Sept. 16, 1947. E. F. VILTER ET AL 2,427,638

COMPRESSOR

Filed Aug. 16, 1944 4 Sheets-Sheet 1

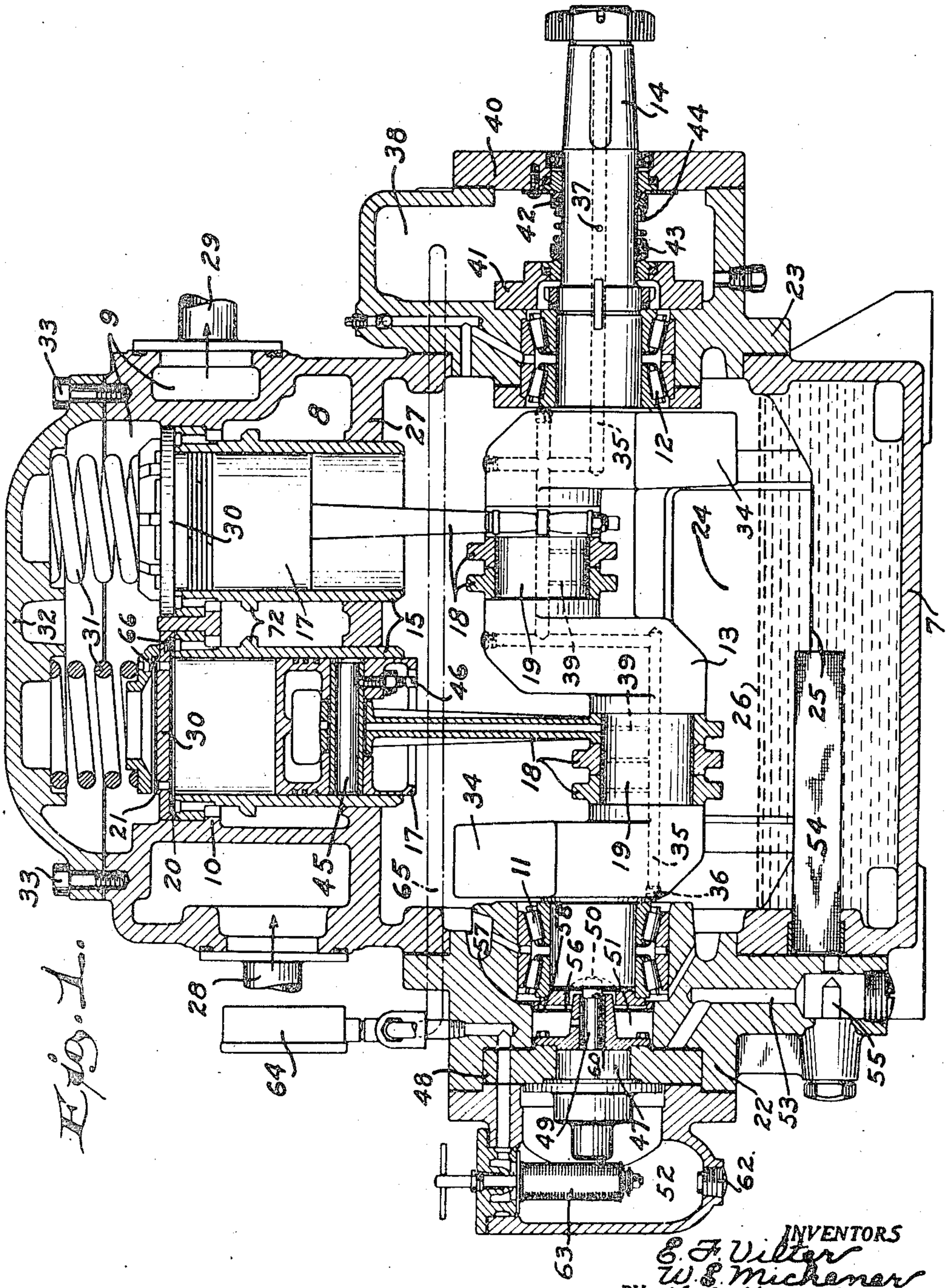

Fig. 1.

