ABSTRACT
A lubrication system is provided for a centrifugal pump of the type having a bearing housing for maintaining the lubrication of a plurality of pump shaft rolling element bearings. The system includes a lubricant reservoir forming a volume, and having at least one supply port for supplying lubricant to the bearing housing, and at least one return port for returning lubricant to the lubricant reservoir. A lubricant recirculation pump has at least one supply stage and at least one suction stage. A connector is provided between the supply port of the reservoir and the suction stage of the lubricant recirculation pump for the supply of lubricant to the suction stage of the recirculation pump. A connector is also provided for interconnecting the supply stage of the lubricant recirculation pump to the bearing housing for the delivery of lubricant to the bearing housing. Lastly, a connector is provided for interconnecting the bearing housing and the at least one suction stage of the lubricant recirculation pump for the return of lubricant to the lubricant recirculation pump.
DRY SUMP LUBRICATION SYSTEM FOR CENTRIFUGAL PUMPS

FIELD OF THE INVENTION

[0001] The present invention relates to lubrication systems for centrifugal pumps, and particularly, to a pump-mounted dry sump lubrication system for centrifugal pumps.

BACKGROUND OF THE INVENTION

[0002] Centrifugal pumps, as the name implies, employ centrifugal force to lift liquids from a lower to a higher level or to produce a pressure. This type of pump, in its simplest form, comprises an impeller consisting of a connecting hub with a number of vanes and shrouds, rotating in a volute collector or casing. Liquid drawn into the center, or eye, of the impeller is picked up by the vanes and accelerated to a high velocity by rotation of the impeller. It is then discharged by centrifugal force into the casing and out the discharge branch of the casing. When liquid is forced away from the center of the impeller, a vacuum is created and more liquid flows into the center of the impeller. Consequently there is a flow through the pump. There are many forms of centrifugal pumps, including the type used to pass solid and liquid mixtures. These are known as slurry pumps.

[0003] Slurry pumps, like other centrifugal pumps, are driven by a shaft that is supported on rolling element bearings that are contained within a housing. Lubrication to the bearings is supplied from oil in a reservoir that is commonly integral to the bearing housing. For proper pump operation, the oil level in the reservoir should be maintained so that the rolling elements continuously run in an oil bath and carry lubricant/oil throughout the bearing surfaces.

[0004] Most pumps, including centrifugal slurry pumps are designed to operate on flat, level mounting pads or foundations. In some applications however, the slurry pump may not be level and there may not be a convenient manner of keeping the pump level, such as might be the case on a marine vessel. As a result, sufficient lubrication of the bearings is not guaranteed. Prior art solutions to this lubrication problem have employed “pillow block” bearing housings which segregated the bearings into smaller distinct sections, each with an individual oil reservoir and bearing seals. This resulted, however, in smaller oil volumes, higher operating temperatures, and reduced oil life.

SUMMARY OF THE INVENTION

[0005] The present invention is directed to a circulating lubrication system for centrifugal pumps of the type having a bearing housing, for maintaining the lubrication of a plurality of pump shaft rolling element bearings and that addresses the problems described above. More particularly, the lubrication system is designed to operate as a “dry” bearing housing sump. This means that substantially all of the lubricant is circulated continuously through the bearing housing so that at any point in time while the pump and system are operating, only a minimal volume of lubricant is in the bearing housing. As will be appreciated by those skilled in the art, removing excess oil volume from contact with the rolling element bearings has the effect of reducing parasitic losses, thus lowering bearing operating temperatures, while increasing operating efficiency of the pump.

[0006] Accordingly, one aspect of the present invention is directed to a circulating lubrication system that includes an external lubricant reservoir that is configured for mounting atop the bearing housing of the centrifugal pump. In that embodiment, the capacity of the external reservoir is sized such that the required maintenance change interval for the lubricant is increased by a factor of 10 or more. As will be appreciated by those skilled in the art, increased oil volume has the effect of reducing pump bearing assembly operating temperatures.

