

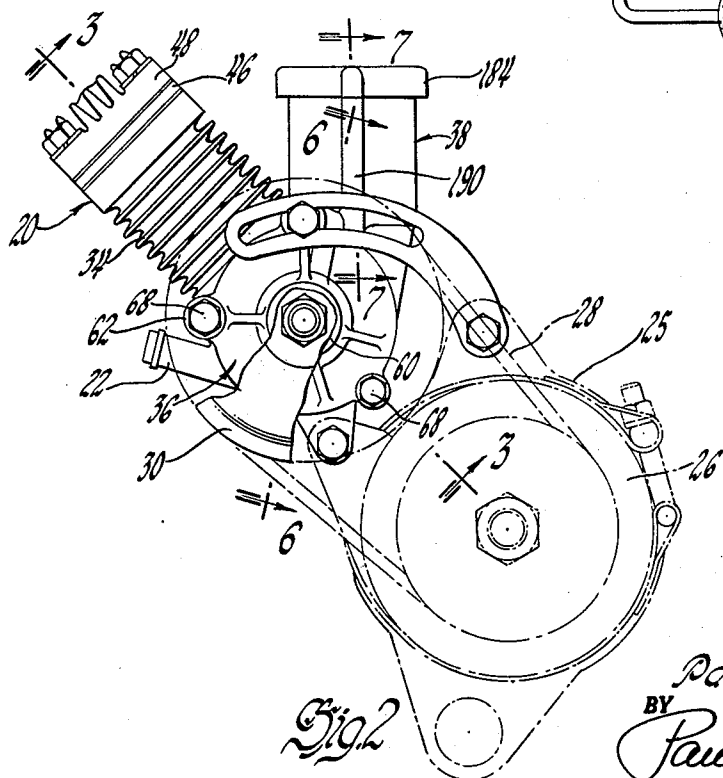
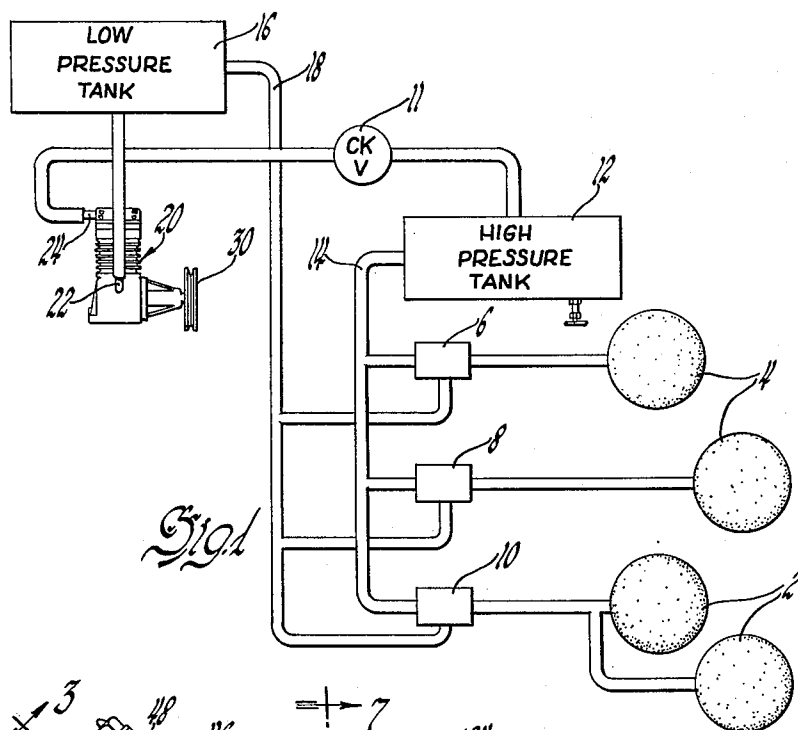
Dec. 6, 1960

P. V. WYSONG, JR
FLUID COMPRESSOR

2,963,217

Filed Sept. 17, 1956

3 Sheets-Sheet 1



INVENTOR.
Paul V. Wysong Jr.
BY
Paul J. Patrick
ATTORNEY.