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COMPRESSOR

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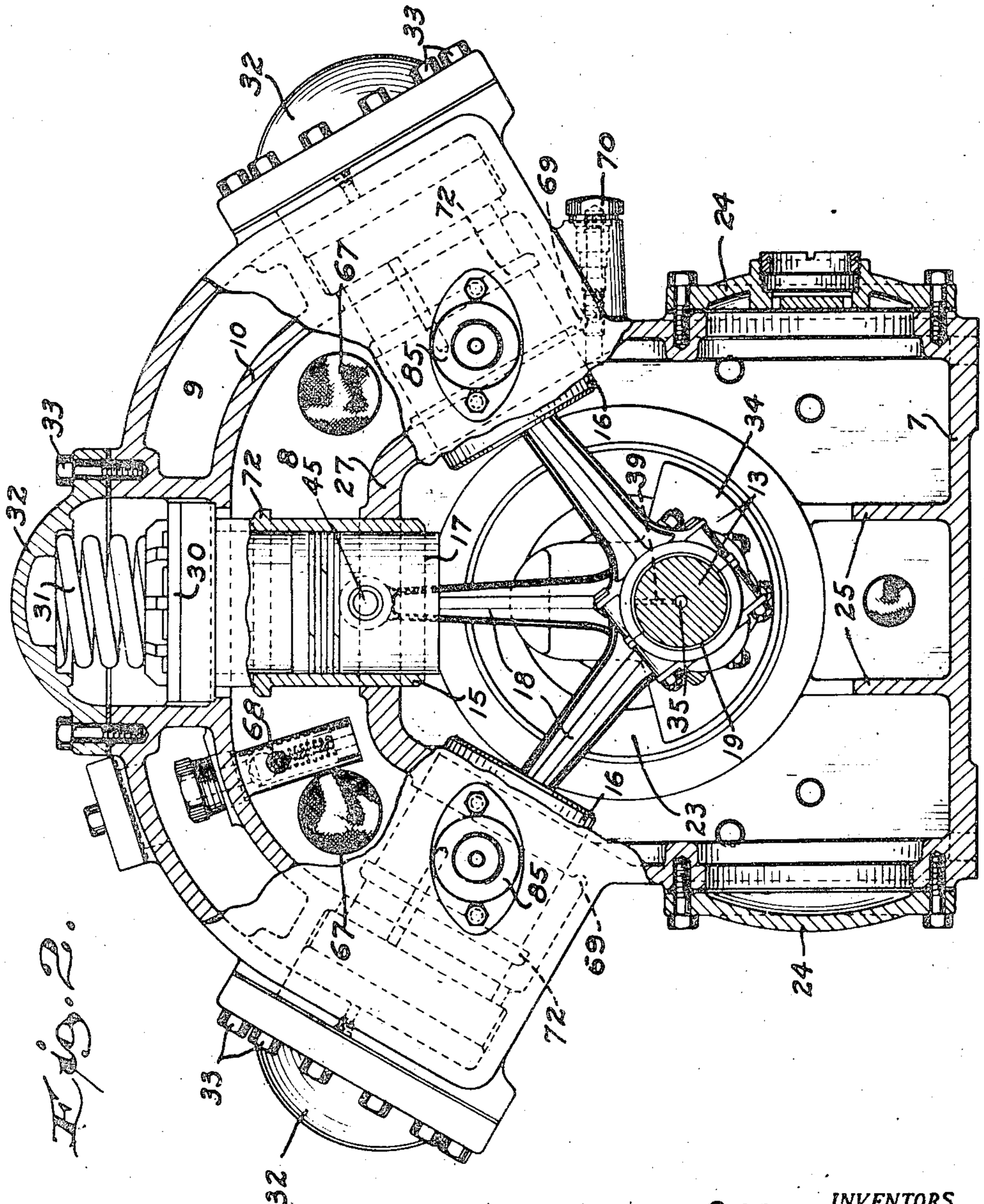

Fig. 2.

