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(54) Antisuckback device for rotary piston pumps.

(57) A rotary piston vacuum pump is provided with an oil pump in the lubricating oil circuit, a pressure relief vent connected to the pumping chamber from a higher pressure source, and biased valve connected between the oil pump and the oil circuit as well as between the pressure relief vent and the first pumping chamber for controlling the flow of oil and pressure, respectively. The oil pump pressurizes the oil in the oil lubrication circuit as a function of vacuum pump operation. The valve is responsive to the oil pressure created by the oil pump. The valve is actuated to maintain the free flow of oil from the oil pump to the oil circuit when the pump is operating. When the pump is shut-off, the bias of the valve shuts off the flow of oil through the oil circuit and opens the connection between the pressure relief vent and the first pumping chamber to increase the pressure in the latter such that lubricating oil is not drawn into that pumping chamber. This increased pressure from the pressure relief vent actuates an inlet shut-off valve which isolates the first pressure chamber from the operating chamber.

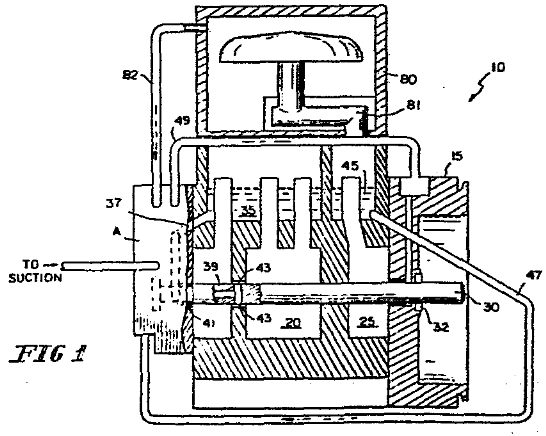

FIG 1

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ANTISUCKBACK DEVICE FOR ROTARY PISTON PUMPS

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates generally to rotary piston vacuum pumps and, more particularly, to such pumps having antisuckback features which cut off the flow of lubricant into the stopped pump.

In rotary mechanical vacuum pumps oil flow about working elements thereof serves to lubricate and provide clearance sealant between elements. In such rotary vacuum pumps without forced oil circulation, the quantity of oil flow from the oil reservoir to the internal pump mechanism is largely a function of the pressure differential between these two areas. Maximum oil flow circulation occurs when the oil reservoir is at its normal atmospheric pressure and the pump is operating at its lowest pump inlet absolute pressure. At higher suction pressures, the oil flow is reduced; indeed, in the inlet pressure range over 500 mmHga, there is no appreciable oil flow into the pump mechanism. Thus, operating time in this pressure range must be limited. Extended operation without oil flow will cause poor lubrication and overheating and can lead to pump failure.

To solve this problem and provide for extended operation time over a wide pressure range, an oil pump may be added in the oil circuit of a mechanical vacuum pump to provide a forced oil flow throughout the operating pressure range of the vacuum pump. In a compound (two stage) mechanical vacuum pump, the oil pump is typically added in the oil circuit of the second or roughing stage, while the first or high vacuum stage oil flow is induced by the small pressure differential and gravity. Further, interstage degassed oil is typically recirculated in a separate and independent oil circuit through the first stage pumping chamber because atmospheric pressure oil often contains air which, if released in the first stage, would drastically decrease net pump capacity.

When the vacuum pump operation ceases, each pumping chamber therein may be at a different pressure. For example, in a two stage rotary piston pump the first stage, being in communication with the operating chamber or chamber being evacuated at the pump inlet, is at a relatively low pressure as compared with the pressure in the second stage, being in communication with the pump outlet through the discharge separator. The presence of this differential pressure between pumping chambers often results in the lubricating and sealing oil seeping or flowing back between working elements into the first pumping chamber. In vacuum pumps employing independent oil circuits, this seepage or back flow typically contaminates the degassed oil supply as well as the operating chamber. Further, even if the differential pressure between chambers is not sufficient to cause oil flow between chambers, if the vacuum pump is stopped at low pumping chamber pressures, oil in the lubrication circuit for that pumping chamber may also draw back into the pumping chamber. This often results, again, in pumping chamber flooding and operating chamber contamination.

Prior vacuum pumps have been equipped with devices to stop the oil flow into the pumping chambers or stages when the vacuum pump is stopped under vacuum or low pressure conditions in the pumping chamber. These devices attempt to avoid flooding the pump chamber and, in turn, oil flowing back through the pump inlet system and to contaminate any operating chamber attached thereto. By preventing oil flooding of the pump, problems associated with starting of a flooded pump are also eliminated. The method and/or device for preventing flow of oil back into the inlet system is typically called an "antisuckback" device. Previous oil backflow prevention devices have included solenoid valves or centrifugally operated mechanisms having, for example, resilient elastomer plunger seals which shut-off oil flow into the stopped pump. However, these devices are relatively expensive and may lack a high level of responsiveness to sudden changes in pump operation. These so-called antisuckback devices are commonly incorporated in oil sealed rotary vane vacuum pumps.

Another technique to prevent oil suckback into the vacuum system has been to use an inlet line isolation valve. This valve is closed before stopping the vacuum pump and a small solenoid valve, located at the pump suction side of the isolation valve and electrically connected to the pump motor, will open and admit atmospheric air or, if necessary, discharged gas from the air/oil separator housing to the pump interior when the pump is stopped. This method, however, does not completely prevent flooding of the pump cylinder and some sort of oil line shut-off device is still desirable. Further, it is also often necessary to provide elaborate sealing means in order to prevent air leakage along this inlet line when the isolation valve is closed.

