough which interconnects at its inner end portion with an opening 345 extending transversely through the tube. The other end portion of the tube 331 has a longitudinally extending opening 347 formed therein which terminates in spaced relation to the transversely extending opening 345. A plurality of openings 349 extend transversely through the sidewalls of the tube 331 surrounding the opening 347 and form communicating passageways between the opening 347 and the interior of the base 63.

Two laterally projecting collars 351 and 352, defining a groove 354, are formed on the tube 331 intermediate the end portions thereof. The collars 351 and 352 are snugly fitted into an opening formed through a flange 356 which projects upwardly, as viewed in Fig. 1, from the bottom of the base 63. A passageway 358, in communication with the groove 354, extends through the flange 356 and opens into the pocket 280 on the inlet side of the gears 274 and 276 of the oil pump 80.

Screw threads are tapped into the outer end portion of the opening 343 in the tube 331 and one end of an oil filler tube 361 is screwed thereinto. An oil cup 363, Fig. 3, made of any suitable transparent material such as, for example, a methyl methacrylate resin ("Lucite"), is rotatably mounted on the other end portion of the tube 361. During the operation of my novel compressor the oil cup 363 is always disposed in such a position that it faces upwardly. This is true whether the compressor is disposed in the vertical position shown in Figs. 1 and 2, or in the horizontal position previously discussed.

Thus, it will be seen from the foregoing that oil may be poured into the oil cup 363 from which it will pass through the tube 361, and the openings 343 and 345 into the base 63. From the base 63 oil may pass, as required, through the openings 349, the openings 347, the groove 354 and the opening 358 into the inlet side of the oil pump 80, suitable filters, such as screens 365 and 366 being mounted on the tube 331 on opposite sides of the collars 351 and 352 to filter the oil entering the openings 349 from the oil reservoir in the base 63. It will be apparent that, the cup 363 being directly connected to the base 63 by the tube 361, the oil level within the cup 363 will be the same as the oil level within the base 63, and will be readily visible through the transparent side walls of the cup 363.

A fan 370, comprising a hub 372 and two blades 374 and 375, is slidably mounted on the upper end portion of the drive shaft 45, as viewed in Figs. 2 and 12, and is connected thereto by a pin-and-slot connection for rotation therewith, a pin 377 on the shaft 45 extending through a slot 379 in the hub 372. Upward movement of the fan 370 relative to the drive shaft 45 is limited by a stop ring 381 mounted in a groove 382 in the shaft 45, and downward movement of the fan 370 is limited by the pin 377.

A lever 384, having a short arm 386 and a long arm 387, extends through slots 389 and 390 in the hub 372 and the shaft 45, respectively, and is pivotally connected to the shaft 45, for rotation therewith, by a pin 392. The short arm 386 of the lever 384 extends into a passageway 394 formed in the upper end portion of the drive shaft 45, and engages the lower end portion of a valve rod 396 of the unloader 270.

The unloader 270 comprises an upper body member 398 and a lower body member 400, Figs. 12 and 13, connected together by suitable means such as bolts 402. The body members 398 and 400 have recesses 404 and 405, respectively, formed therein. The recesses 404 and 405 are adjacent to each other but are separated by a flexible diaphragm 407 mounted between the upper and lower body members.

The lower body member 400 of the unloader 270 includes an outwardly projecting shaft 409 which is journaled in ball bearings 411 and 412 mounted in the passageway 394 in the drive shaft 45, the lower bearing 412 seating on a shoulder 414 formed in the passageway 394 to limit movement of the unloader in a downward direction, as viewed in Fig. 14, and a snap ring 416 mounted in a suitable groove in the drive shaft 45 above the bearing 411 limiting movement of the unloader 270 in an upward direction.

The valve rod 396 extends through the shaft 409 into the recess 405, wherein it terminates in a valve head 418 which has an annular shaped flange 419 projecting from the lower face thereof. A valve disc 421, formed of suitable material such as a chlorabutadiene polymer, is mounted in the flange 419. The valve head 418 has a shoulder 422 formed in the outer peripheral edge portion thereof which is adapted to seat on an inwardly projecting flange 424 formed on a valve 426 mounted within the recess 405 concentrically to the valve head 418. The lower end portion of the ring 426, as viewed in Fig. 13, projects downwardly below the flange 424 to form a base 428, and the upper end portion of the ring 426 terminates in an outwardly projecting flange 430. A thrust plate 432 is seated upon the flange 430 below the diaphragm 407 for a purpose which will be discussed in greater detail hereinafter, and a compression spring 434 is positioned between the flange 430 and the base of the recess 405 to yieldingly urge the ring 426 and the thrust plate 432 toward the diaphragm.