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COMPRESSOR

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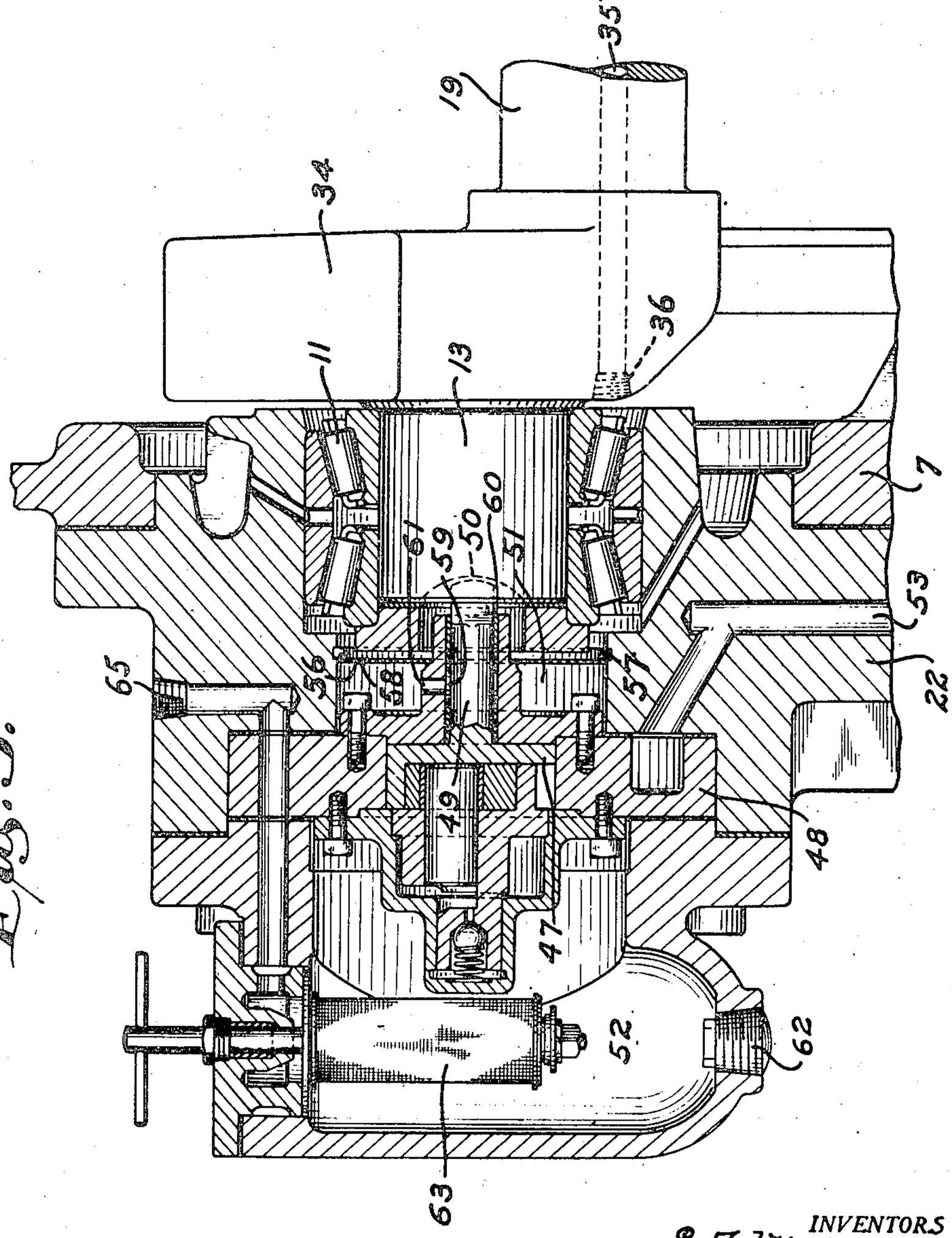

Fig. 3.

