

Feb. 2, 1965

R. E. LAMBERTON ETAL

3,168,236

OIL SCAVENGING SYSTEM FOR A ROTARY COMPRESSOR

Filed Sept. 5, 1963

5 Sheets-Sheet 1

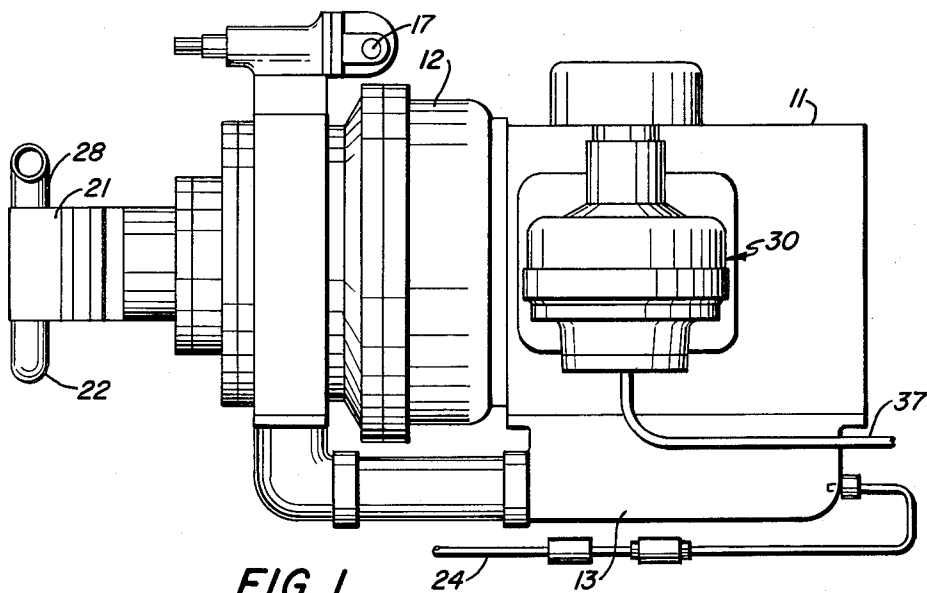


FIG. 1

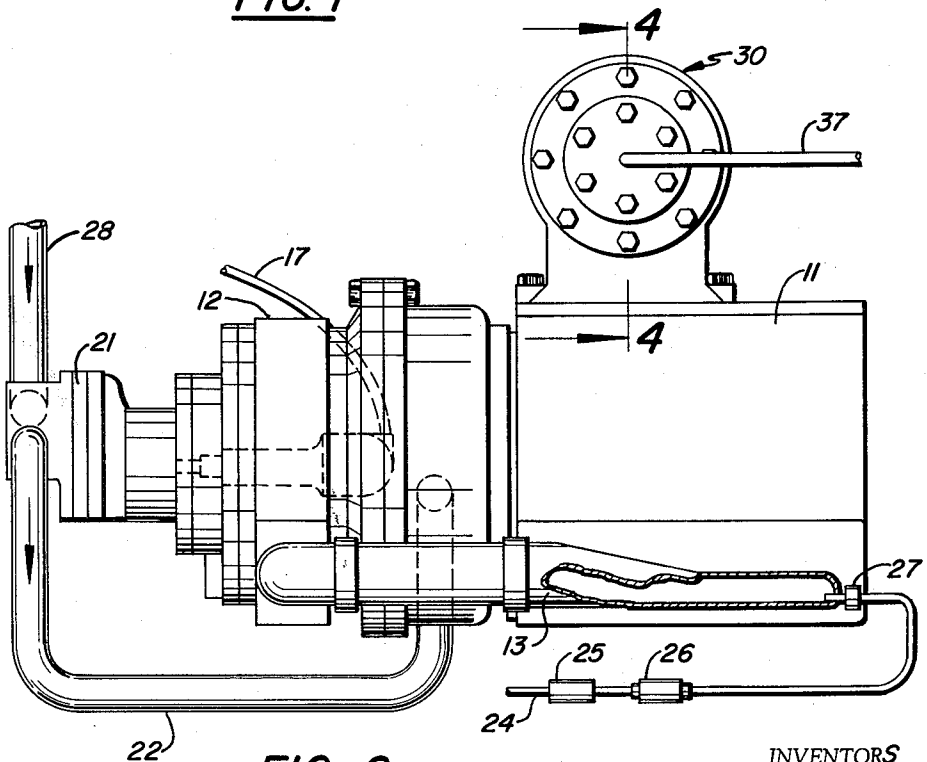