A passageway 436, Figs. 12 and 14, is formed in the lower body member 400 of the unloader 270 and extends from the recess 405 outwardly through the side wall of the lower body member 400. A valve nipple 438 is mounted in the inner end portion of the passageway 436 and projects into the recess 405. A coupling member 440 attached to one end portion of the tube 266 which extends from the aftercooler 260 is mounted in the outer end portion of the passage-

way 436, and thus it will be seen that communication is established between the aftercooler 260 and the recess 405.

A substantially vertically extending passageway 442, as viewed in Fig. 12, is formed in the lower body member 400 of the unloader 270 and is in direct communication with a similar passageway 444 formed in the upper body member 398. The upper end portion of the passageway 444 is connected to the recess 404, above the diaphragm 407, by a passageway 446 formed in the upper body member 398, and the lower end portion of the passageway 442 is connected to the tube 294, extending from the oil pump 80, by a coupling 448 screwed into the lower body member 400.

Another passageway 450, Fig. 14, is formed in the lower body member 400, extending from the outer surface of the side wall thereof to the recess 405. A coupling 452, Figs. 1 and 14, is screwed into the outer end portion of the passageway 450 and is connected to one end portion of a tube 454, the other end portion of which is open to the atmosphere, Fig. 1. Thus it will be seen that, as will be discussed in greater detail presently, an exhaust passage is provided by the passageway 450, the coupling 452 and the tube 454, from the recess 405 to the atmosphere.

A compression spring 456 is mounted in a recess 458 formed in the lower end portion of the shaft 409 on the body of the unloader 270, with one end portion engaged with the base of the recess 458 and the other end portion engaged with a washer 460 carried by and pinned to, the lower end portion of the valve rod 396. The spring 456 yieldingly urges the valve rod 396 downwardly into engagement with the short arm 386 of the lever 384.

A pin 462, carried by the hub 372 of the fan 370, is in alignment with the free end portion of the long arm 387 of the lever 392 and the downward urging of the valve rod 396 by the spring 456 is effective to yieldingly urge the lever 384 to rotate in a counter-clockwise direction, as viewed in Fig. 12, to thereby maintain the long arm 387 of the lever 384 in engagement with the pin 462.

Two tension springs 601 and 602, Fig. 1, are connected between two bolts 604 on the hub 372 of the fan 370 and the pin 377, Fig. 2, and yieldingly urge the fan 370 toward the normal, lower, position shown in Figs. 2 and 12.

From the foregoing it will be noted that, as will be discussed in greater detail hereinafter, when my novel compressing unit is "at rest" in the vertical position shown in Figs. 1 and 2, the weight of the fan 370 together with the action of the springs 601, and 602 holds the fan in the lower position shown in Figs. 2 and 12, to thereby hold the valve disk 421 off from the valve nipple 438 and thereby maintain an open passageway from the aftercooler 260 through the tube 266, the passageway 436, the valve nipple 438, the chamber 405, the passageway 450 and the tube 454 to the atmosphere, to thereby maintain the compressing unit in unloaded condition. However, as will be discussed in greater detail presently, when the compressing unit is being operated in a normal manner and at normal operating speeds, the air thrust on the fan 370 is sufficient to raise the fan against the stop ring 381 out of engagement with the lever 384, Fig. 13, and the pressure of the oil pumped by the oil pump 80 into the chamber 404 is effective to move the diaphragm 407 downwardly from the position shown in Fig. 12 to that shown in Fig. 13 to thereby move the thrust plate 418 and the ring 426 downwardly against the urging of the spring 434 and thus move the shoulder 424 down out of engagement with the valve head 418. This movement of the fan 370 and the shoulder 424 of the ring 426 frees the valve 418 for downward movement, and, therefore, the spring 456 is effective to move the valve 418 downwardly and thereby move the disk 421 into engagement with the valve nipple 438 to thereby close the passageway 436 and load the compressing unit.

At any time during the operation of my novel compressing unit if the speed of rotation of the drive shaft 45, and, therefore, if the fan 370 falls below a predetermined speed, or, if the pressure of the oil discharged by the oil pump 80 falls below a predetermined pressure, the spring 456 is rendered ineffective to maintain the valve disk 421 in closed position on the valve nipple 438 and the compressing unit is unloaded. Thus it will be seen that my novel unloader 270 comprises an effective means for maintaining my novel compressing unit unloaded during the starting thereof until the speed of operation and the oil pressure have raised to their normal amounts, and also comprises a safety unit for unloading the compressor during operation of my compressing unit if either the speed of operation or the oil pressure falls below a predetermined amount.