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COMPRESSOR

Filed Aug. 16, 1944 4 Sheets-Sheet 4

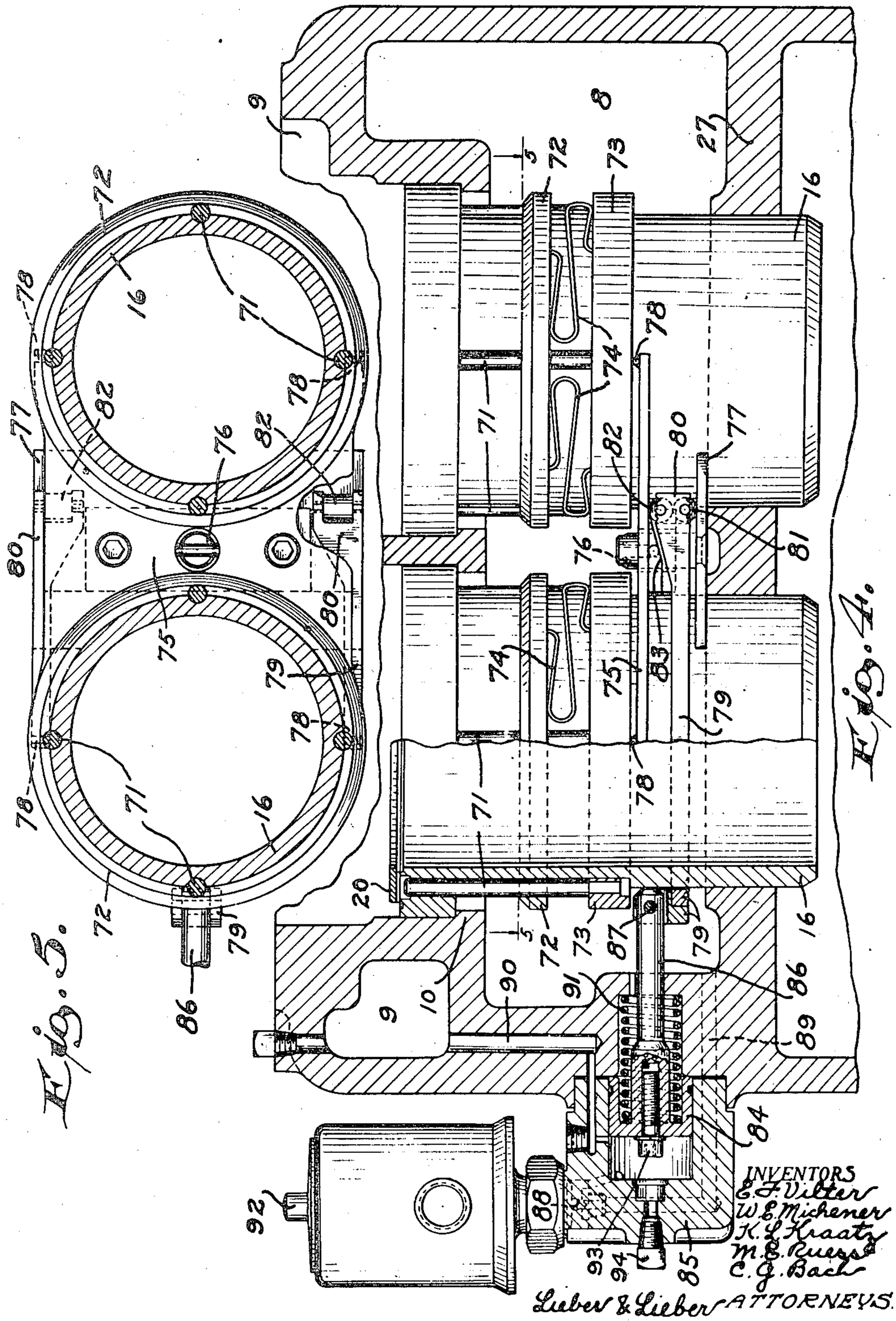

Fig. 5.

Fig. 4.

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Patented Sept. 16, 1947 2,427,638

UNITED STATES PATENT OFFICE

2,427,638

COMPRESSOR

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Application August 16, 1944, Serial No. 549,736

6 Claims. (Cl. 230—206)

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Our invention relates in general to improvements in the art of fluid compression, and relates more specifically to various improvements in the construction and operation of compressors for fluids such as refrigerants.

The primary object of our invention is to provide a new and useful fluid compressor which is simple and durable in construction, and which is moreover highly efficient in operation and flexible in its adaptations.

Some of the more important specific objects of the invention are as follows:

To provide an improved multiple cylinder compressor of variable capacity which is extremely compact in structure and quiet in operation, and all important parts of which are readily accessible for inspection.

To provide a relatively light but strong compressor assemblage having relatively large capacity but occupying minimum space, and which may be used advantageously to handle various kinds of refrigerants and other fluids.

To provide an improved reciprocating piston compressor all parts of which may be easily manufactured, which may be conveniently assembled and dismantled, and similar parts of which are interchangeable.

To provide a compressor for refrigerant or the like, the various bearings of which are abundantly and effectively lubricated at all times, without permitting undesirable escape of lubricant with the fluid being pumped.

To provide a relatively high speed compressor the various elements of which are balanced so as to insure smooth and silent operation, and which is operable with minimum power consumption.

To provide an improved fluid compressor and improved unloading mechanism therefor which is readily manipulable to vary the output or capacity without undesirable shock or vibration.

To provide an improved lubricant circulating system for compressors or the like, wherein sufficient oil is constantly supplied to all parts requiring lubrication, while excess lubricant is bypassed to the supply chamber.

To provide an improved compressor lubricating assemblage wherein full pressure lubrication for the crank, connecting rod, and piston wrist pins is provided through accurately formed passages, and in which the oil lines are readily accessible for inspection.

To provide improved compressor valve mechanism in which valves of ample size and simple

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construction are utilized, and wherein the valves are conveniently accessible and replaceable.

To provide a compact but durable crank shaft and connecting rod assembly for reciprocable piston multiple cylinder compressors, wherein expansion and contraction of elements due to varying temperatures is effectively compensated for.

To provide an improved multi-cylinder compressor wherein the cylinders are disposed to provide for compactness and smooth operation, and in which the driving torque is minimized.

To provide various other improvements in the details of construction of fluid compressors, whereby the costs of manufacture and maintenance are reduced to a minimum, while the efficiency of operation is enhanced to a maximum.

These and other specific objects and advantages of the invention will be apparent from the following detailed description.

A clear conception of the several features constituting the present improvement, and of the mode of manufacturing and operating compressors built in accordance with the invention, may be had by referring to the drawings accompanying and forming a part of this specification wherein like reference characters designate the same or similar parts in the various views.