Dec. 6, 1960

P. V. WYSONG, JR

2,963,217

FLUID COMPRESSOR

Filed Sept. 17, 1956

3 Sheets-Sheet 2

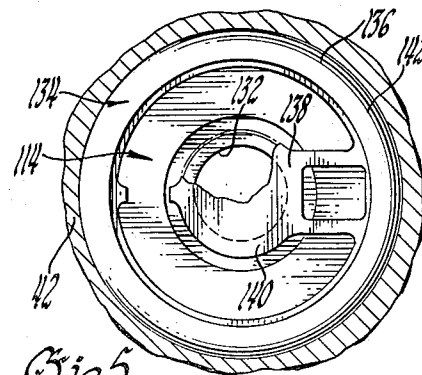
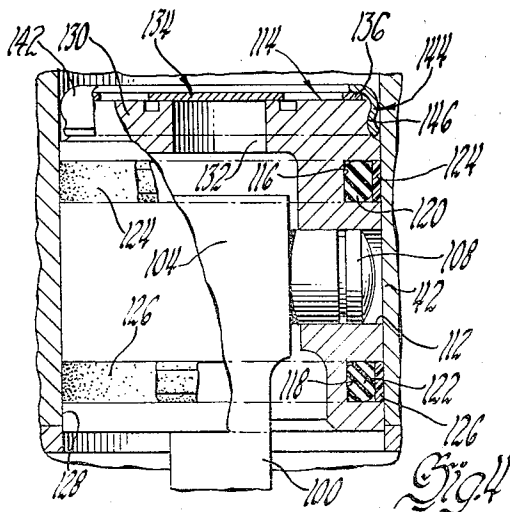
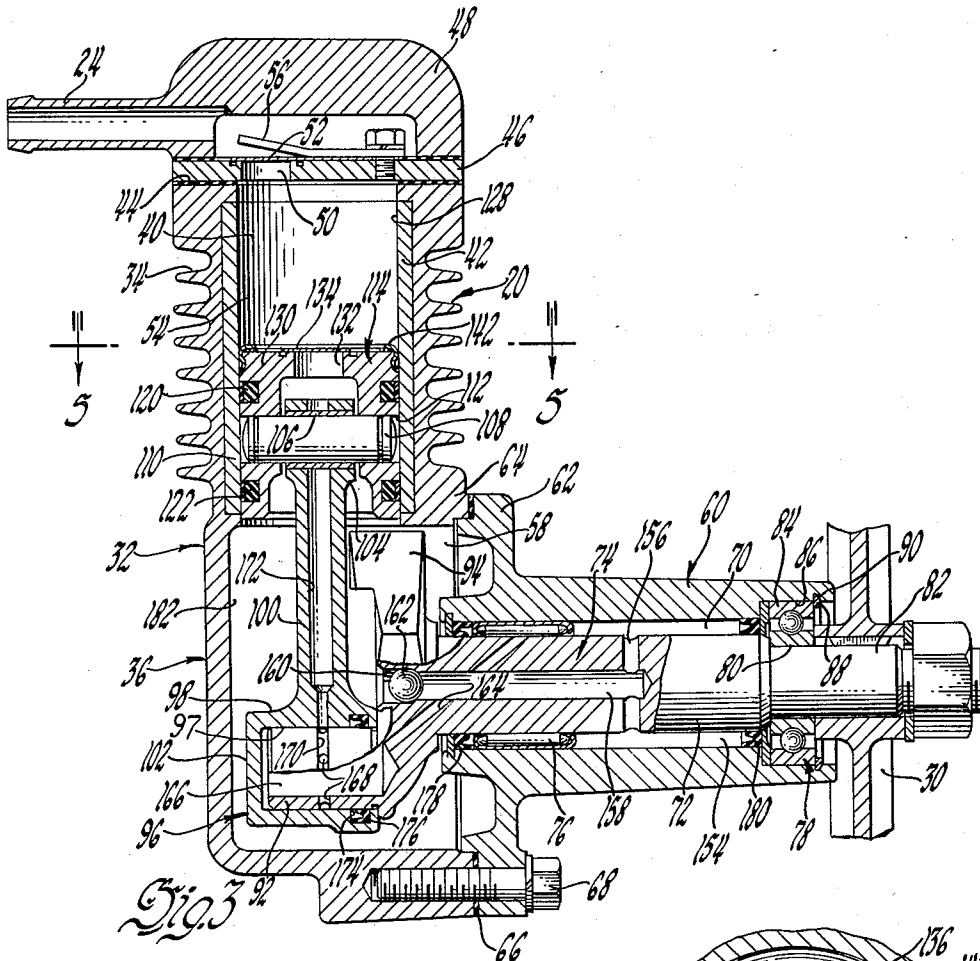


Fig. 5

INVENTOR.
Paul V. Wysong, Jr.
BY
Paul J. Patrick
ATTORNEY

1

2,963,217

FLUID COMPRESSOR

Paul V. Wysong, Jr., Saginaw, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Sept. 17, 1956, Ser. No. 610,222

7 Claims. (Cl. 230—190)

This invention relates to fluid pumps and more particularly to reciprocating air compressors for use in conjunction with pneumatic suspension systems for vehicles.