For some applications these previous antisuckback techniques perform adequately even if some small amount of oil does leak back. However, in manufacturing semiconductor chips and microprocessor devices, vacuum pumps are often required to achieve very low pressures (on the order of .5 to 1.5 mmHga) and remain completely uncontaminated by oil back flow through the vacuum pump inlet and into the semiconductor operating chambers.

Thus, the need has arisen for an inexpensive, highly reliable antisuckback device.

It is therefore an object of the present invention to provide an inexpensive, highly reliable antisuckback device for vacuum pumps.

Another object is the provision of improved antisuckback devices for rotary piston pumps having hydraulically actuated control valves for simultaneously controlling lubricant flow and pumping chamber pressure relief.

A further object is to provide an improved, hydraulically controlled antisuckback device for compound or multi-stage vacuum pumps.

Still another object is the provision of a means of achieving pressure equalization in the pump chamber after stopping the vacuum pump and further preventing backflow of lubricant thereto by means of a highly responsive shut-off valve in the lubricant flow path.

These and other objects of the present invention are achieved by the provision, in a rotary piston vacuum pump, of an oil pump in the lubricating oil circuit, a pressure relief vent connected to the pumping chamber from a higher pressure source, and biased valve connected between the oil pump and the oil circuit as well as between the pressure relief vent and the first pumping chamber for controlling the flow of oil and pressure, respectively. The oil pump pressurizes the oil in the oil lubrication circuit as a function of vacuum pump operation. The valve is responsive to the oil pressure created by the oil pump. The valve is actuated to maintain the free flow of oil from the oil pump to the oil circuit when the vacuum pump is operating. When the vacuum pump is shut-off, the bias of the valve shuts off the flow of oil through the oil circuit and opens the connection between the pressure relief vent and the first pumping chamber to increase the pressure in the latter such that lubricating oil is not drawn into that pumping chamber. This increased pressure from the pressure relief vent actuates an inlet shut-off valve which isolates the first pressure chamber from the operating chamber.

In multistage rotary vacuum pumps with several independent oil circuits, the valve arrangement of the present invention can simultaneously control oil flow in a plurality of those oil circuits. Pressurized oil from a single oil circuit provides the control signal to actuate the valve arrangement. Thus, only that oil circuit requires an oil pump. The pressure relief vent, connected to at least the first pumping chamber, is also controlled by the valve arrangement. The valve arrangement may include either a single slide valve intersecting each oil circuit and pressure relief path to the pumping chambers or multiple slide valves each intersecting one or more oil circuit and/or pressure relief paths. When the vacuum pump stops, the valve arrangement responds to the oil pressure drop in the oil circuit providing its control signal to prevent oil flow to at least the first pumping chamber and simultaneously permit pressure relief to that pumping chamber.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial cross-sectional view along the drive shaft of a vacuum pump embodying the present invention.

Figure 2 is a partial cross-sectional view coplanar with and enlarging a portion of Figure 1 showing specific features of the antisuckback device according to the present invention when the vacuum pump is operating.

Figure 3 is a partial cross-sectional view of the same portion shown in Figure 2 when the vacuum pump has been stopped.

Figure 4 is a partial cross-sectional view of another vacuum pump showing an alternative embodiment of the present invention when the vacuum pump is in operation.

Figure 5 shows a partial cross-sectional view of the same portion of the pump shown in Figure 4 when vacuum pump operation has been stopped.

For comparative purposes, it should be noted that the cross-sectional views of Figures 4 and 5 are on planes generally perpendicular to the planes of the cross-sectional views of Figures 1, 2 and 3.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1, which illustrates a preferred embodiment of the present invention, shows a partial cross-sectional view of a two-stage rotary vacuum pump 10 having a housing 15 with first and second pumping chambers 20 and 25, respectively, therein. Drive shaft 30 is mounted through first and second pumping chambers 20 and 25, and is supported by housing 15.

First and second pumping chambers 20 and 25 are each provided with an independent oil circuit to lubricate operating elements within that chamber and seal clearances between relatively moving members. With respect to first pumping chamber 20, the oil circuit employs degassed oil from reservoir 35. Degassed oil flows out of reservoir 35 along line 37 to valve member 50 (shown in Figures 2 and 3 and discussed in detail herein below) at portion A. From there degassed fluid flow continues to line 41 directly to first pumping chamber 20 or to line 39 within drive shaft 30 to outlet ports 43 within first pumping chamber 20. The rotating and reciprocating action of the piston pump (not shown) of first pumping chamber 20 results in the return flow of degassed oil to reservoir 35.

The oil circuit of second pumping chamber 25 includes oil reservoir 45. Oil flows from that reservoir through line 47 and then to valve 50 at portion A. Oil flow returns along line 49 from valve 50 to drive shaft 30 at bearing 32. Oil flows along drive shaft 30 to second pumping chamber 25 and is carried by pumping action therein to reservoir 45 and, through conduit 81, to discharge separator 80. Discharge separator 80 passes the vacuum pump working fluid, typically air, to the vacuum pump atmospheric outlet (not shown) and returns oil carried thereby to reservoir 45 through conduit 81. Discharge separator 80 is also provided with a pressure relief vent line 82 for providing a flow of working fluid back to valve 50.