Fig. 1 is a longitudinal vertical section taken centrally through our improved compressor, but showing some of the internal parts in elevation;

Fig. 2 is a part sectional end elevation of the improved compressor, the section having been taken vertically and transversely through one of the cranks, cylinders, and the crank case;

Fig. 3 is an enlarged central longitudinal section taken through the lubricating oil circulating pump of the compressor;

Fig. 4 is an enlarged section taken longitudinally of the compressor through one of the capacity controls which are associated with each of the inclined sets or pairs of cylinders; and

Fig. 5 is a transverse section through the assemblage of Fig. 4, taken along the line 5—5 thereof.

While our invention has been shown and specifically described herein in connection with a six-cylinder V-type refrigerant compressor, it is not our desire or intention to thereby unnecessarily restrict the scope or the utility of the invention.

Referring to the drawings, the improved gas compressor assemblage shown therein comprises in general, a main casing having a lower crank case 7 and upper inlet and discharge chambers 8, 9 respectively, separated from each other by a

partition 10; anti-friction or roller bearings 11, 12 carried by the opposite ends of the main casing adjacent to the crank case 7; a crank shaft 13 rotatably journalled in the bearings 11, 12 and having an outer end 14 adapted to be drivingly connected to an electric motor or other source of power; two central upright cylinders 15 having their axes disposed in the vertical longitudinal central plane of the crank shaft 14 and spanning the inlet chamber 8; two pairs of oppositely inclined cylinders 16 radiating from the crank shaft axis on opposite sides of the vertical cylinders 15, and also spanning the intake chamber 8; a piston 17 reciprocable within each of the cylinders 15, 16 by means of a hollow connecting rod 18 coacting with an adjacent crank 19 of the crank shaft 13; an annular inlet valve 20 interposed between the outer end of each cylinder 15, 16 and the common suction chamber 8; an annular discharge valve 21 interposed between the outer end of each cylinder 15, 16 and the common outlet chamber 9; improved unloading mechanism coacting with the inlet valves 20 of the inclined cylinders 16 only; an improved lubricant circulating pump assemblage coacting with the housing and support 22 of the crank shaft bearing 11; and suitable strainers for removing lubricant from the gas which is to be compressed, and impurities from the oil being circulated by the pump assemblage.

The main casing of the pump may be formed of a single integral casting having relatively large end openings within which the bearing housings and supports 22, 23 are secured, and also having large opposite side openings normally closed by rectangular cover plates 24; and the crank case 7 is provided with longitudinal ribs 25 and with an abundant supply of lubricant such as an oil basin 26, as shown in Fig. 1. The medial portion of the main pump casing also has an integral partition 27 separating the crank chamber from the suction chamber 8, and the suction and discharge chambers 8, 9 are provided with gas inlet and outlet connections 28, 29 respectively. The sleeves which form the cylinders 15, 16 are snugly fitted within bores in the partitions 10, 27; and the outer end of each cylinder 15, 16 is provided with a closure head 30 with which the valves 20, 21 are associated. These heads 30 are normally held in place by means of stiff compression springs 31 coacting therewith and with removable closure caps 32 secured to the main casing by cap screws 33 as illustrated in Figs. 1 and 2; so that all portions of the interior of the main pump casing are readily accessible through the various openings therein which are normally sealed by the supports 22, 23 and the cover plates 24, the connections 28, 29, and the closure caps 32.

The crank shaft 13 which is rotatable within the anti-friction bearings 11, 12 and the outer end 14 of which is adapted to be driven at any desired speed by a motor or the like, has two oppositely directed cranks 19, and counter balancing weights 34 adjacent to the bearings 11, 12. The interior of the shaft 13 is provided with a longitudinal lubricant conducting passage 35 one end of which is sealed by a plug 36, and the opposite end of which communicates through one or more small radial ports 37 with a sealed chamber 38 formed in the bearing support 23, while the crank pins 19 are also provided with ports 39 leading to the adjacent bearings of the connecting rods 18, as depicted in Figs. 1 and 2. The chamber 38 is enclosed by a cover plate 40 and an inner plate 41 and sealing rings 42, 43 are pressed

into sealing engagement with these plates 40, 41 by means of a spring 44, so that lubricant admitted to the chamber 38 under pressure, must pass through the ports 37 into the passage 35 and from this passage through the ports 39 to the lower bearings of the hollow connecting rods 18. The upper ends of the hollow connecting rods 18 coact with wrist-pins 45 which are secured to the adjacent pistons 17 by set screws 46, and the excess lubricant delivered from the ports 39 flows through the rods 18 and lubricates the upper bearings and pins 45. All of the crank and connecting rod bearings are thus constantly and abundantly lubricated by oil under pressure, and the bearings 11, 12 are likewise well lubricated by oil splashed from the crank case basin 26 and by the improved oil pump assemblage which will subsequently be described.