Although numerous forms of air compressors are well known in the prior art, providing a suitable quantity of air under pressure for use in conjunction with pneumatic vehicle suspension presents numerous problems which have not been fully appreciated heretofore. Generally speaking, pneumatic air suspension systems may be classified as either "open" or "closed." In the former, an air compressor draws air from atmosphere to progressively increase the pressure in a high pressure storage tank until a predetermined cut-off point is reached, after which the compressor either idles or the valve operation of the compressor is disabled by means of external pilot control so that air drawn into the compressor cylinder merely recirculates between the exhaust and inlet side of the compressor. As air is drawn from the high pressure tank to satisfy the operating requirements of the vehicle air springs, the pilot control causes the compressor to resume operation and replenish the high pressure tank with additional air drawn from atmosphere. Although, superficially, this system appears eminently simple, as a practical matter numerous disadvantages arise. First, the necessity of replenishing the air supply from atmosphere carries with it the disadvantage of progressive increase in the contaminants, notably moisture, in the air supply. In addition, because of the relatively great pressure differential between atmospheric pressure and the normal operating pressure of the high pressure tank, in order to accomplish rapid recovery of operating pressure, either a high capacity compressor is required or a certain degree of flexibility of operation of the suspension system must be sacrificed, as for example, by totally disabling the leveling action when the vehicle is parked. However, in the latter case, in the event that a leak exists in the system, considerable time is required to return the sprung mass of the vehicle to its normal standing height after the compressor is placed in operation.

In the closed type pneumatic suspension system, the compressor also supplies air to the high pressure storage tank which, in turn, serves the operating requirements of the vehicle air springs. However, air exhausted from the springs during leveling action of the system passes into a low pressure storage tank rather than being returned to atmosphere. The low pressure storage tank, in turn, communicates with the intake side of the compressor so that once the system is filled, little or no additional air from atmosphere is required. Because the pressure level in the low pressure tank will normally be super-atmospheric whenever pressure in the high pressure tank drops sufficiently below normal operating level as to require replenishing, super-atmospheric air is supplied to the intake side of the compressor and the speed of recovery of pressure in the high pressure tank will be greatly increased in comparison with an open type system. In addition, the closed type system virtually eliminates the problem of

2

moisture contamination, since the same air continues to cycle through the system.

While conventional air compressors theoretically may be adapted for utilization in either open or closed types of pneumatic suspension systems, in practice it has been found that compressors heretofore available tend to cause an undesirably high degree of oil contamination in the compressed air. Exhaustive tests have shown that the presence of oil in the air produces several undesirable effects which ultimately inhibit or completely disable the operation of the system. Since it is desirable for reasons of economy as well as size to produce a compressor of relatively low displacement, it follows that such a compressor must be capable of virtually continuous high speed operation in order to provide a satisfactory recovery rate. This, of course, implies an even greater necessity for adequate lubrication. Hence, the goal is to provide an inexpensive high speed compressor in which the operating parts are fully lubricated with little or no contamination of the air passing through the compressor.

According to the present invention, a pneumatic suspension system for vehicles including a high pressure storage tank and a low pressure return tank is provided with a reciprocating compressor for supplying and maintaining compressed air in the system in accordance with the requirement thereof. The compressor comprises a unitary housing forming the cylinder body and crankcase. The crankcase has an open side wall over which is bolted an elongated annular crankcase cover in which is rotatably supported a single throw counter-balanced crankshaft. Operatively engaging the crankshaft throw is a one-piece connecting rod which, in turn, is connected to a piston movable in the cylinder. The open top end wall of the cylinder body has bolted thereover an exhaust valve plate assembly and cylinder head.

In operation, air is drawn from a low pressure tank, through the crankcase, passes through a suitable intake valve in the piston and is exhausted to the high pressure tank through an outlet formed in the cylinder head. An exhaust valve disposed between the outlet and the piston prevents return of the compressed air to the cylinder during the downstroke of the piston. The air thus stored in the high pressure tank is then metered by any suitable means to the individual air springs for each wheel of the vehicle as required, for example, to increase the standing height of the sprung mass. To decrease the standing height of the vehicle, air is bled from the air springs and passes therefrom to the low pressure tank from which it is ultimately returned to the high pressure tank by operation of the compressor. Since the source of air supplied to the intake side of the pump is normally super-atmospheric, it will be seen that the compressor displacement and overall size may be relatively small and still effect rapid recovery of the high pressure tank to its operating capacity.

Pursuant to the general features of the invention, the compressor operates on the controlled compression ratio principle; that is, a compression ratio is selected which will provide a predetermined desired capacity or rate of delivery. If desired, the compressor may have a "stall pressure" roughly equivalent to the desired cut-off pressure of the high pressure tank. For the purposes of this application, stall pressure is defined as compression ratio times atmospheric pressure, without considering valve efficiency or thermal effects. Accordingly, in the case stated, when the pressure in the high pressure tank equals the stall pressure of the compressor, the latter "stalls" or stops compressing air; that is, the air in the compressor cylinder compressed by the piston on each compression stroke is not displaced into the high pressure tank, but merely expands back to normal volume on the return stroke of the piston. Thus, the power required to drive

the compressor on the compression stroke is returned to the compressor by expansion of the compressed air against the piston on return stroke so that the total power consumption of the compressor operating at stall pressure, ignoring thermal losses, is substantially zero.