FIG. 2

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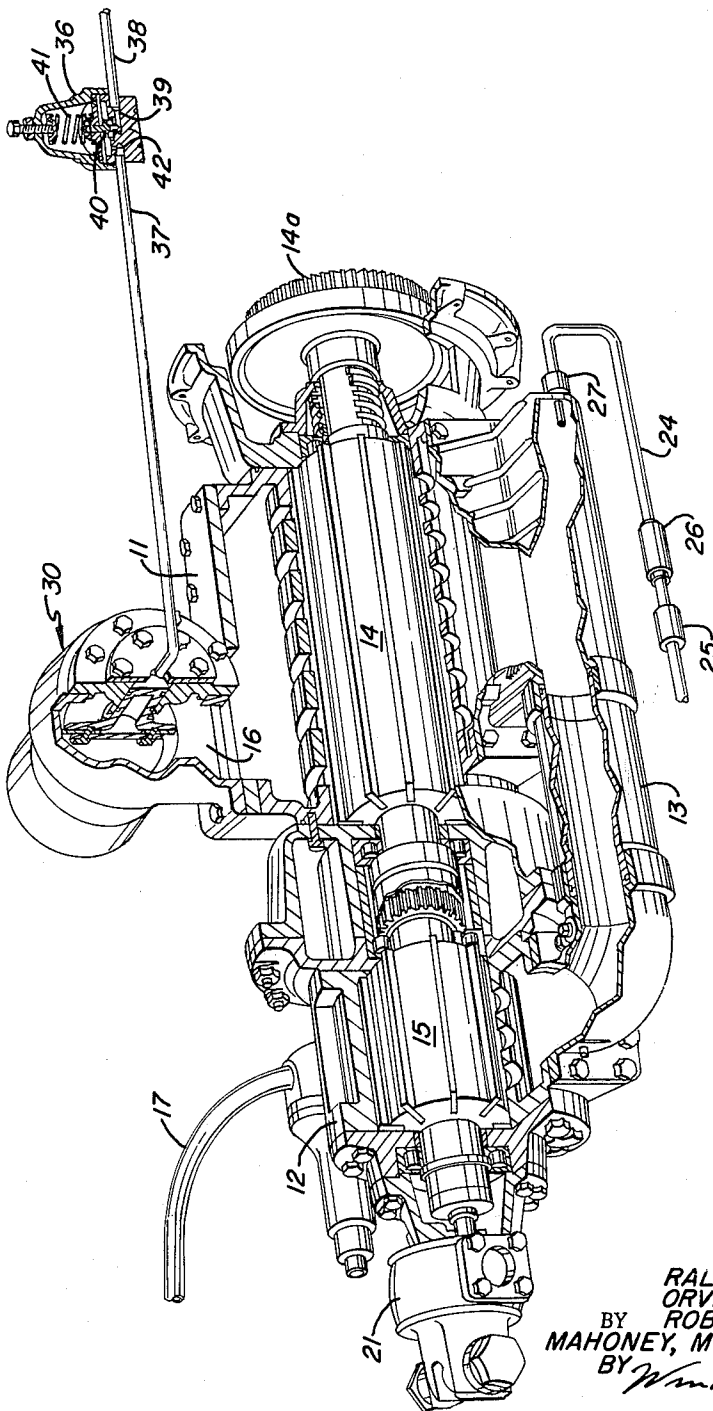
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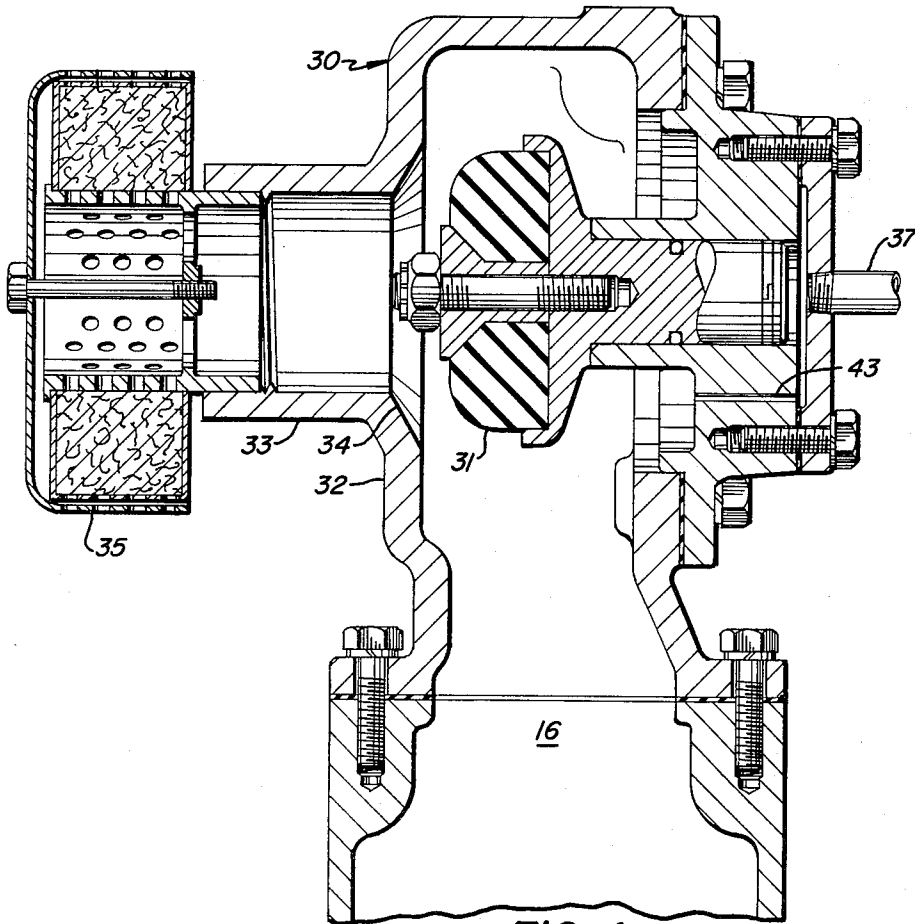