Lubricant under pressure is constantly circulated from the crank case oil basin 26 by means of an improved oil pump assemblage such as shown in detail in Figs. 1 and 3, and which is associated with the bearing support 22. The improved oil pump assemblage comprises in general a positive displacement rotary pump provided with a rotor 47 revolvable within the bore of a plate 48 secured to the bearing support 22, by means of a driving shaft 49 having a flat end coacting with a slot 50 formed in the adjacent end of the crank shaft 13: and oil confining chambers 51, 52 communicating with the pump discharge. The pump illustrated is of a well known type, and may be replaced by other rotary positive displacement types, and the suction line 53 of this oil pump communicates with the crank case oil basin 26 through a strainer 54 and past a needle control valve 55 as indicated in Fig. 1. The pressure oil chamber 51 is exposed to a flexible diaphragm 56 held in place by a peripheral snap ring 57 and having a small oil delivery hole 58 in the upper portion thereof, communicating with the adjacent main bearing 11, see Fig. 3; and the pump shaft bearing is vented through a groove 59 in the bearing sleeve 60, and through an opening 61 communicating with the adjacent pressure chamber 51. The opposite pressure chamber 52 coacts with the chamber 51 to balance the pressure acting upon the rotor 47, and is provided with a drain plug 62 and with a strainer 63 through which oil under pressure is constantly delivered to a gage 64 and pipe line 65 leading into the upper portion of the chamber 38 as shown in dot-and-dash lines in Fig. 1. In this manner an abundance of oil under pressure is constantly delivered to the various bearings during normal operation of the compressor and the oil is returned by gravity to the basin 26; and the strainers 54, 63 maintain the circulating oil in clean condition.

As previously indicated, each of the compressor cylinders 15, 16 is provided with annular inlet and discharge valves 20, 21, associated with its cylinder head 30, and these valves are normally urged toward their seats by means of helical spiral springs 66, of well known construction. In order to prevent oil or other liquid from entering the cylinders 15, 16, two liquid removing strainers 67 are interposed between the inlet connection 28 and the suction chamber 8, and a safety relief valve 68 is also interposed in the partition 10 between the suction chamber 8 and the discharge chamber 9. This safety valve 68 may be adjusted so as to open automatically when the pressure in the discharge chamber 9 reaches dangerously high predetermined values, from the ex-

terior of the main pump casing, through an opening normally sealed by a removable cap 69 as shown in Fig. 2; and the strainers 67 are tubular and extend throughout the major portion of the length of the suction chamber between the central cylinders 15 and the inclined cylinders 17. The oil and other liquid removed from the gas by the strainers 67 flows downwardly along the inclined portions of the lower partition 27 to troughs 69 located below the inclined cylinders 16, from whence it may be removed or drained into the crank case basin 27 past removable plugs 70 one of which is shown in Fig. 2.

All of the pump cylinders 15, 16 are normally adapted to receive the gas through the strainers 67 from the common suction chamber 8, and to deliver the compressed gas to the discharge chamber 9 past their respective discharge valves 21, but as previously indicated, the inclined cylinders 16 are provided with improved automatic unloading mechanisms for making them either active or inactive in accordance with the demand for compressed gas. One of these unloading assemblages is shown in detail in Figs. 4 and 5, and it is to be understood that one of these unloading rigs for controlling the compressor capacity, is applied to each parallel set of the inclined cylinders 16, and that the unloaders are independently operable so as to make either one, two, or three parallel sets of the cylinders 15, 16 either active or inactive depending upon the demand.

Each of the improved unloaders illustrated in Figs. 4 and 5, comprises a series of parallel pins 71 slidable through openings in a medial flange 72 of each cylinder 16, and having their upper ends cooperable with the adjacent suction valve 20 while their lower ends are firmly attached to a ring 73 slidably embracing the lower portion of the corresponding cylinder 16; a series of leaf springs 74 interposed between each fixed flange 72 and the adjacent ring 73 for constantly urging the pins 71 away from the valves 20; a motion transmitting bracket 75 slidable between each parallel set of cylinders 16 along a central bifurcated fixed post 76 secured to a stationary plane reaction plate 77, and having contact elements 78 engageable with diametrically opposite portions of the two adjacent guide rings 73; a wedge yoke 79 having two wedges 80 at its extreme ends, each of which has a lower roller 81 engageable with the fixed plate 77 and an upper roller 82 cooperable with a wedge surface 83 formed on the movable bracket 75; and a plunger 84 slidable within an auxiliary pressure cylinder 85 and having a stem 86 pivotally connected to the medial portion of the corresponding wedge yoke 79 by a pin 87. Each of the cylinders 85 is communicable past a solenoid actuated valve 88 and through a port 89, with the main suction chamber 8, and through another port 90 with the main discharge chamber 9; and each plunger 84 is adapted to be moved toward the left as viewed in Fig. 4, by a helical compression spring 91 so as to close the port 90 when the pressure within the cylinder 85 drops belows a predetermined maximum. The extent of travel of each plunger 84 may be varied by adjusting a screw 93 associated therewith, upon removal of a plug 94. Each valve 88 may be opened so as to connect the corresponding cylinder 85 with the suction chamber 8, either automatically or with the aid of a push-button switch 92, and when a valve 88 is opened, the corresponding spring 91 will become quickly effective to raise the two corresponding suction valves 20 through the pins 71, collars 73,