Briefly, the present invention provides means for preventing excess oil flow into the pumping chambers when the vacuum pump has been stopped. This is accomplished by a hydraulically responsive valve arrangement which both interrupts the oil circuit and equalizes the pressures within the pumping chambers when vacuum pump operation ceases. More specifically, in the exemplary two stage vacuum pump 10 of Figure 1, oil from both reservoirs 35 and 45 is prevented from flowing into first and second pumping chambers 20 and 25 when hydraulic control signals to valve 50 indicate the vacuum pump has stopped. At the same time, valve 50 permits the flow of discharged working fluid through line 82 to first pumping chamber 20 to provide pressure relief. Thus, when the vacuum pump has stopped, valve 50 permits pressure equalization between first and second pumping chambers 20 and 25, respectively. The hydraulic control signals applied to valve 50 result from pressurization of oil by oil pump 70 from reservoir 45 only. Oil pump 70 operates in response to operation of vacuum pump 10.

By simultaneously cutting off oil circulation in both oil circuits and equalizing the pressure in pumping chambers 20 and 25, oil is prevented from flowing into those chambers, from both the oil supply of each pumping chamber and the oil supply of the adjacent pumping chamber, when operation of vacuum pump 10 is stopped. Using oil pressure to provide the hydraulic control signals of the present invention assures quick and accurate responsiveness of valve 50 to the cessation of operation of vacuum pump 10.

Figure 2 shows a partial cross-sectional view enlarging that portion of Figure 1 designated by "A". The position of valve 50 in Figure 2 is shown for when vacuum pump 10 is operating. This figure may be compared with a similar cross-sectional view of Figure 3, illustrating the position of valve 50 when the vacuum pump has been stopped.

As shown in Figure 2, valve 50 is, for example, a slide valve movable along bore 56, biased upwardly by spring 52. Valve 50 is actuated downwardly by oil pressure in bore chamber 54 to oppose the spring bias of spring 52. An oil pump 70 is provided as, for example, a gear pump driven by extension 72 of drive shaft 30 past sealing means 34 and having gear members 74. Oil from reservoir 45 incoming on line 47 is pressurized by the pumping action of oil pump 70, and, when vacuum pump 10 is in operation, then flows along line 76 to sealing line 78 and input line 62 to bore chamber 54 of valve 50.

Degassed oil from reservoir 35 flows along line 37 to valve 50 and is not subject to pumping pressurization. This degassed oil flows through the degassed oil circuit only as a result of gravitational and pressure differential forces. Incoming degassed oil on line 37 passes through control valve 50 along line 58 when vacuum pump 10 is operating. Degassed oil from line 58 exits bore 56 to input ports 36 of drive shaft 30. This oil then flows along line 39 within drive shaft 30 to outlet ports 43 or along line 41 directly to first pumping chamber 20.

Pressure relief vent line 82 from discharge separator 80 reaches valve 50 through line 64. Line 68 communicates with pumping chamber 20. During operation of vacuum pump 10, valve 50 blocks communication between lines 64 and 68. Pressurized oil from line 78 forms an oil seal at recess 60 on valve 50 between lines 64 and 68 to prevent leakage to first pumping chamber 20 from pressure relief line 82.

When vacuum pump 10 is operating, drive shaft 30 drives oil pump 70 to pressurize the oil in the oil circuit of second pumping chamber 25. When vacuum pump 10 is not operating, oil pump 70 is not operating and does not pressurize that oil and, thus, oil pressure in chamber 54 does not overcome the spring bias of spring 52. Valve 50 will then move upwardly into bore chamber 54, as illustrated in Figure 3.

When valve 50 moves upwardly past the inlet to line 49, oil flow from reservoir 45 and line 62 to line 49 back to second pumping chamber 25 will be restricted and cut off. Simultaneously, the inlet to line 58 will move upwardly past the outlet of line 37 and oil flow from reservoir 35 and line 37 to lines 39 and 41 back to first pumping chamber 20 will be restricted and cut off. This same upward movement of valve 50 will cause the outlet of line 64 to align with the inlet of line 66 and, simultaneously, the outlet of line 66 to align with the inlet of line 68, permitting pressure relief to flow from discharge separator 80 to first pumping chamber 20. Thus, as valve 50 cuts off oil flow in both of the oil circuits to pumping chambers 20 and 25, it opens up pressure relief flow to increase the pressure in first pumping chamber 20 and equalize the pressure between pumping chambers 20 and 25. By this arrangement oil flowback or seepage into either of the pumping chambers from either or both oil circuits is prevented when vacuum pump 10 is not operating.

When vacuum pump 10 resumes operation, oil pump 70 also resumes operation and will again pressurize oil in chamber 54. This causes valve 50 to move downwardly from bore chamber 54 against the bias of spring 52. Thereby, oil flow between lines 62 and 49 to second pumping chamber 25 and between lines 37, 58, and 39 and 41 to first pumping chamber 20 is permitted. Simultaneously, communication between lines 64, 66 and 68 from discharge separator 80 to first pumping chamber 20 is restricted and cut off. Likewise, high pressure oil communication from line 78 will be resumed with recess 60 and, thus, the oil seal between lines 64 and 68 will be reestablished when vacuum pump 10 resumes operation.