FIG. 4

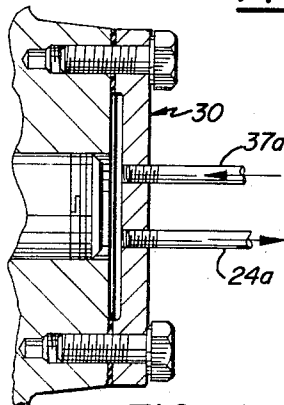


FIG. 4a

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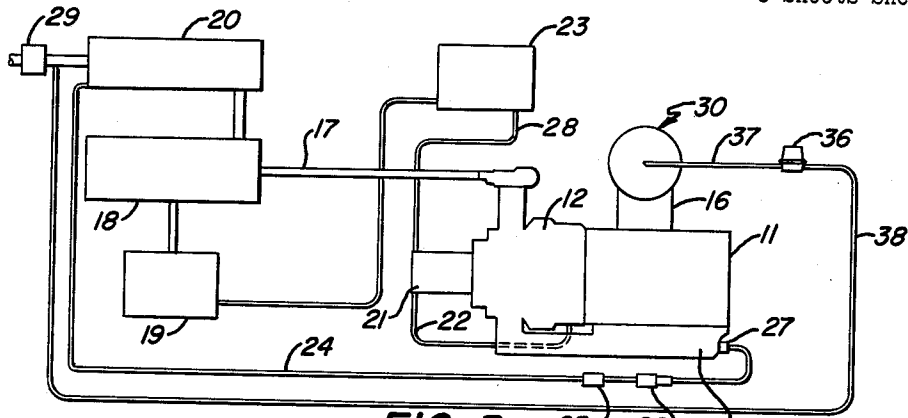