yoke wedge 79 and plunger 84, thereby unloading the corresponding pair of cylinders 16. However, if the valves 88 remain closed when the discharge pressure in the chamber 9 is high, the pressure within the cylinders 85 will be sufficient to overcome the corresponding spring pressures, and the plungers 84 will then be held in the position shown in Fig. 4 subjected to discharge pressure through the ports 90, so that the suction valves 20 will be under the normal influence of the springs 66 coacting therewith. It should be noted that since the two central upright cylinders 15 are not provided with an unloading device, these will always be active, but the two sets of inclined cylinders 16 are subject to either simultaneous or successive unloading and loading, depending upon the demand for compressed gas.

During normal operation of our improved compressor, the crank case basin 21 should be provided with an abundant supply of clean lubricant such as high grade oil, and all closures should be tightly sealed. When high speed rotary motion is imparted to the main crank shaft 13 through its outer end 14, the lubricating pump rotor 47 will be constantly revolved to properly circulate oil under pressure through the various bearings, and the pistons 17 will be rapidly reciprocated within their respective cylinders 15, 16. If the discharge pressure within the chamber 9 is low, due to large demand for compressed gas, the unloading devices associated with the inclined cylinders 16 will be inactive as shown in Fig. 4, and all of the six cylinders 15, 16 and pistons 17, will function to deliver compressed gas to the discharge chamber 9 and delivery line 29. The solenoid actuated valves 88 of the unloading devices will then be closed and discharge pressure will be maintained within the auxiliary cylinders 85 through the ports 90 to hold the plungers 84 to the right as shown in Fig. 4, and to thereby permit the leaf springs 74 to retract the pins 71 from the zones of action of the suction valves 20. However, if the demand for compressed gas decreases, the valves 88 will automatically open either simultaneously or successively, depending upon the setting of the stop screws 93, and this opening of the valves 88 will cause the pressures within the cylinders 85 to quickly drop through the ports 89, thus permitting the springs 91 to force the wedge rollers 81, 82 to the left as viewed in Fig. 4, and to thereby raise the collars 73 and pins 71 so as to lift the suction valves 20 and thus unload the corresponding cylinders 16. Subsequent increase in the demand for compressed gas will again cause the valves 88 to close either simultaneously or successively, and this closing of the valves 88 will be promptly followed by restoration of the collars 73 and pins 71 to inactive position, so that the suction valves 20 will again be free to function normally. It will thus be noted that the compressor functions automatically and quickly to meet varying demands for compressed gas, and that proper lubrication is maintained at all times.

From the foregoing detailed description it will be apparent that our present invention provides an improved compressor assemblage which may be operated at relatively high speed to meet varying desirable conditions of operation, and to automatically maintain desirably high pressures in the discharge line. While the improved compressor is especially useful in connection with refrigerating apparatus, it may be used for the compression of air and gases of various types, and by virtue of the improved construction of the assemblage with numerous removable cov-

ers and closure plates, the machines may obviously be readily assembled, dismantled or inspected with minimum effort. The improved oil pump assemblage maintains efficient lubrication of all working parts at all times, and the strainers 54, 63 function to prevent foreign matter from reaching the bearings. The strainers 67 effectively separate the oil from the gases being delivered to the cylinders, and this oil may be quickly returned to the crank case basin 26 for re-use. The improved lubricant circulating pump is effectively balanced and is automatically driven by the revolving crank shaft, and all joints are thoroughly sealed against possible escape of lubricant and gas. The improved unloading device functions to automatically unload the successive valves 20 and to restore these valves to normal operation condition when unloading is not desired, and by providing three sets of cylinders and two unloading devices, either one, two, or three sets of the cylinders may be made active or inactive under varying conditions of operation. The improved unloading device besides being extremely simple and compact, is also reliable in operation, and insures simultaneous operation of the set of cylinders 16 with which it is associated. This unloading device while being applied to only two sets of the cylinders 16, may also be applied to the third set of cylinders 15 if so desired, and the pressure relief valve 68 positively prevents the establishment of excess pressure within the discharge chamber 9 thus enhancing the safety of operation of the unit.