An object of the present invention is to provide an improved air compressor.

Another object is to provide a controlled compression ratio air compressor for pneumatic suspension systems.

A further object is to provide a simplified air compressor capable of continuous high speed operation.

Still another object is to provide a dry sump air compressor.

Still a further object is to provide a compressor wherein air drawn through the compressor crankcase passes through an intake valve in the compressor piston and is ejected through an exhaust valve in the compressor head.

Yet another object is to provide in a pneumatic suspension including a high pressure storage tank and a low pressure return tank, an air compressor having its intake port in direct communicating relation with the return tank, the compressor body being pressurized so that air confined in the low pressure tank may not escape through the compressor body.

Yet a further object is to provide in a system of the type described a controlled compression ratio air compressor wherein the stall pressure approximately equals the rated operating pressure of the high pressure tank, thus eliminating the necessity for external or pilot control of the intake and exhaust valve.

Still a further object is to provide a sealed compressor of the type described including a gravity feed lubricating system and means for equalizing the internal pressure on the crankcase side of the compressor and the interior of the lubrication reservoir.

A yet further object is to provide a reciprocating piston type air compressor wherein the piston is provided with an improved piston ring and seal construction assuring optimum efficiency and requiring little or no lubrication.

A still further object is to provide an improved and simplified valve structure for a reciprocating air compressor.

These and other objects, advantages and features of the invention will become more fully apparent as reference is had to the accompanying specification and drawings wherein:

Fig. 1 is a diagrammatic view of a closed air suspension system incorporating the present invention.

Fig. 2 is a front elevational view showing the mounting location of an arrangement of the invention, certain parts being broken away to more clearly illustrate the construction.

Fig. 3 is a side elevational view in section looking in the direction of arrows 3—3 of Fig. 2.

Fig. 4 is an enlarged fragmentary elevational view of a portion of the structure shown in Fig. 3, certain parts being broken away to more clearly reveal the construction.

Fig. 5 is an enlarged fragmentary top plan view looking in the direction of arrows 5—5 of Fig. 3.

Fig. 6 is an enlarged fragmentary view, partly in section, looking in the direction of arrows 6—6 of Fig. 2; and

Fig. 7 is an enlarged fragmentary view, partly in section, looking in the direction of arrows 7—7 of Fig. 2.

Referring now to the drawings and particularly Fig. 1, there is illustrated diagrammatically a closed suspension system utilizing an air compressor embodying the present invention. Reference numeral 2 designates generally a pair of air springs associated with the front wheels of a vehicle, not shown, while reference numeral 4 designates a pair of air springs for the rear wheels of the vehicle. Flow of air into and out of springs 2 and 4 is regulated by three leveling valves 6, 8 and 10. Valves 6 and 8 individually regulate air flow in rear wheel springs 4, while valve 10 regulates air flow for both front air springs 2. To supply air to springs 2 and 4, there is provided a high

pressure tank 12 which is connected in parallel by a conduit 14 to valves 6, 8 and 10. A low pressure tank 16, in turn, is connected in parallel by a conduit 18 to valves 6, 8 and 10. Thus, when the vehicle standing height or load condition requires introduction of additional air into springs 2 and 4, leveling valves 6, 8 and 10 operate to permit air to pass from high pressure tank 12 to the respective air springs. Upon a change in vehicle attitude requiring bleeding of air from springs 2 and 4, valves 6, 8 and 10 function to permit air to pass from springs 2 and 4 to low pressure tank 16. As soon as the pressure in high pressure tank 12 drops below the high pressure cut-off level, compressor 20 immediately restores the desired operating pressure to high pressure tank 12. Since the intake 22 of compressor 20 communicates with low pressure tank 16, while the exhaust 24 communicates with high pressure tank 12, it will be evident that once the system has been initially filled with the required quantity of dry air or inert gas, the compressor functions primarily to transfer air from the low pressure tank to the high pressure tank rather than to provide a continuous supply of new air from the atmosphere. As a result, the moisture level of air utilized in the system remains at a very low level.