[0007] The external lubricant reservoir is used in combination with a multiple stage circulating pump, a supply manifold, lubricant return lines, and related controls. The multiple stage pump has a supply stage and two suction stages. The supply stage of the pump delivers clean, cooled, and filtered lubricant from a suction port on the external reservoir to the supply manifold. An internal baffle is provided within the external reservoir to separate the volume of the reservoir into lubricant return and lubricant supply compartments.

[0008] The supply manifold interconnects, through the bearing housing casing, to delivery ports proximate each of the pump shaft bearings, typically two or more. At least one return, or scavenge, line interconnects the bearing housing to the suction stage of the multiple stage circulating pump. Each of the return lines is dimensioned to return 100 percent of the required return flow back to the suction stage of the pump. Since, as described above, slurry pumps in particular are not always mounted or moved on a level surface, the bearing housing may be tilted along its primary axis such that a single return line might not be sufficient to remove all or even any of the lubricant flow from the bearing housing. Accordingly, in addition to each line being dimensioned to return 100 percent of the required flow, the return lines are spaced a sufficient distance apart to accommodate up to a 10 degree tilt along the primary axis of the pump shaft bearing housing. The lubrication system will continue to function fully.

[0009] During system operation of the pump and the dry sump lubricating system, a pressure balancing vent valve mounted atop the external lubricant reservoir creates an air flow from the air volume in the reservoir to the bearing housing. This balances the lubricant and air circulation through the system. Further, the external reservoir is so dimensioned that during normal system operation, a specified volume and level of lubricant are maintained relatively constant in the external reservoir. Should the system fail, for example by failure of the multiple stage lubricant pump, a check valve mounted interior to the external lubricant reservoir is positioned so that a failsafe gravity feed of about one gallon of lubricant per minute for about five minutes will drain from the reservoir and into the bearing housing. Thus necessary lubrication is ensured to the pump shaft rolling element bearings at all times that the centrifugal pump is running.

[0010] These and other aspects of the present invention will become apparent to those skilled in the art after a reading of the following description of the preferred embodiments when considered in conjunction with the drawings. It should be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a schematic illustrating a typical centrifugal pump,
FIG. 2 is a schematic illustrating the elements and interconnections of the circulating lubrication system and circulation paths and flows for the system of the present invention;

FIG. 3 is a right rear perspective environmental view of the system of the present invention;

FIG. 4 is a left side environmental view of the system of the present invention; and

FIG. 5 is a rear view of the system of the present invention illustrating the placement of manifold and return lines to and from the bearing housing of a typical centrifugal pump.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is directed to a circulating lubrication (oil) system for centrifugal pumps that addresses the problems described above. More particularly, and with reference to FIG. 1, the lubrication system of the present invention is for use with a centrifugal pump 110 of the type having a cartridge-type bearing housing 140 for maintaining sufficient lubrication to a plurality of pump shaft rolling element bearings 141, 142, and 143. The lubrication system described and claimed herein is hereafter referred to as a “dry” bearing housing lubrication system wherein lubricant is continuously circulated through the bearing housing so that at any point during which the pump and lubrication system are operating, at least some volume of lubricant is actually in the bearing housing.

The pump shaft bearing housing 140 shown in FIGS. 1, 3, and 4 is rather conventional. The system described herein, as will be appreciated by those skilled in the art, may be installed on a range of centrifugal pump designs during fabrication and assembly of new pumps, or may be retrofitted for existing pumps, as well as other pump types or rotating shaft equipment.

Referring now to FIGS. 2 through 5 in general, and FIG. 2 in particular, the lubrication system of the present invention is shown generally as 100. In one embodiment, the system 100 comprises an external lubricant reservoir 120 that is mounted atop the bearing housing 140 of the centrifugal pump 110, or alternatively separate from, but above, the bearing housing 140. As shown in FIGS. 3 and 4, the external lubricant reservoir 120 is generally box-like and may be mounted atop the bearing housing 140 with any conventional brackets, mounting plates, elastomer isolators 129, or other suitable hardware. For convenience, the external reservoir 140 is generally rectangular; however, the actual geometry of the reservoir 140 is not important to the present invention. As will be explained in greater detail below, the mounting location and configuration of the reservoir 140 of the embodiment shown in the Figures, while not limiting of the broad invention, provides for an economy of volume in the vicinity of the pump and facilitates the failsafe function described below by providing a gravity feed of lubricant in the event of system failure.