Figures 4 and 5 show partial cross-sectional views of another rotary piston vacuum pump 110 having therein an alternative embodiment of the present invention. Figure 4 shows the location of the various antisuckback elements of the present invention when vacuum pump 110 is in operation. Figure 5 shows the location of the same elements when vacuum pump 110 has been stopped. In comparison with Figures 1, 2 and 3, Figures 4 and 5 are cross-sectional views along planes generally perpendicular to the view of Figures 1, 2 and 3. Again, vacuum pump 110 may be a two chamber pump having separate oil circuits for each chamber and be similar to vacuum pump 10 in all other respects except those shown and described herein with respect to Figures 4 and 5.

As illustrated in Figures 4 and 5, vacuum pump 110 includes housing 115, discharge separator 180, and first and second pumping chambers (not shown). Each pumping chamber includes an oil circuit associated therewith as in the embodiment of Figure 1. Each oil circuit includes an oil reservoir and oil lines extending to and from the antisuckback features of the present invention shown in Figures 4 and 5.

This embodiment also provides antisuckback capabilities. Instead of controlling oil circuit flow to both pumping chambers and pressure relief and equalization between pumping chambers by a single valve, vacuum pump 110 includes a plurality of valves. Valve 250 controls pressure relief to the first pumping chamber and equalization of pressure between pumping chambers. This valve also controls the flow of control signal oil to valve 150 which controls the flow of lubricating oil in both of the independent lubricating oil circuits Again, the valves are hydraulically actuated by oil. pressure from an oil pump responsive to operation of vacuum pump 110.

Valves 150 and 250 are, for example, biased by springs 152 and 252 and slidably disposed in bores 156 and 256, respectively. Bore chambers 154 and 254 are provided at the end of valves 150 and 250 which are opposite from springs 152 and 252, respectively. Thus, pressurized oil supplied to bore chambers 154 and 254 may overcome the biasing effect of springs 152 and 252, respectively, and cause valves 150 and 250 to be activated.

Oil from the second pumping chamber flows through line 147 to oil pump 170 having pump gears 174. Oil pump 170 supplies pressurized oil along line 176 to bore chamber 254 of valve 250. Valve 250 is biased downwardly toward bore chamber 254 by spring 252. As shown in Figure 4, when vacuum pump 110 is operating, oil pump 170 supplies an oil pressure to bore chamber 254 which exceeds the biasing force of spring 252 and causes valve 250 to slide upwardly out of bore chamber 254, permitting oil flow to line 162 and then to bore chamber 154.

Valve 250 includes valve element 255 at the end opposite bore chamber 254. Bore 256 includes valve seat 257 about the outlet of line 164 to valve 250. Bore 256 also includes outlet port 258 through a side wall of bore 256. Valve 250, for example, is illustrated as having a hollow portion interiorly of valve element 255. Line 164 receives pressure relief from discharge separator 180 along pressure relief vent 182. As shown in Figure 4, when valve 250 is forced up out of bore chamber 254 by oil pressure, valve element 255 covers the outlet of line 164 and seats against valve seat 257 to cut off pressure relief air flow through line 164 past valve element 255 and through outlet port 258 to line 168 and to the first pumping chamber. The pressure relief path to the first pumping chamber extends through a portion of bore 254 and then through outlet port 258 to line 168 to inlet shut-off valve 220. The pressure relief path continues past valve 220 and into first pumping chamber inlet 240. However, when vacuum pump 110 is operating, inlet shut-off valve 220 rests against stop 222, at least partially blocking this relief pressure path.

When oil pressure causes valve 250 to move out of bore chamber 254, communication with line 162 is opened up and oil flows along line 162 to bore chamber 154 of valve 150. Valve 150 is biased upwardly toward bore chamber 154 by spring 152. As in valve 50 of Figures 2 and 3, valve 150 includes central degassed oil line 158 which may be aligned with lines 137 and 161 to permit degassed oil flow therethrough from the degassed oil reservoir of the first pumping chamber (not shown) to the first pumping chamber, through interior line 139 of the drive shaft (not shown). This alignment will result when vacuum pump 110 is operating and oil pressure in bore chamber 154 from line 176, bore 254, and line 162 causes valve 150 to slide downwardly in bore 165 to overcome the bias of spring 152, as shown in Figure 4. At the same time, valve 150 opens up communication with line 149, leading to the second pumping chamber (not shown), such that oil from line 162 may flow through bore chamber 154 to line 149 and the second pumping chamber.

Therefore, when vacuum pump 110 is in operation, oil pump 170 is supplying pressurized oil to bore chambers 254 and 154, sequentially in the oil circuit of the second pumping chamber. This oil pressure causes valve

250 to cut off pressure relief from line 164 to the first pumping chamber by closing valve element 255 against valve seat 257 and opening inlet shut-off valve 220. Likewise, the oil pressure causes valve 150 to permit oil flow to lines 139 and 149 leading to first and second pumping chambers, respectively. Again, the oil pressure of only a single oil circuit (that of the second pumping chamber) is employed to provide hydraulic control signals actuating valve 150 to control oil flow through multiple oil circuits.

When, as illustrated in Figure 5, operation of vacuum pump 110 has ceased, oil pump 170 is also inoperative and does not supply pressurized oil flow through line 174 to valve 250 to overcome the spring bias of spring 252. Valve 250 then slides downwardly into bore chamber 254. Thus, valve element 255 disengages from valve seat 257 and permits pressure relief flow from discharge separator 180 through pressure relief vent line 182 and line 164 into bore 256 of valve 250 to line 168 and then to inlet shut-off valve 220.