When my novel compressing unit is mounted in the previously discussed horizontal position for operation, the operation of the unloader 270 is substantially the same as when the compressing unit is in the vertical position just discussed, the principal difference being that the springs 601 and 602, unassisted by the force of gravity on the fan 370 are relied on to hold the fan 370 in normal, lowered, position.

The housing 43 of the compressing unit 30, and the cylinder heads 175 and 180 have cooling fins 465 formed thereon and it will be apparent that the fan 370, when my compressor is in operation, is effective to draw air in through the screen 60 in the cap 57 and force it down through the casing 34, over the motor 32, and the compressing unit 30, and out the screen 61 in the cap 58, the air thus forced through the casing 34 passing over and between the cooling fins 465 and passing over the intercoolers 220 and the aftercooler 260, to thereby effect cooling of the compressing unit 30 and of the air passing through the intercoolers 220 and the aftercooler 260.

Lubrication of the cams 84 and 86, the cam blocks 88 and 89, and the yokes 101 and 140 is effected by the oil pump 80 through the drive shaft 45. For this purpose a passageway 470 is formed in the drive shaft 45 which interconnects the recess 284 in the oil pump 80 with passageways 472 and 473 which extend transversely through the cams 84 and 86, respectively, and are in communication with recesses 475 and 476 formed in the cam blocks 88 and 89, respectively. Two passageways 478 and 479 extend transversely through the cam blocks 88 and 89, respectively, and interconnect the recess 475 with the recesses 129 and 130, and the recess 476 with the recesses 155 and 156. Thus, it will be seen that, during operation of my compressor, oil is pumped from the pump 80 through the passageway 470 and the respective transverse passageways extending therefrom into the spaces between the cam 84, the cam block 88 and the yoke 101, and into the spaces between the cam 86, the cam

black 89 and the yoke 140 to lubricate these respective parts.

Operation of the compressor shown in Figs. 1–16

As previously discussed, when my compressor is not in operation the spring 434 in the unloader 270 is effective to hold the valve ring 426 and, therefore, the valve disk 421, in the position shown in Fig. 12, in which position the valve disk 421 is out of engagement with the valve nipple 438, and an open passage is, therefore, maintained from the high pressure cylinders 164 and 165 through the aftercooler 260, the coupling 264, the tube 266, the coupling 440, the passageway 436, the nipple 438, the recess 405 in the lower body member 400 of the unloader 270, the passageway 450, the coupling 452, and the tube 454 to the atmosphere, to thereby maintain the compressor in "unloaded" condition. However, with the compressor in the vertical position shown in Figs. 1 and 2, when, upon initiation of an operation of my compressing unit, the motor 32 is energized to thereby effect rotation of the drive shaft 45, the fan 370 is caused to rotate, and the pump 80 is caused to operate. Operation of the pump 80 forces oil from the reservoir in the base 63 through the drive shaft 45 to lubricate the cam blocks 88 and 84 and the yokes 101 and 140, as previously described, and forces oil through the tube 294, the coupling member 448 and the passageways 442, 444 and 446 into the recess 404 above the diaphragm 407 in the unloader 270. As the speed of the compressor increases, the pressure of the oil being pumped by the pump 80 increases and finally becomes effective to deflect the diaphragm 407 downwardly to thereby press the thrust plate 432 and the valve ring 426 downwardly against the urging of the spring 434 to the position shown in Fig. 13 wherein the base 428 of the ring 426 rests on the base of the recess 405. This downward movement of the ring 426 moves the flange 424 thereof out of engagement with the valve head 418 and thereby frees the valve head 418 and the valve rod 396 to the action of the spring 456. However, until the compressor has obtained its normal speed of operation, the weight of the fan 370 and the action of the springs 601 and 602 holds the lever 384 against full counterclockwise rotation and, therefore, restrains movement of the valve head 418 and the valve rod 396. As the speed of the compressor increases the force of the air on the blades 374 and 375 of the revolving fan 370 lifts the fan 370 on the shaft 45 to thereby permit counter-clockwise rotation of the lever 384, until, when the speed of the compressor has increased to the normal operating speed thereof, the fan 370 has been lifted to its fully raised position and the spring 456 has moved the valve head 418 and the valve rod 396 downwardly to the position shown in Fig. 13, wherein the valve disk 421 is seated on the valve nipple 438 and closes the nipple 438 to thereby close the high pressure cylinders 164 and 165 and the aftercooler 260 to the atmosphere and establish "loaded" condition of the compressor. Thus it will be seen that during starting, the compressing unit 30 is maintained in "unloaded" condition by my novel unloader 270 until both the oil pressure of the pump 80 and the speed of rotation of the fan 370 have reached certain predetermined amounts, and that at any time during the operation of my novel compressor if either the pressure of the oil pumped to the unloader 270 by the pump 80 drops below a predetermined level, or the speed of rotation of the compressing unit 30, and, therefore, of the fan 370, falls below a predetermined speed, the unloader 270 will be caused to atomatically open to thereby open the aftercooler 260 to the atmosphere and relieve the load on the compressing unit 30.