The external lubricant reservoir 140 of the exemplary embodiment of FIGS. 2 through 5 is further dimensioned so that it can contain a significantly greater volume of oil than the standard bearing housing. As will be appreciated, the increased volume of oil reduces oil, bearing, and pump bearing assembly operating temperatures and extends the required maintenance lubricant change intervals by a factor of ten or more. In one exemplary embodiment of the type shown in the Figures, the external lubricant tank 120 is sized to hold approximately 25 US gallons (94.6 liters) of lubricant, or approximately 6.7 times the normal oil volume in the bearing housing 140 of 3.7 US gallons (14 liters); however, the capacity of the tank 120 is dependent upon the application. This further equates to approximately 16.7 times the normal oil volume in the prior art pillow block design bearing housing which contains a total of about 1.5 US gallons (5.7 liters). As shown in FIG. 5, the external lubricant reservoir 120 is provided with at least one internal baffle 121 that is designed to prevent contaminants from reaching the inlet of the multistage pump supply pickup line. The baffle 121 separates the reservoir into return and supply compartments with an air volume therebetween. The baffle 121 is offset toward the supply side of the reservoir 120, forming a larger compartment on the return side, thus creating a larger volume there. This reduces the velocity of the lubricating oil as it circulates through the return side of the reservoir, promoting additional time for both de-aeration and the settling out of any contaminants or water that may be contained within the lubricant. The return and supply compartments are then connected by one or more orifices located in the lower portion of the internal baffle 121 at the end opposite of the return line connection. This provides the maximum distance of oil travel to provide sufficient time for heat dissipation through the walls of the reservoir 120. In addition, a drain tube 124 is positioned at the bottom of the reservoir 120 for the collection and removal of water and solids from the supply cycle as they drop out of suspension from the lubricant.

As shown in FIG. 5, a check valve 122 is mounted vertically in the interior center of the reservoir 120 at approximately the mid-height of the reservoir 120. The check valve 122 is so positioned for gravity discharge during failsafe (failure mode) operations. The height of the check valve 122 is such that it allows only a prescribed volume of lubricant to gravity drain from the reservoir 120 and into the bearing housing 140 by virtue of the check valve 122 being positioned higher than the bearing housing 140.

As will be explained in greater detail below, and as shown in FIGS. 2 through 5, a pressure balancing vent valve 123 is provided at the apex of the external reservoir 120. Since the reservoir 120 and bearing housing 140 volumes comprise both lubricant (oil) and air, and the multistage pump 150 necessarily pumps a mixture thereof, the pressure balancing vent valve 123 regulates the air pressure and air flow between the reservoir 120 and bearing housing 140.

Further, with respect to the reservoir 120, an oil level monitor 125 is mounted on the side of the external reservoir 120 proximate the scavange hoses (described below) so that the oil level can be easily viewed from a safe distance. Further, the design and placement of the oil level monitor is such that it shows whether the oil level is correct during normal equipment operation as well as during shutdown. The location of the oil level monitor 125 reduces the problem of debris obscuring visibility so that an operator can obtain an accurate reading. The location of the monitor 125 also reduces the possibility of damage to the monitor from tools used in the routine maintenance of the bearing assembly 140.