FIG. 5

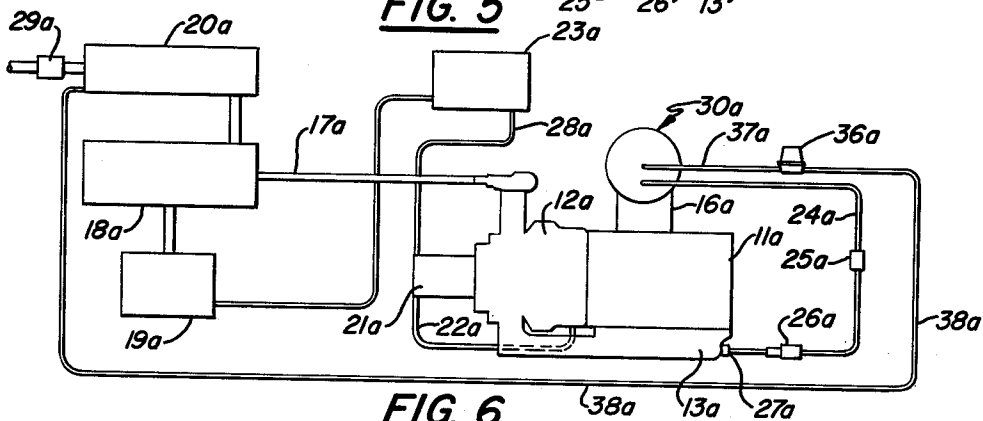


FIG. 6

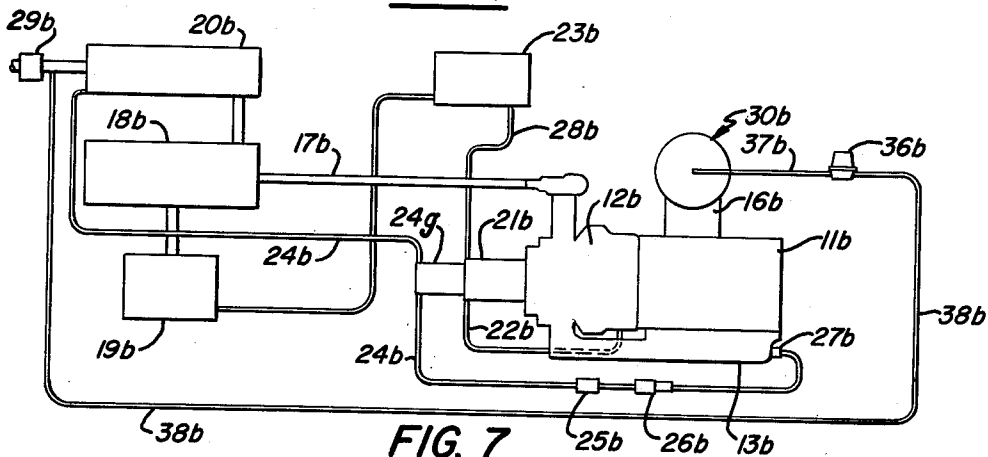


FIG. 7

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OIL SCAVENGING SYSTEM FOR A ROTARY COMPRESSOR

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Filed Sept. 5, 1963, Ser. No. 306,760
15 Claims. (Cl. 230—207)

Our invention relates to an oil scavenging system for a rotary compressor. It relates, more particularly, to an oil scavenging system for a multi-stage rotary compressor having an interstage manifold connecting the high-pressure and low-pressure cylinders and having an oil-supplying pressure system connected to the cylinders. The present invention constitutes an improvement over the oil-scavenging system disclosed and claimed in the patent to Lamberton No. 2,739,758, issued March 27, 1956.

According to the present invention, we provide a scavenging system, connected with the interstage manifold, for preventing the accumulation of an excessive amount of oil in the manifold, during unloaded periods, which might interfere with the proper operation of the compressor when again loaded and cause damage to parts of the compressor, such as to the rotor blades thereof. The scavenging system of this invention comprises means for creating a jet of fluid, either air, oil, or a mixture of oil and air, which is connected to the manifold and which jets the fluid through the manifold, during the unloaded cycle, in the direction of normal flow through the manifold thereby scavenging therefrom any oil tending to accumulate therein so as to prevent increase of the oil level therein to a dangerous extent. Thus, when the compressor is again loaded, there will be no accumulation of oil to interfere with proper operation of the compressor or cause damage to the rotor blades.

In the accompanying drawings, we have illustrated a preferred embodiment of our invention and in these drawings:

FIGURE 1 is a plan view of a two-stage compressor showing one scavenging system according to our invention applied thereto.

FIGURE 2 is a side elevational view, partly broken away, of the compressor with the scavenging system applied thereto.

FIGURE 3 is a broken away, perspective view illustrating the compressor cylinders and connected interstage manifold and the scavenging system of our invention associated therewith.

FIGURE 4 is an enlarged vertical sectional view, taken along line 4—4 of FIGURE 2, through the unloading valve of the compressor.

FIGURE 4a is a view similar to FIGURE 4 but showing a connection thereto of another scavenging system according to our invention.

FIGURE 5 is a schematic view of the scavenging system shown in FIGURES 1 to 3, and illustrating its connections to the compressor unit.

FIGURE 6 is a similar schematic view of another form of a scavenging system according to our invention connected to the unloader valve as in FIGURE 4a.

FIGURE 7 is a similar view of still another form of scavenging system according to our invention.

FIGURE 8 is a schematic view of an additional form of scavenging system embodying our invention.

FIGURE 9 is a schematic view of another variation of a scavenging system according to our invention.