Pump 20 operates on the controlled compression principle and is, therefore, capable of continuous mechanical operation regardless of existing pressure conditions in the high and low pressure tanks. Thus, when the pressure in high pressure tank 12 is below the desired level, operation of pump 20 produces progressively increased pressure in tank 12 until a predetermined pressure level has been reached. By selecting a compression ratio properly correlated with the desired high pressure level, continued mechanical operation of the compressor after maximum tank pressure has been reached causes the compressor to "stall" or stop compressing air. Thereafter, the compressor continues to function mechanically but does not displace air into tank 12 until the pressure therein is again lowered below the compressor stall pressure.

Since compressor 20 is intended for continuous operation, it is preferably mounted adjacent an existing engine driven accessory and driven simultaneously therewith. As seen in Fig. 2, in the preferred embodiment compressor 20 is mounted "piggyback" on the vehicle electrical generator 25. The latter is then equipped with a double V-belt pulley 26 in order to accommodate a second V-belt 28 for driving the drive pulley 30 of the compressor. Because of the relatively high speed of operation, compressor 20 may have a relatively low displacement, which in turn reduces the overall space requirements.

As seen best in Fig. 3, compressor 20 utilizes a cast unitary body 32 preferably aluminum, comprising a ribbed cylinder housing 34, crankcase 36, and an oil reservoir 38 (Fig. 2). Cast in place interiorly of housing 34 is a sintered iron cylinder liner 42, the inner wall of which is subsequently precision finished. Secured coincidentally over the open top end wall 44 of cylinder housing 40 are an exhaust valve plate 46 and cylinder head 48, respectively. Exhaust valve plate 46 is formed with an exhaust port 50 and has secured thereon a cantilever reed valve 52 which functions to open and close port 50 in accordance with pressure differential on opposite sides thereof. To prevent excess opening movement of reed valve 52, a cantilever abutment finger 56 is mounted to overlie reed valve 52 and limit the upward travel of the latter.

Disposed over the open side face 58 of crankcase 36 is an elongated annular crankshaft support 60 having an enlarged circular flange 62 formed integrally at the inner end thereof. Flange 62 is machined to fit in nesting relation with a cooperating machined face of the peripheral wall 64 of crankcase 36 surrounding opening 58. A suitable gasket 66 is interposed between the cooperating faces and forms an air tight juncture therebetween when machine bolts 68 are drawn up. Centrally thereof

5

crankshaft support 60 is provided with a bored axial passage 70 in which is rotatably disposed the journal portion 72 of a single throw counterbalanced crankshaft 74. A pair of spaced anti-friction bearings 76 and 78 provide anti-friction support for journal 72. In the preferred embodiment, inner bearing 76 is a needle bearing assembly, while outer bearing 78 is a ball bearing assembly providing both radial and thrust load support. Accordingly, inner race 80 of bearing 78 is press-fitted on the reduced outer end portion 82 of crankshaft 74, while the outer race 84 of bearing 78 is disposed in an enlarged counterbore 86 formed near the outer end of axial passage 70 in concentric relation therewith. To lock outer race 84 against axial movement, a beveled circular snap ring 88 is disposed in a groove 90 in counterbore 86 and abuts the outer side of the former.

At its inner end, crankshaft 74 is formed with a single throw having a crankpin 92 and a counter-balance weight 94. Crankpin 92 is adapted for endwise insertion into a socket 96 formed in the enlarged lower end 98 of a one-piece cast aluminum connecting rod 100. As seen best in Fig. 3, socket 96 terminates in a closed end wall 102, the purpose of which will be described shortly. At its upper end 104, connecting rod 100 is provided with a transverse drilled passage which in the illustrated embodiment has a high density sintered bronze wrist pin bearing 106 press fitted therein. Bearing 106 surrounds a wrist pin 108 which, in turn, is press fitted into spaced axially aligned openings 110 and 112 extending transversely through a piston 114. The outer wall of piston 114 is machined to a diameter slightly less than the inside diameter of cylinder liner 42 and is formed with a pair of axially spaced circumferentially extending ring grooves 116 and 118. Disposed in grooves 116 and 118 are a pair of circular elastomeric rings 120 and 122 which, in turn, are surrounded by relatively thin endless rings 124 and 126 formed of Teflon. When in assembled relation with cylinder liner 42, rings 124 and 126 are compressed radially inwardly against rings 120 and 122 sufficiently to provide partial edgewise engagement with the axial shoulders of the adjacent ring grooves. For a more complete description of the ring and seal structure, reference may be had to copending United States application Serial No. 512,670, now abandoned, Walter H. West, entitled Seal, assigned to General Motors Corporation. The piston ring seal thus effected has proved to be extremely efficient, since the rings 124 and 126 not only very closely engage the cylinder wall 128, but in addition any tendency toward leakage around the inner periphery of the rings is prevented by the compression seal provided by rings 120 and 122.