Also, during rotation of the drive shaft 45, as will be apparent to those skilled in the art, the rotation of the cams 84 and 86 within the cam blocks 88 and 89 is effective to reciprocate the yokes 101 and 140 and, therefore, the low-pressure pistons 113 and 114 and the high-pressure pistons 161 and 162, respectively. In this connection it will be noted that with my novel yoke arrangement the side thrust on the low-pressure and high-pressure pistons is relatively small, the force exerted by the well lubricated cam blocks 88 and 89 on the yokes 101 and 140, respectively, within which they are relatively freely slidable, being substantially longitudinal of the respective yokes, and thus the wear on the sides of the pistons and the cylinder walls is reduced to a minimum.

During each complete rotation of the cam shaft 45 the low-pressure pistons 113 and 114, and the high-pressure pistons 161 and 162 are each caused to reciprocate through an intake stroke and a compression stroke. The arrangement of the pistons and the cams is such that while half the pistons are moving through compression strokes the others are moving through suction strokes so that the feeding of compressed air from the compressing unit 30 is substantially continuous. Each pair of adjacent low-pressure and high pressure cylinders comprises substantially a complete pumping unit. For example, it will be seen that when the low pressure piston 114 is moving through a compression stroke the intake valve 194 for that piston is closed and the exhaust valve 210 therefor is open so that air is forced from the cylinder head 175 on the cylinder 117 through the intercooler 220 connected thereto to the cylinder head 180 on the high-pressure cylinder 165. The high-pressure piston 162 is at that time moving through an intake stroke, so the exhaust valve 250 therefor is closed and the inlet valve 234 is open and the air forced from the low-pressure cylinder 117 enters the high pressure cylinder 165. During the next one hundred and eighty degrees of rotation of the camshaft 45 the movement of the pistons 114 and 162 is reversed so that the low-pressure piston 114 is on an intake stroke, with the exhaust valve 210 therefor closed and the intake valve 192 open, so that air is drawn in through the intake manifold 182 into the cylinder 114, and during this time the high-pressure cylinder is moving outwardly on a compression stroke, compressing the air which entered the high-pressure cylinder 165 from the low pressure cylinder 117 during the preceding one hundred and eighty degrees of rotation, so that the intake valve 234 therefor is closed and the exhaust valve 250 therefor is open and air is, therefore, forced under high pressure from the high-pressure cylinder 165 to the aftercooler 260 from whence it flows to a suitable storage tank or the like. During these strokes of the low-pressure piston 114 and the high-pressure piston 162, the low-pressure piston 113 and the high-pressure piston 161, respectively, on the other side of the housing 43 are moving in the opposite direction so that, as previously stated it will be apparent that the feeding of com-

pressed air from the aftercooler 260 to the storage tank is substantially continuous.

From the foregoing it will be seen that I have provided a novel compressor embodying a novel yoke arrangement whereby the forces exerted on the high and low pressure pistons is substantially longitudinal of the path of reciprocation of the pistons and the side thrust on the pistons is at a minimum.

Also, it will be seen that I have provided a compressor of the aforementioned type wherein the yokes, connecting rods and pistons may be integrally cast of suitable material such as aluminum and wherein the yokes may be fitted to the drive mechanism therefor in a novel and expeditious manner.

In addition it will be seen that when either the pressure of the oil pumped by the oil pump is below a predetermined pressure, or the speed of rotation of the drive shaft of the compressor is below a predetermined speed, the compressing unit of my compressor is maintained in "unloaded" condition by my unloader which operates in a novel and expeditious manner.

Furthermore it will be seen that I have provided a novel compressor which is adapted to operate in either a horizontal or vertical position, and which is relatively small in size and compact in form, and presents a pleasing appearance.

Also it will be noted that my novel compressor is constructed so as to provide good interchangeability of parts between the various capacities of compressors which may be manufactured and assembled.