As indicated previously, our invention is applicable to the type of rotary compressor illustrated in the patent to Lamberton No. 2,739,758, issued March 27, 1956. In

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that patent, an oil scavenging system is disclosed for a similar purpose but the present invention provides a number of improvements over that system. The present invention operates on a fluid-jet principle provided by proper connections in the system between a source of fluid under pressure, such as air, oil, or an air-oil mixture, and the interstage manifold to provide a jet of fluid through the manifold while the compressor is unloaded, in the direction of normal fluid flow through the manifold, to force therefrom any oil tending to accumulate therein and thereby prevent undue accumulation thereof during the unloaded period. This will prevent oil entering the high-pressure cylinder, upon loading of the compressor, in a volume or mass sufficient to completely or nearly fill the space between two vanes of the high-pressure rotor and thereby possibly damage it.

An example of a multi-stage rotary compressor of the type to which our invention is applicable is illustrated in the drawings. It is shown as being of the two-stage type and as including a low-pressure cylinder 11 and a high-pressure cylinder 12. These cylinders are shown connected together at their lower sides by an interstage manifold 13 so that the low-pressure air discharged from the cylinder 11 will be conducted into the cylinder 12 for further compression but it is possible to have the manifold built-in into the cylinders.

The low-pressure cylinder 11 (FIGURE 3) houses the rotor 14 which is driven from a suitable engine (not shown) coupled to the rotor-driving gear 14a. The rotor 14 is coupled to and drives the rotor 15 which is housed in the high-pressure cylinder 12. The low-pressure cylinder is provided with the valve-controlled air inlet 16. The high-pressure cylinder 12 is provided with a discharge outlet which connects by a discharge line 17 to the air-receiver 18 (FIGURE 5) of the compressor. This air-receiver 18 will have the usual oil reservoir tank 19 and oil separator 20 connected thereto.

When the compressor is operating, air is drawn into the low-pressure cylinder 11 through the air inlet 16. After compression in the low-pressure cylinder 11, the air is forced through the manifold 13 to the high-pressure cylinder 12. The air is further compressed in this high-pressure cylinder and is then discharged through the line 17 into the air-receiver tank 18.

To provide lubrication and cooling for the cylinders 11 and 12, oil is pumped into the respective cylinders in the usual way. This oil may be supplied by a lubricating pump 21 which is coupled to the high-pressure rotor 15 so that it is driven thereby. This pump may be an oil-gear type or any other suitable type. The oil supplied from the discharge line 22 of the pump to the various parts by the pressure systems serves as a lubricant, a sealing agent, and for cooling. The oil supplied to the low-pressure cylinder 11 passes therefrom, with the air compressed therein, through the interstage manifold 13 to the high-pressure cylinder 12. This air, bearing a supply of oil, is further compressed in the cylinder 12 and is discharged through the line 17 into the air-receiver 18. Thus, substantially all oil supplied to each cylinder 11 and 12 is carried along by the velocity of the air.

Most of the oil supplied to the air receiver is collected in the oil tank 19 connected thereto and is returned to the pump 21 through the line 28 after passing through the oil cooler 23. Any oil vapors in the compressed air are collected in the oil separator 20 and will be returned under pressure with air through a bleed line 24 to the interstage manifold 13 in a novel manner according to our invention to scavenge oil from the manifold during the unloaded state of the compressor. This line 24 is provided with a filter 25, a check valve 26, which will close upon the creation of sufficient positive pressure in

the manifold 13, and a choke 27 to provide a restricted jet or stream of fluid into the upstream end of the manifold to prevent the accumulation of oil in the manifold.

The compressor air inlet 16 is controlled by a common type of unloading valve unit 30, a suitable valve unit being illustrated in FIGURE 4. It comprises a piston-type valve member 31 which is pressure-actuated. This valve member 31 is disposed in a housing 32 mounted on the low-pressure cylinder 11 over the inlet 16 and communicating therewith. The housing is provided with an inlet collar portion 33 leading thereinto and having a valve seat 34 at its inner end with which the valve member 31 cooperates. On the outer end of the inlet collar portion 33, a filter unit 35 is mounted. Atmospheric air will be drawn through the filter unit 35 and be filtered before it enters the housing 32 through the inlet collar portion 33. Air for operating the valve 30 will be supplied when a predetermined pressure is reached in the receiver side of the compressor through a pressure-relief valve 36 which is connected thereto by a line 37. The valve 36 is connected to the receiver side of the compressor by a line 38 which, in the example shown, is connected to the air service outlet line between the discharge end of the separator 20 and a check valve 29 in that line, as shown in FIGURE 5. The valve 36 may take various forms but a suitable type is shown in FIGURE 3. The inlet line 38 leads into an inlet passage 39 which is controlled by a diaphragm-carried, semi-spherical valve member 40 normally held on its seat by an adjustable spring 41. An outlet passage 42 leads from the valve into the line 37. When receiver pressure, exerted through the separator 20, reaches a predetermined extent, the valve member 40 is unseated and the air under pressure reaches the line 37 through the outlet 42. This pressure will seat the unloading valve member 31 and the valve 36 may be adjusted to vary the actuating pressure. A vent 43 allows some of the air to escape from the inlet valve piston chamber as closing pressure is supplied in order to modulate the closing movement.