Extending axially through the top wall 130 of piston 114 is an intake port 132. Secured over the top of end wall 130 is a second cantilever reed valve 134 which functions to open and close port 132 in accordance with pressure differential conditions existing at opposite ends of the piston. As seen best in Figs. 4 and 5, according to one feature of the invention reed valve 134 is a relatively thin metal disk having a circular rim portion 136 and an integral inwardly extending finger portion 138. The circular terminal end 140 of finger 138 is axially aligned with and normally closes the opening formed by port 132. In accordance with another feature of the invention, reed valve 134 is secured in position on piston 114 by means of a circular clasp ring 142. As seen best in Fig. 4, ring 142 is generally L-shaped in cross section, a portion of which overlies the circular ring 136 of valve 114. The skirt portion 144 of ring 142 surrounds a circumferential groove 146 formed in piston 114 and is spun into engagement therewith to positively secure reed valve 134 in position.

When constructed and arranged in the manner described, compressor 20 operates in either a clockwise or counterclockwise direction to deliver compressed air. Operation of the mechanism produces a "straight flow"

6

compression action in the following manner. Upon rotation of crankshaft 72 from the bottom deadcenter position shown in Fig. 3, piston 114 travels upwardly in cylinder 40. Since intake port 132 is closed by reed valve 134, air confined in the compression chamber 54 above piston 114 is progressively compressed and passes through exhaust port 50, displacing exhaust reed valve 52, and is ejected through exhaust port 24 to high pressure tank 12. Simultaneously with the compression stroke of piston 114, the normally super-atmospheric air in low pressure tank 16 is admitted through intake port 22 in the crankcase housing 36. As soon as the piston reaches top deadcenter, exhaust valve 52 and check valve 11 for high pressure tank 12 close preventing return flow from the latter. As piston 114 moves downwardly in cylinder 40, intake valve 134 opens intake port 132 due to the pressure differential above and below the piston and, therefore, allows air from the crankcase to pass upwardly into the compression chamber 54. Upon reaching bottom deadcenter, intake valve 134 again closes and the compression cycle is repeated.

In accordance with another feature of the invention, a gravity feed lubrication system is provided which assures adequate lubrication of the crankshaft journal, crankpin, connecting rod and wrist pin while virtually eliminating oil contamination of air passing through the compressor body. To this end, a pair of endwise abutting drilled passages 148 and 150 are formed respectively at the bottom of oil reservoir 38 and in the web portion 152 of crankshaft support flange 62. Oil contained in reservoir 38 travels through passages 148 and 150 into the annular space 154 between axial passage 70 and journal portion 72 of crankshaft 74 to provide lubrication for needle bearing 76. To conduct oil from annular space 154 to crankpin 92 and socket 96, journal portion 72 is provided with a drilled radial passage 156 communicating with an axial passage 158. The open end 160 of passage 158 is subsequently closed by press fitting a ball 162 therein. A diagonal drilled passage 164 provides communication between passage 158 and the hollow interior 166 of crankpin 92. Axially midway thereof, crankpin 92 is provided with a drilled radial passage 168 and a circumferential groove 170. Groove 170 is aligned with a rifled passage 172 extending the full length of connecting rod 100. Subsequent insertion of wrist pin bearing 106 closes the upper open end of passage 172 and subsequently blocks the flow of oil other than that absorbed by bearing 106. It is to be understood, however, that bearing 106 is not necessarily restricted to a plain bearing, but might also take the form of a needle bearing assembly or other suitable type. To prevent oil leakage at the crankpin connecting rod juncture, the inner peripheral wall 97 of socket 96 near the open side thereof is formed with a circumferential groove 174 in which is disposed an expansion type synthetic rubber or plastic oil seal 176 of generally V-shaped cross section. Since the opposite side of socket 96 is closed by wall 102, previously mentioned, only one seal is required. Two additional oil seals 178 and 180 similar to oil seal 176 are disposed in opposite ends of crankshaft support bore 70 to prevent leakage of oil therefrom into the interior 182 of crankcase 36 or to atmosphere. It will be evident from the foregoing that gravity feed lubrication is confined to the crankshaft journal, crankpin, connecting rod and wrist pin. Since it is desired to reduce or eliminate oil contamination in both the crankcase interior and compression chamber, the compressor is intended for operation without continuous lubrication of the cylinder wall and piston rings. In this regard, it has been found that by utilizing the Teflon piston ring structure, previously mentioned, only an initial lubrication of the cylinder wall with a relatively high temperature grease is required.