The pressure from discharge separator 180 is typically at a higher pressure than the pressure within the first pumping chamber. Thus, as the air flow continues from valve 250 through line 168 to inlet shut-off valve 220, the differential pressure lifts inlet shut-off valve 220 off stop 222 and forces valve face 225 of inlet shut-off valve 220 to seat against inlet valve seal 230. This restricts pressure relief flow back through inlet filter 210 and vacuum pump inlet 200 to the operating chamber (not shown). As inlet shut-off valve 220 is so actuated, relief pressure flow follows the working fluid path of vacuum pump 110 through first pumping chamber inlet 240 to the first pumping chamber. This results in an increase of the pressure within that pumping chamber and creates a pressure equilibrium between the first and second pumping chambers.

When vacuum pump 110 is not operating, valve

250 cuts off the flow of oil from lines 147 and 176 to line 162 and bore chamber 154. Thus, pressurized oil is not available to act on valve 150 to overcome the bias of spring 152. Valve 150 then slides upwardly into bore chamber 154, restricting and cutting off oil flow between bore chamber 154 and line 149 to the second pumping chamber as well as between lines 137, 158 and 139 to the first pumping chamber. Thus, the supply of oil available to be drawn into the pumping chambers by either low pressure or pressure differential is restricted. In combination with pressure relief to eliminate low pressure and pressure differential conditions, no significant back flow or oil flooding will result.

Since, when vacuum pump 110 is not operating, oil back flow and flooding of pumping chambers is effectively prevented, contamination of the operating environment of the operating vacuum chamber is significantly reduced. Actuation of inlet shut-off valve 220 further assures that no such contamination will result from lubricating oil in vacuum pump 110. When vacuum pump 110 resumes operation, oil pump 170 will resume operation and again pressurize the oil flow to cause valve 250 to shut-off the pressure relief flow to inlet shut-off valve 220. As the pressure in the first pumping chamber drops, valve face 225 of inlet shut-off valve 220 will be unseated from valve seal 230 and drop to stop 222, permitting working fluid flow to resume from the operating vacuum chamber to pump 110.

Although the present invention has been described above with respect to oil flow and air pressure relief, it should be clearly understood that these embodiments are merely exemplary. The present invention contemplates the use of any other suitable lubricant besides oil to hydraulically actuate the valve arrangement controlling lubricant flow and pressure relief. Any other suitable fluid besides air, such as a chemically inert gas or liquid, may be employed for pressure relief to the pumping chambers when the vacuum pump is not operating. Also, the pressure relief vent need not be connected to the discharge separator. In some applications it may be permissible to have the pressure relief vent in communication with another pressure source. This other pressure source may, for example, be an air vent to atmospheric pressure. In some applications of the present invention a different fluid, besides expelled working fluid, may be employed for pressure relief.

Further, the pressure relief to the first pumping chamber need not be exactly equal to the pressure within the second pumping chamber. It is only necessary that this pressure relief be at least substantial. By this it is meant that the pressure relief should be at least sufficient to reduce the pressure differential, in combination with the lubricant flow restrictions, to prevent lubricant flow between pumping chambers and, in particular, into the first pumping chamber.

From the preceding description of the preferred embodiments, it is evident that the objects of the invention are attained, and although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation. The spirit and scope of the invention are to be limited only by the terms of the appended claims.

CLAIMS

1. A rotary piston vacuum pump having a housing with at least a first pumping chamber therein, a lubricant circuit for lubricating the working elements of said vacuum pump, and fluid lubricant in said lubricant circuit, characterized by:

lubricant pump means, connected in fluid communication with said lubricant circuit, for creating a lubricant pressure sufficient to cause said lubricant to flow through said lubricant circuit during operation of said lubricant pump, and said lubricant pump being responsive to said vacuum pump such that said lubricant pump operates only when said vacuum pump operates;

pressure relief means, in communication with said first pumping chamber, for supplying pressure to said first pumping chamber; and

valve means, connected between and in communication with said lubricant pump means and said lubricant circuit, and between and in communication with said pressure relief means and said first pumping chamber, for controlling the flow of said lubricant and pressure into said first pumping chamber, and said valve means being responsive to said lubricant pressure in said lubricant circuit created by operation of said lubricant pump to prevent backflow and seepage of said lubricant into said first pumping chamber when said vacuum pump is not operating by restricting lubricant flow and permitting pressure relief flow into said first pumping chamber.

2. The vacuum pump according to claim 1, characterized in that means are provided for interconnecting said lubricating pump and said working elements of said vacuum pump such that said lubricant pressure created by said lubricant pump in said lubricant circuit is a function of the operating speed of said vacuum pump.

3. The vacuum pump according to claim 1, character-

ized in that said valve means is responsive to the operation of said vacuum pump to permit the flow of lubricant to said lubricant circuit and prevent the flow of relief pressure to said first pumping chamber when said vacuum pump is operating.

4. The vacuum pump according to claim 1, characterized in that said valve means further includes means, in communication with said lubricant circuit, for establishing a lubricant seal about said valve means at that portion of said valve means which prevents flow from said pressure relief means to said first pumping chamber during vacuum pump operation.