Hence, while I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. A compressor comprising an elongated housing embodying diametrically opposed cylinders extending transversely to the longitudinal axis of said housing, said housing having a closed end, and lateral sides projecting transversely to said closed end, said housing having a vertical operative position wherein said one end is disposed downwardly, and a horizontal position wherein one of said sides is disposed downwardly, said one side being substantially parallel to the longitudinal axis of said cylinders, pistons reciprocably mounted in said cylinders, a drive shaft journaled in said housing and extending longitudinally of said housing between said opposed cylinders substantially transversely to said cylinders, means on said drive shaft for reciprocating said pistons simultaneously upon rotation of said drive shaft, an oil pump mounted on said housing and operatively connected to said drive shaft for feeding oil to said means for lubricating the latter upon rotation of said drive shaft, and means for feeding oil to said pump, said last named means including a reservoir defined in said one end portion of said housing, a pocket formed in said one end portion of said housing at the junction of said closed end of said housing and said one side, and conduit means connecting said pocket with the inlet of said pump.

2. A compressor comprising an elongated housing embodying diametrically opposed cylinders extending transversely to the longitudinal axis of said housing, said housing having a closed end and side walls projecting from said end, said housing having a vertical operative position wherein said one end is disposed downwardly, and a horizontal position wherein one side is disposed downwardly, said one side being substantially parallel to the longitudinal axis of said cylinders, pistons reciprocably mounted in said cylinders, a drive shaft journaled in said housing and extending longitudinally of said housing between said opposed cylinders substantially transversely to said cylinders, means on said drive shaft for reciprocating said pistons simultaneously upon rotation of said drive shaft, an oil pump mounted on said housing and operatively connected to said drive shaft for feeding oil to said means for lubricating the latter upon rotation of said drive shaft, and means for feeding oil to said pump, said last named means including a reservoir defined by said one end portion of said housing, an elongated pocket formed in said one end portion of said housing at the junction of said closed end of said housing and said side wall on said one side, said pocket being disposed in substantially parallel relation to said longitudinal axis of said cylinders, an elongated tube mounted in and extending along said pocket, said tube having perforations in the side walls thereof for admitting oil thereinto from said reservoir, and conduit means operatively connected to the interior of said tube and the inlet of said oil pump for feeding oil from said tube to said pump.

3. In an air compressor of the type including supporting means, a housing mounted on said supporting means and embodying two pairs of diametrically opposed cylinders, and pistons reciprocably mounted in said cylinders, two yoke members, each of said yoke members interconnecting the pistons mounted in a corresponding one of said pairs of cylinders and having recesses formed in opposite end portions of each of two oppositely disposed inner edge portions thereof, plate members mounted in operative position on said edge portions, said plate members having ends projecting into said recesses for releasably holding said plates in said operative position on said edge portions, the said recesses in the yokes being bevelled to afford overhanging lips for accommodating plate members of varying thicknesses, two cams carried by said drive shaft for rotation therewith and projecting transversely therefrom in substantially opposite directions, each of said cams being disposed within a corresponding one of said yoke members, two block members, each of said block members being reciprocably mounted in a corresponding one of said yoke members between said yoke member and said corresponding cam and having outer edge portions engaged with said plate members mounted in said yoke member, said cams being operable upon rotation of said drive shaft to reciprocate said block members along said plate members within said yoke members transversely to said cylinders and to reciprocate said yoke members and said pistons longitudinally of said cylinders, and means for rotating said drive shaft.

4. A compressor comprising an elongated housing adapted to set on a supporting surface and embodying diametrically opposed cylinders, pistons reciprocably mounted in said cylinders, a drive shaft extending between said opposed cylinders in substantial transverse relation thereto, cam means mounted on said drive shaft to re-

ciprocate the pistons, there being an open connection between the cam means and the pistons, said housing having both a vertical operating position in which the drive shaft extends substantially vertically in relation to the plane of the supporting surface and a horizontal position in which the drive shaft extends substantially horizontally in relation to the plane of the supporting surface, the housing being adapted to be pivoted about a bottom edge from said vertical to said horizontal position, a reservoir in said housing for holding a supply of oil at a level below said cylinders when said compressor is in either the vertical or horizontal operating position, the oil reservoir including a storage area at the bottom, the housing being located adjacent said edge and substantially below the level of the cylinders whereby the level of the oil in the storage area is below the level of the cylinders in either the vertical or horizontal position of the housing thereby assuring that the pistons do not pump oil in either of the two said positions, and means including a conduit and an oil pump operatively connected to said drive shaft and said area for feeding oil to the cam means.

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