Although the subject compressor is equally efficient when used in either an open or closed type air suspension system, the present invention includes a pressure equaliz-

ing feature which permits the intake side of the compressor to be connected in open communicating relation with the low pressure tank of a closed system. In the past, in closed systems it has been the practice to provide a check valve or suction cut-off valve to prevent bleeding of air from the low pressure tank through the compressor housing to atmosphere. However, in the present invention, the need for a check valve between the compressor and the low pressure tank is totally eliminated. In order to accomplish this end in accordance with the present invention, as shown best in Fig. 7, the oil reservoir is provided with a pressure closure cap 184 having a gasket 186 for effecting an air tight seal between the cap and the open end wall of the reservoir. A drill passage 188 extends through a rib 190 on the wall of reservoir 38 and communicates directly with the interior 182 of crankcase 36. The spherical-shaped object at the top of passage 188 in Figure 7 of the drawing is a ball which is pressed into the counterbore to close one end of the passage 188. This is a common expedient where die cast bodies are formed with passages in the casting process. Press fitted into a diagonal bore 194 in a wall 196 of reservoir 38 is a tube 192 which provides communication between passage 188 and the air space between the oil level and cap 184. In this manner, pressure differential between crankcase interior 182 and reservoir 38 is eliminated. Consequently, super-atmospheric pressure induced in crankcase 36 by low pressure tank 16 is prevented from leaking to atmosphere through the lubricating system, while at the same time the normal operation of the gravity feed is not impaired. As a result, the vehicle may remain inoperative for extended periods of time without loss of air pressure in low pressure tank 16. Although, as previously mentioned, the pressure equalizing feature of the invention offers singular advantages in connection with closed type air suspension systems, it will be evident that a compressor employing this feature will perform equally well in both open and closed systems.

From the foregoing it will be seen that a novel and improved air compressor has been devised. A compressor according to the present invention not only provides exceptional performance and durability, but in addition may be economically produced due to the successful elimination of auxiliary controls heretofore required, as well as substantial simplification of design. The significance of economy in connection with components intended for vehicle air suspension will be readily apparent even from casual consideration of the substantially greater overall cost and complexity of pneumatic suspension as compared with conventional suspension presently in use. While each of the numerous features described herein contributes substantially in simplifying and improving the mechanism, the advantages of the piston ring construction should be particularly noted. Tests have shown that the features embodied therein assure continued efficiency of compressor operation even under the most extreme altitude conditions encountered in vehicle operation, whereas compressors equipped with conventional ring construction display marked loss of efficiency under similar conditions. When considered together with such additional advantages as ability to withstand extreme temperatures and to function virtually without lubrication, it will be apparent that the significance of the ring construction cannot be overemphasized.

While but one embodiment of the invention has been shown and described, it will be apparent that numerous changes and modifications and variations may be made therein. It is, therefore, to be understood that it is not intended to limit the invention to the embodiment shown, but only by the scope of the claims which follow.

I claim:

1. In an air compressor, a unitary body comprising a cylinder housing, crankcase, and lubricant reservoir, a crankshaft support secured to said crankcase, a crankshaft journaled in said support, a piston movable in

said cylinder, a wrist pin for said piston, a connecting rod operatively connecting said crankshaft and said wrist pin, the crankshaft end of said connecting rod including an integral cap-like recessed portion surrounding said crank, an intake passage formed in said crankcase, an intake valve on said piston, an exhaust valve mounted on said cylinder housing, a cylinder head connected to said cylinder housing adjacent said exhaust valve, means forming a hollow space in said head, the hollow space being connected to said exhaust valve, an exhaust port formed in said head, means providing communication between said reservoir and the interior of said support for lubricating said crankshaft journal, additional means forming a lubricant passage in said crankshaft communicating with said connecting rod and said journal bearing, a lubricant passage in said connecting rod providing communication between said crankshaft and said wrist pin, a pair of lubricant seals disposed respectively at opposite ends of said crankshaft journal, a third lubricant seal disposed between said crankshaft and said connecting rod at the open end of the connecting rod recess, a fluid tight cover connected to said lubricant reservoir, and means for equalizing fluid pressure in said crankcase and said reservoir, said means comprising a passage providing direct communication between said crankcase and the space between said lubricant and the fluid tight cover for said reservoir.

2. In an air compressor, a unitary body comprising a cylinder housing, crankcase, and lubricant reservoir, means forming an opening in a side wall of said crankcase, a crankshaft support secured over the open side of said crankcase and forming a fluid tight juncture therewith, a crankshaft journaled in said support, a crank throw on said crankshaft, a piston movable in said cylinder, a wrist pin for said piston, a connecting rod operatively connecting said crank throw and said wrist pin, said connecting rod having an open ended bearing at its wrist pin end and a cap shaped bearing at its crank throw end, an intake passage formed in said crankcase, an intake valve on said piston, an exhaust valve mounted on said cylinder housing, a cylinder head connected to said cylinder housing adjacent said exhaust valve, an exhaust port formed in said head, a cavity in said head providing communication between said exhaust valve and said exhaust port, means providing communication between said reservoir and the interior of said support for lubricating said crankshaft journal, additional means forming a lubricant passage in said crankshaft communicating with said connecting rod and said crankshaft journal, a lubricant passage in said connecting rod providing communication between said crankshaft and said wrist pin, a pair of lubricant seals disposed respectively at opposite ends of said crankshaft journal, a third lubricant seal disposed between said crankshaft and said connecting rod, a fluid tight cover engaging said lubricant reservoir, and means for equalizing fluid pressure in said crankcase and said reservoir, said means comprising a passage providing direct communication between said crankcase and the space between said lubricant and the fluid tight cover for said reservoir.