5. The vacuum pump according to claim 1, characterized in that said valve means includes a first sliding valve element spring biased toward permitting the pressure from said pressure relief means to flow to said first pumping chamber, and a second sliding valve element spring biased toward restricting the flow of said lubricant from said lubricant pump means to said lubricant circuit, and in that both said first and second sliding valve elements are in communication with said oil circuit such that the spring bias of said first sliding valve element is overcome by said lubricant pressure to restrict pressure relief to said first pumping chamber and the spring bias of said second valve element is overcome by said lubricant pressure to permit lubricant flow through said lubricant circuit when said vacuum pump is operating.

6. The vacuum pump according to claim 5, characterized in that said first pumping chamber includes inlet means having shut-off valve means therein actuated to restrict working fluid flow into said first pumping chamber in response to operation of said first sliding valve element to permit pressure relief to said first pumping chamber.

7. The vacuum pump according to claim 5, characterized in that the spring bias of said first and second sliding valve elements are simultaneously overcome by the lubricant pressure, created by said lubricant pump means during operation

of said vacuum pump, to restrict pressure relief to said first pumping chamber and permit lubricant flow through said lubricant circuit.

8. The vacuum pump according to claim 1, further characterized by a second pumping chamber and separate lubricant circuits and separate supplies of fluid lubricant for each of said first and second lubricant circuits for lubrication of working elements in each of said first and second pumping chambers, and wherein said valve means is also in communication with the lubricant circuit associated with said second pumping chamber to control flow therethrough in response to operation of said vacuum pump.

9. The vacuum pump according to claim 8, characterized in that said lubricant pump means is provided in the lubricant circuit of said second pumping chamber and said valve means is responsive to lubricant pressure in this circuit to control lubricant flow and pressure relief to said first pumping chamber.

10. The rotary piston pump according to claim 8, characterized in that said pressure equalization means is in fluid communication with a pressure source for supplying fluid pressure to said first pumping chamber which is substantially equal to or greater than the fluid pressure within at least adjacent pumping chambers, such that the lubricant sealing the working elements between said first pumping chamber and said adjacent pumping chambers is not drawn into said first pumping chamber by the fluid pressure differential therebetween when said vacuum pump is not operating.

11. The rotary piston pump according to claim 8, characterized in that said pressure equalization means is in fluid communication with working fluid at atmospheric pressure such that said working fluid is supplied to said first pumping chamber when said vacuum pump is not operating.

12. The rotary piston pump according to claim 8, characterized in that said pressure equalization means is in communication with each of said pumping chambers for permitting the flow of pressure between said pumping chambers

to achieve at least substantial pressure equalization therebetween, and in that said valve means is in communication with said pressure equalization means and responsive to operation of said lubricant pump means such that said flow of pressure between said pumping chambers is restricted during operation of said vacuum pump and permitted when said vacuum pump is not operating.

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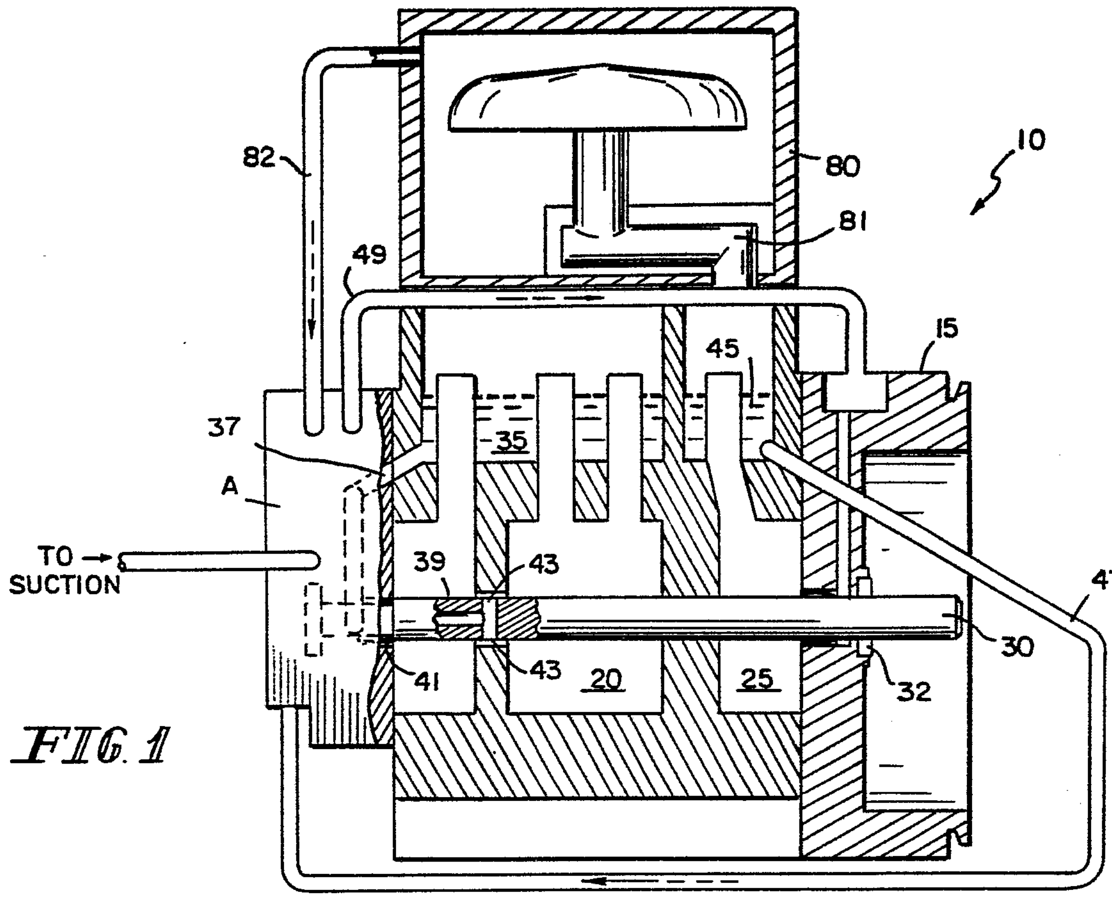