During the normal operation of the compressor, the oil passing from the low-pressure cylinder 11 with the air will pass into the high-pressure cylinder 12 and out to the air receiver 18. During both the loaded and unloaded states of the compressor, the interstage manifold 13 will be at a much lower pressure than the oil separator 20. While the compressor is loaded, the oil passing from the low-pressure cylinder 11 with the air will pass into the high-pressure cylinder 12 and out to the air receiver 18. The compressed air flows from the receiver 18 into the separator 20 and any oil vapors remaining in the air are retained in the filtering elements in the oil separator and are passed from the separator into the drain line 24. The check valve 26 in the line 24 will prevent oil from being forced back up into the separator when the compressor is started. As soon, after starting of the compressor, as air pressure in the discharge end of the oil separator 20 exceeds the pressure in the manifold 13, any oil collected by the oil separator 20 will be forced into the manifold. The main stream of oil and air, as indicated, during loaded operation of the compressor will flow through the manifold 13 and there will be no tendency for oil to accumulate therein at this time. The oil and air returned from the discharge end of the separator 20 by the line 24 will merely be added to that main stream. However, the connection of the line 24 to the interstage manifold 13 according to our invention, will prevent the accumulation of oil in the manifold when the compressor is running unloaded at which time there is a tendency for oil to accumulate in the manifold since there is very little air in circulation within the compressor at this time, due to the fact that the intake valve 30 is closed. It will be noted from the drawings that the outlet end of the line 24 is connected to the upstream end of the mani-

fold preferably directly over the bottom wall thereof, as shown best in FIGURES 2 and 3. The inlet end of the line 24 is connected to the separator 20 at the lowest point adjacent the air discharge end of the separator 20, as shown in FIGURE 5.

Without our scavenging system, if the compressor runs for long periods unloaded, it might be possible for an excessive amount of oil to accumulate in the low-pressure manifold 13. If this should take place prior to a sudden air demand equal to the full capacity of the compressor, the compressor will instantly accelerate to full speed, sucking in a large volume of oil into the high-pressure cylinder 12, causing a hydraulic jam between the vanes of the rotor 15. Such an accumulation of oil could damage or distort the vanes. Also, if the air compressor is a portable compressor and is used for work on very irregular terrain, the compressor may be operating at very steep angles which could possibly cause an excessive accumulation of oil in the lowest end of the manifold with resulting serious damage or breakage of the vanes of the rotor 15 in the high-pressure cylinder. However, with the line 24, running from the separator 20, connected to the upstream end of the manifold 13, the oil and air mixture from the separator, being under pressure at all times during operation of the compressor, will be injected into the manifold toward the downstream end thereof. Thus, there is a jet of fluid created and directed through the interstage manifold 13 from its upstream end to its downstream end which is the normal direction of flow of the main stream of air and oil mixture, from the low-pressure cylinder 11 to the high-pressure cylinder 12. However, since during the unloaded state of the compressor there is no substantial flow of air through the manifold 13 from the low-pressure cylinder to the high-pressure cylinder but on the other hand there is a very low-pressure or vacuum condition in the manifold, which tends to cause accumulation of oil in the manifold, the jet of scavenging fluid created by our scavenging system and acting in the same direction as the normal flow through the manifold, will prevent the accumulation of oil therein.

The oil tank 19, the receiver 18 and the separator 20 are shown as separate tanks but it is to be understood that the oil could collect in the bottom of the receiver tank so that the separate oil tank 19 could be eliminated. Also, the oil separator tank could be disposed within the receiver tank. Our scavenging system would work equally well with such modifications of the compressor system.