3. In an air compressor, a unitary cylinder housing, crankcase, and lubricant reservoir including a permanently lubricated cylinder liner, said cylinder and lubricant reservoir each having an open end, means forming an opening in the side wall of said crankcase, a flanged annular support secured over the open side of said crankcase, means forming a fluid tight juncture between said flange and said crankcase, a crankshaft journaled in said support, anti-friction bearing means for said crankshaft carried by said support, a piston movable in said cylinder, said piston having a pair of self-lubricating piston rings mounted thereon, a wrist pin carried by said piston, a connecting rod having an integral socket operatively connected to said crankshaft and an integral sleeve operatively connected to said wrist pin, an intake

passage formed in a wall of said crankcase, a cantiliver intake valve mounted on said piston, a valve plate disposed over the open end of said cylinder housing, a cantiliver exhaust valve mounted on said plate, a cylinder had connected to said cylinder and overlying said valve plate, an exhaust passage formed in said head, a cavity in said head providing communication between said exhaust valve and said exhaust port, passage means providing communication between said reservoir and the interior of said support for lubricating said crankshaft journal, additional means forming a lubricant passage in said crankshaft communicating with said connecting rod, a lubricant passage in said connecting rod providing communication between said crankshaft and said wrist pin, a pair of lubricant seals disposed respectively at opposite ends of said crankshaft journal, a third lubricant seal disposed between said crankshaft and the open end of the integral socket on said connecting rod, a fluid tight cover for said lubricant reservoir, and means for equalizing fluid pressure in said crankcase and said reservoir, said means comprising a passage providing direct communication between said crankcase and the space between said lubricant and the fluid tight cover for said reservoir.

4. The structure defined in claim 3 wherein said anti-friction bearing means includes a ball bearing assembly adapted to carry both radial and thrust loads.

5. The structure set forth in claim 3 wherein said cylinder liner is permanently lubricated with high temperature grease.

6. The structure set forth in claim 3 wherein said cylinder liner is formed of sintered iron impregnated with high temperature grease.

7. In an air compressor including a reciprocable piston and a crankshaft, a connecting rod, a cup-shaped bearing formed at one end of said connecting rod, a crank throw on said crankshaft extending into said bearing, a gravity feed lubrication system for said bearing comprising a reservoir communicating with a lubricant passage formed in said crankshaft, said lubricant passage in-

cluding a portion opening into the peripheral space between said crank throw and bearing, and an annular seal carried by said bearing adapted to prevent leakage of lubricant out of the open end thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

825,973	Miles	July 17, 1906
1,295,491	Hazard	Feb. 25, 1919
1,311,693	Hazard	July 29, 1919
1,470,548	Spohrer	Oct. 9, 1923
1,578,880	De Luiz	Mar. 30, 1926
1,717,847	Little	June 18, 1929
1,738,560	Brewer	Dec. 10, 1929
1,910,902	McKone	May 23, 1933
1,942,182	Moorhouse	Jan. 2, 1934
1,947,023	Shoemaker	Feb. 13, 1934
2,136,097	Browne	Nov. 8, 1938
2,197,256	Kucera	Apr. 16, 1940
2,229,054	Dick	Jan. 21, 1941
2,265,971	Paul et al.	Dec. 9, 1941
2,280,296	Mantle	Apr. 21, 1942
2,382,006	Dusevoir	Aug. 14, 1945
2,417,197	Hewitt et al.	Mar. 11, 1947
2,525,054	Voss	Oct. 10, 1950
2,587,405	Stevens et al.	Feb. 26, 1952
2,595,738	Walker	May 6, 1952
2,607,644	Smith et al.	Aug. 19, 1952
2,622,792	Ramclow	Dec. 23, 1952
2,660,459	Collins	Nov. 24, 1953
2,666,678	Carney	Jan. 19, 1954
2,678,609	Ashton	May 18, 1954
2,705,177	Waring	Mar. 29, 1955
2,738,687	Meile	Mar. 20, 1956
2,751,146	Moseley	June 19, 1956
2,753,014	Baudin	July 3, 1956
2,757,376	Brueder	July 31, 1956
2,762,633	Gouirand	Sept. 11, 1956