FIG. 1

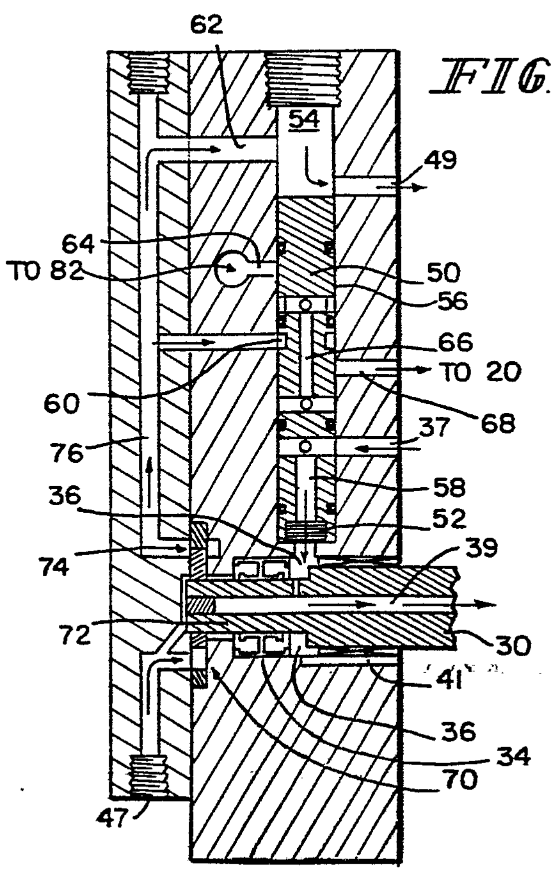

FIG. 2

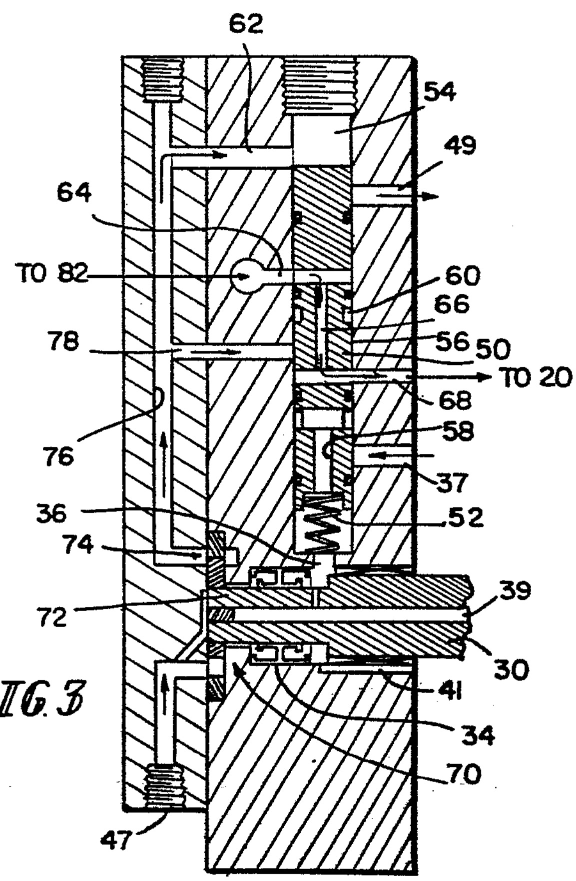

FIG. 3