A somewhat different but effective scavenging system, in accordance with our invention, is illustrated diagrammatically in FIGURE 6. In this example, the line 38a from the separator 20a serves both as a pressure line for actuating the inlet valve 30a and as a bleed line from the separator. This line is connected to the inlet side of the pressure relief valve 36a which is connected by the line 37a to the actuating chamber of the valve 30a, as indicated in FIGURE 4a. An oil-scavenging line 24a leads from this actuating chamber to the manifold 13a. This oil-scavenging line has the filter 25a, the check valve 26a, and the choke 27a, interposed therein as before and is connected to the manifold 13a in exactly the same manner. This oil-scavenging system will function in the same manner as the one previously described, except that the scavenging jet producing fluid will first pass through the valves 36a and 30a before reaching the manifold 13a. Assuming the compressor is operating under its loaded state, the air and oil mixture from the separator 20a does not reach the manifold 13a since the flow is interrupted at the closed valve 36a. However, when the pressure at the receiver side of the compressor reaches a high point at which time it is desirable to unload it, the valve 36a is opened, allowing the air and oil mixture to flow into the actuating chamber of the inlet valve 30a, opening it, and flowing on through the line 24a into the manifold 13a. An actual

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vent, similar to the vent 43 of FIGURE 4, is not provided in this instance since the desired modulating effect will be accomplished by the choke 27a connected to the line 24a. Thus, the valve 30a is actuated to unload the compressor and simultaneously the scavenging jet is created in the manifold 13a. This jet will continue to function as long as the compressor is operating in the unloaded state. When the pressure at the receiver side falls to a predetermined extent, the valve 36a will close, permitting the valve 30a to open, causing the compressor to again be loaded, and simultaneously interrupting the scavenging jet through the line 24a.

Still another form of oil-scavenging system embodying our invention is illustrated in FIGURE 7. This system is similar to that illustrated in FIGURE 5 except that a pump is used in the jet-producing line to increase the pressure of the fluid therein. Thus, in this example, the bleed line 24b runs from the separator 20b to the inlet side of a pump 24g and then on to its connection with the manifold 13b at the upstream side thereof, as before. This line 24b has the filter 25b, the check valve 26b, and the choke 27b connected therein as before. The pump 24g may be of a type similar to the pump 21b adjacent to which it may be mounted and it may be driven by the same drive from the high-pressure rotor shaft. The inlet valve 30b will be actuated by the valve 36b which is connected to the separator 20b by a line 38b, as in the example shown in FIGURE 5. The oil-scavenging jet will function exactly the same as that described with reference to FIGURE 5 but the pressure of the fluid discharged into the upstream end of the manifold 13b will be increased by the pump 24g.

FIGURE 8 illustrates another form of scavenging system according to our invention. This is identical with the system shown in FIGURE 6 except that an additional scavenging line is provided to the manifold. In this instance, the additional line 38c leads from the air service outlet line between the outlet end of the separator 20c and the check valve 29c provided in that line and connects to the actuating chamber of the inlet valve 30c through the valve 36c and the line 37c. An oil-scavenging line 24c leads from this actuating chamber to the upstream end of the manifold 13c. This line has the filter 25c, the check valve 26c, and the choke (not shown) therein. The drain or bleed line 24d from the oil separator 20c also serves as a scavenging line and connects to the upstream end of the manifold 13c adjacent the bottom thereof side-by-side with the line 24c. This line has the filter 25d, the check valve 26d, and the choke 27d connected therein. This line will function the same as the line 24 in FIGURE 5, to provide a jet of oil and air mixture into the upstream end of the manifold. However, the line 24c will function to provide an additional jet of practically oil-free air into the upstream end of the manifold, directed toward the downstream end thereof. Thus, the two jets directed side-by-side will serve effectively to prevent accumulation of oil in the manifold 13c.

The arrangement illustrated in FIGURE 9 is similar to the one just described including the air line 38e, valve 36e, line 37e, valve 30e, and scavenging line 24e connected to the upstream end of the manifold 13e. However, in this instance, the bleed or drain line 24f runs from the bottom of the separator 20e to the inlet 16e of the low-pressure cylinder. The scavenging line 24e will function exactly the same as the line 24c in FIGURE 8 to provide a jet of air in the upstream end of the manifold 13e directed toward the downstream end thereof to prevent accumulation of oil in the manifold.

It will be apparent from the above description that we have provided an effective oil-scavenging system which will prevent the accumulation of oil in the interstage manifold during the operation of the compressor in the unloaded state. This system comprises means for creating a jet or jets of fluid directed into the manifold at

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the upstream end thereof toward the downstream end thereof in the direction of the normal flow from the low-pressure cylinder to the high-pressure cylinder and will, therefore, prevent the accumulation of oil therein which tends to occur during the unloaded operation of the compressor. The jet of fluid is produced by a pressure differential created by proper connections from the receiver or high-pressure side of the compressor to the lower pressure manifold. This jet of fluid will move any oil tending to accumulate in the manifold toward the inlet of the high-pressure cylinder.