The improved oil pump and diaphragm assemblage is relatively important since it permits the pump rotor to draw oil from an external container in order to add lubricant to the machine while in operation. The diaphragm and the vent hole in the upper portion thereof permits the pump to draw oil from such outside source against the normal crank case pressure, and prevents gas from going through the pump bearing and into the pump pressure chambers under such operating conditions. By providing a structure such as illustrated in Fig. 3, the pump bearing is sealed with oil by gravity during the time that oil is being drawn in from the outside of the machine, and this improved assemblage has therefore proven highly advantageous in eliminating oil pump difficulties. The improved compressor with its lubricating and unloading systems, has gone into highly successful commercial use and is obviously extremely compact considering its great capacity and may be manufactured and sold at moderate cost.

It should be understood that it is not desired to limit this invention to the exact details of construction or to the precise mode of use, herein shown and described, for various modifications within the scope of the appended claims may occur to persons skilled in the art.

We claim:

1. In a compressor, an upright cylinder and oppositely inclined cylinders on opposite sides of said upright cylinder, a casing forming segregated suction and discharge chambers common to and surrounding all of said cylinders, a pressure relief valve interposed between said chambers, suction and discharge valves interposed between each cylinder and said chambers respectively, a piston reciprocable in each cylinder, and an independent unloading device for the suction valves of said oppositely inclined cylinders only, each of said devices comprising a ring slidable along the adjacent cylinder and having pins cooperable with the adjacent suction valve to hold it open, leaf springs normally urging said ring and pins away from said valve, wedge rollers for compressing said springs, and a plunger subjectable to suction pressure within said suction chamber to move said wedge rollers to open said valve.

2. In a compressor, a casing having an enclosed crank chamber and a plurality of cylinders radiating from said chamber, a piston reciprocable within each of said cylinders, a crank shaft rotatable in said chamber, connecting rods operatively connecting said shaft with said pistons, a liquid pump direct connected to an end of said shaft for delivering lubricant under pressure from said chamber to said pistons and cylinders, and a flexible diaphragm interposed between said chamber and said pump and having a vent opening connecting the interior of the pump with the chamber.

3. In a compressor, a casing having an enclosed crank chamber and a plurality of cylinders radiating from said chamber, a piston reciprocable within each of said cylinders, a crank shaft rotatable in said chamber, connecting rods operatively connecting said shaft with said pistons, a liquid pump direct connected to an end of said shaft for delivering lubricant under pressure from said chamber to said pistons and cylinders, a flexible diaphragm interposed between said chamber and said pump and having a vent opening connecting the interior of the pump with the chamber, and conduit means connecting the shaft bearing of said pump with the internal pump chamber exposed to said diaphragm, said conduit means being completely submerged in lubricant at all times.

4. In a compressor, an upright cylinder and oppositely inclined cylinders on opposite sides of said upright cylinder, a casing forming segregated suction and discharge chambers common to and surrounding all of said cylinders, a pressure relief valve interposed between said chambers, suction and discharge valves interposed between each cylinder and said chambers respectively, a piston reciprocable in each cylinder, and an independent unloading device for the suction valves of said oppositely inclined cylinders only, each of said devices comprising a member slidable along the adjacent cylinder and having elongated parallel elements cooperable with the adjacent suction valve to hold it open, springs normally urging said member and elements away from said valve, wedge rollers for compressing said springs, and a plunger subjectable to suction pressure within said suction chamber to move said wedge rollers to open said valve.

5. In a compressor, an upright cylinder and oppositely inclined cylinders on opposite sides of said upright cylinder, a casing forming segregated suction and discharge chambers common to and surrounding all of said cylinders, a pressure relief valve interposed between said chambers, suction and discharge valves interposed between each cylinder and said chambers respectively, a piston reciprocable in each cylinder, and an independent unloading device for the suction valves of said oppositely inclined cylinders only, each of said unloading devices comprising an annular member slidable along the adjacent cylinder and cooperable with the adjacent suction valve to hold it open, resilient means normally urging said member away from said valve, wedge rollers for compressing said resilient means, and

means subjectable to suction pressure within said suction chamber to move said wedge rollers to open said valve.

6. In a compressor, a unitary casing having therein an enclosed crank chamber and a plurality of cylinders radiating from said chamber, a piston reciprocable within each of said cylinders, a crank shaft rotatable within said chamber, connecting rods operatively connecting said shaft with said pistons, a liquid pump direct connected to an end of said shaft for delivering lubricant under pressure from said chamber to said pistons and cylinders, and a flexible diaphragm having opposite sides exposed to said chamber and said pump respectively and also having a vent opening connecting the interior of the pump with the crank chamber.

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