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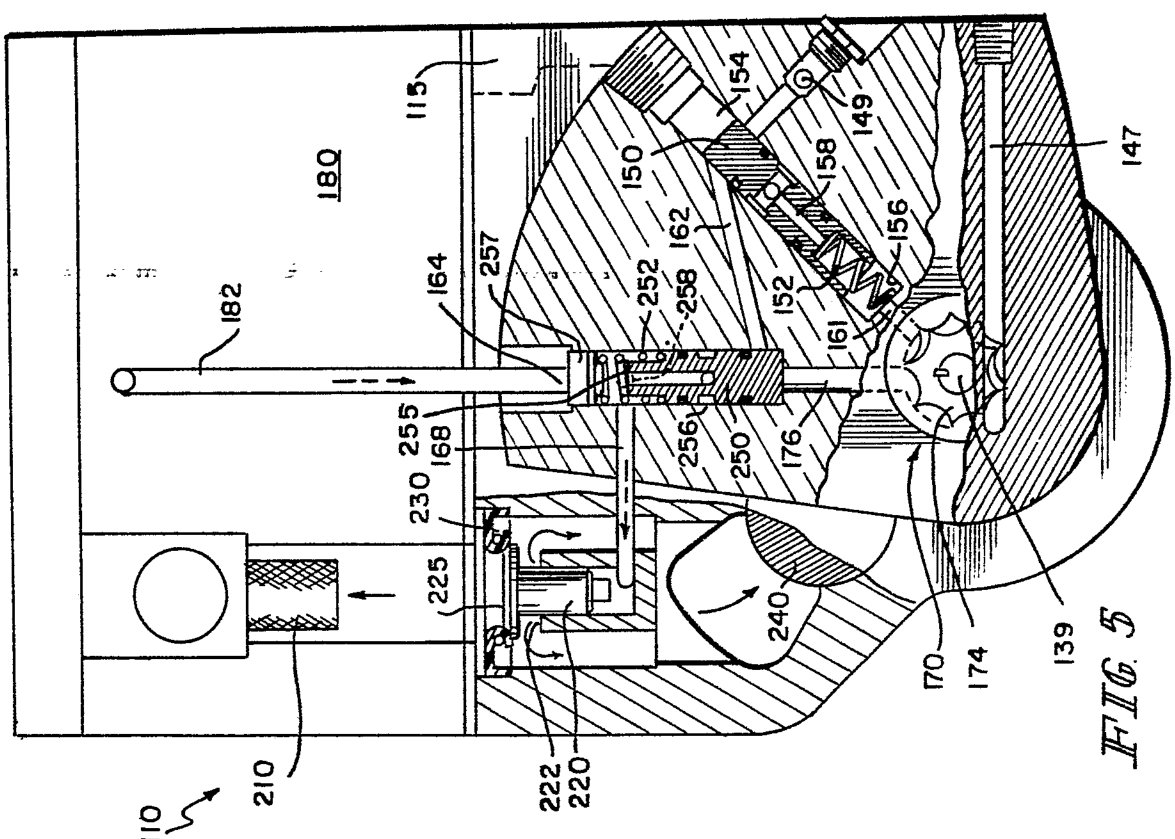

FIG 5

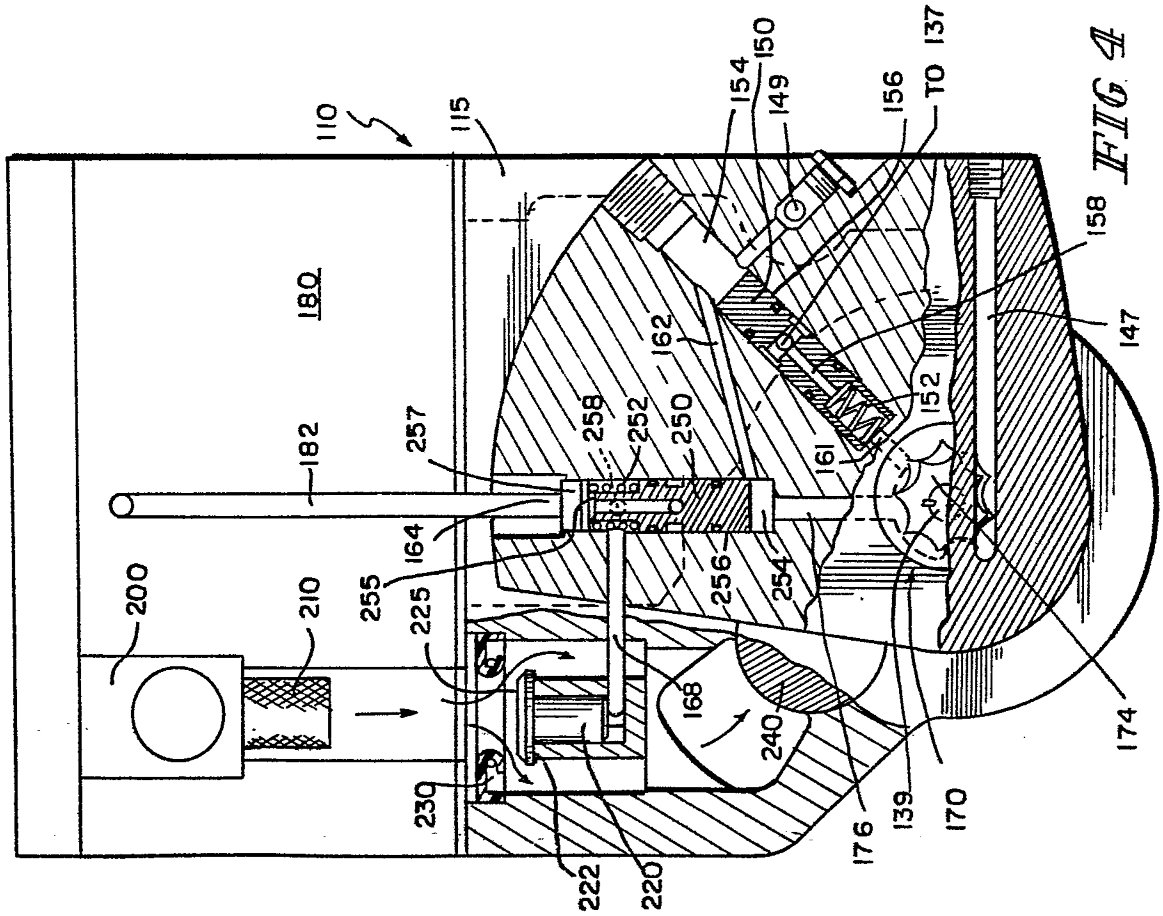

FIG 4