According to the provisions of the patent statutes, the principles of this invention have been explained and have been illustrated and described in what is now considered to represent the best embodiment. However, it is to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

Having thus described our invention, what we claim is:

1. In combination with a multi-stage rotary compressor having a high-pressure side including a high-pressure cylinder and a low-pressure side including a low-pressure cylinder and an interstage manifold connecting the high and low pressure cylinders thereof and having a high-pressure oil lubricating system connected to the cylinders, means for preventing the accumulation of excessive amounts of oil in the interstage manifold and comprising a fluid line connected between said interstage manifold and a source of higher pressure on the compressor to provide a pressure differential for creating a positive jet of fluid in the manifold to aid in removing the oil therefrom.
2. The combination of claim 1 wherein said line is connected between the high-pressure side of the compressor and the lower pressure interstage manifold.
3. The combination of claim 1 wherein the high-pressure side of the compressor also includes an oil separator and the said line is a line from the said oil separator to the interstage manifold.
4. The combination of claim 3 in which said manifold has an upstream end connected to said low-pressure side and a downstream end connected to said high-pressure side and including an additional scavenging line running from the discharge of the separator to the upstream end of the manifold.
5. The combination of claim 1 wherein the high-pressure side of the compressor also includes an oil separator, said interstage manifold has an upstream end connected to said low-pressure side and a downstream end connected to said high-pressure side and said line is connected from the discharge of the oil separator to the upstream end of the interstage manifold.
6. The combination of claim 3 in which the interstage manifold has an upstream end connected to the low-pressure cylinder and a downstream end connected to the high-pressure cylinder, said line having a discharge end extending into the upstream end of the manifold at the lower side thereof toward said downstream end thereof.
7. The combination of claim 3 in which the interstage manifold has an upstream end connected to the low-pressure cylinder and a downstream end connected to the high-pressure cylinder, said line being connected to the upstream end of the manifold, and a pressure-relief valve in the line for controlling the flow through said line into said manifold.
8. The combination of claim 7 including an inlet valve connected to the low-pressure cylinder, said pressure-relief valve being connected to and actuating the inlet valve, and also being connected to said upstream end of the manifold by a portion of said line.
9. The combination of claim 3 in which the interstage manifold has an upstream end connected to the low-pressure cylinder and a downstream end connected to the high-pressure cylinder, said line being connected to the

upstream end of the manifold, an inlet valve connected to the low-pressure cylinder, an additional line running from the separator at its discharge side to said inlet valve through a pressure relief valve, and a line running from said inlet valve to the upstream end of the manifold.

10. The combination of claim 3 in which the inter-stage manifold has an upstream end connected to the low-pressure cylinder and a downstream end connected to the high-pressure cylinder, said low-pressure cylinder having an inlet, said line being connected to said low-pressure cylinder at said inlet, an inlet valve connected to said low-pressure cylinder at said inlet, an additional line running from the separator at its discharge side to said inlet valve, and a line running from said inlet valve to the upstream end of the manifold.

11. The combination of claim 3 wherein a pump is interposed in said line to aid in withdrawing the fluid from said separator and supplying it into said manifold.

12. The combination of claim 11 wherein the low-pressure cylinder has an inlet with a pressure-actuated inlet valve controlling the inlet, and an actuating line leading from said separator to said inlet valve.

13. In a multi-stage rotary compressor with an inter-stage manifold and a high-pressure oil supply system including an oil separator, said manifold having an inlet upstream end, an outlet downstream end and a fluid line leading from the separator and connected to the upstream

end of the manifold to supply a jet of fluid under pressure toward the downstream end of the manifold to aid removing oil therefrom.

14. The combination of claim 13 in which an additional line leads from the separator and is connected to the upstream end of the manifold.

15. In a multi-stage rotary compressor having a manifold, a low-pressure stage and a high-pressure stage with the manifold leading from the low-pressure stage to the high-pressure stage, said manifold having an upstream end connected to the low-pressure stage and a downstream end connected to the high-pressure stage and a high-pressure oil-supply system for the stages, means for preventing the accumulation of excessive amounts of oil in the manifold, said means comprising a fluid connection between the high-pressure stage and the upstream end of the manifold for directing a jet of fluid therein toward the downstream end of the manifold.

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