Turning again to FIGS. 1, and 3 through 5, a bearing housing 140 is generally shown. As best seen in the Figures, the bearing housing 140, which is conventional for
centrifugal pumps, comprises an elongated cartridge, or cylinder, through which the shaft 112 (FIG. 1) of the pump passes. The purpose of the bearing housing 140 is to support rotation of the shaft 112 via a plurality of pump shaft rolling element bearings 141, 142, 143 that are spaced apart along the entire length of the bearing housing and mounted in fixed positions as is conventional and known in the art. The number and placement of bearings are typical, and in no way affect the embodiments and functions thereof described and claimed herein. In the exemplary embodiment shown for the present invention, three ports 141a, 142a, 143a are formed through the casing wall of the bearing housing 140 and open into the interior volume of the bearing housing 140 proximate the radial positions of the bearings 141, 142, 143. As will be explained in greater detail below, a supply manifold 161 supplies lubricant simultaneously to each of the three ports in a volume sufficient to lubricate and cool the bearings during anticipated operational conditions. Also formed through the casing of the bearing housing are spaced apart return, or scavenge, ports 144a, 144b which function as described in greater detail below. An upper inlet port 144c is provided to connect to the air pressure balance and flow system described herein.

The lubrication system 100 of the present invention includes the multiple-stage recirculation pump 150. The multiple-stage pump 150 comprises two suction stages 150a, 150b and one discharge, or supply, stage 150c. One suitable multiple-stage pump 150 is available from Viking Pump of Cedar Falls, Iowa as Model No. GPV-0782-47. This model pump is double suction, single discharge gear pump.

Referring again to the Figures in general, and to the schematic of FIG. 2 in particular, the remaining components of the system 100 will better be understood through a description of the operation of the system 100. At the initial startup of the centrifugal pump 110, a specified volume of lubricant is held in the bearing housing 140. With startup of the pump 110 and of the multiple-stage recirculation pump 150, the two suction stages 150a, 150b of the recirculation pump 150 take oil from the scavenge ports 144a, 144b. As best seen in FIG. 5, scavenge hoses 145a, 145b extend into the bearing housing 140 along channels in the outer periphery of the lower bearing housing interior, where they extend in opposite directions along the primary axis of the bearing housing 140 and pump shaft 112 (FIG. 1). By routing the scavenge hoses 145a, 145b in this fashion, the lubrication system 100 can operate at its design capacity regardless of whether the pump is subjected to movement or tilt; i.e., each of the suction ports 144a, 144b and hoses 145a, 145b are dimensioned to return 100 percent of the required system flow rate to one of the suction stages 150a or 150b of the recirculation pump 150. In one embodiment, the ports 144a, 144b and scavenge hoses 145a, 145b are so sized and positioned that the system in operations will continue to function at design capacity with a tilt of up to about ten degrees upwardly or downwardly along the primary axis of the bearing housing 140. During level, stable operation, each scavenge return line 146a, 146b delivers about 50 percent of the required system flow rate to their respective suction stages 150a, 150b of the multiple stage recirculation pump 150. The lubricant entering the pump 150 is then directed via a discharge line 146 through an oil filter 147 and into the reservoir 120.

Clean and cooled lubricant is drawn from the reservoir 120 via a supply port 157 through a hose 157a to the supply stage 150c of the pump 150. As shown in FIG. 2, the supply stage 150c of the pump 150 discharges through a line 154 to a flow control device/flow switch 155 which directs the lubricant through line 160 to the manifold 161 and a specified flow rate back to the reservoir 120 via connection 156.

The supply manifold 161 comprises three branches 161a, 161b, and 161c interconnected to the ports 141a, 142a, and 143a for the bearings 141, 142, and 143. To ensure an even distribution of lubricant to each of the bearings 141, 142, 143, an orifice (not shown) is provided at the terminal ends of each of the ports 141a, 142a, and 143a internal to the bearing housing 140. Each of the orifices has a diameter sized to provide the required individual flow rate to each of the respective bearings 141, 142, and 143. Simultaneously therewith, the pressure balance vent valve 123 directs a specified flow rate of air through line 123a to the bearing housing 140 via port 144c.

In one exemplary embodiment of the present invention, at the initial startup of the centrifugal pump 110, approximately five gallons of lubricant are held in the bearing housing 140. With startup of the pump 110 and of the multiple-stage recirculation pump 150, the two suction stages 150a, 150b of the recirculation pump 150 take oil from the scavenge ports 144a, 144b. As best seen in FIG. 5, scavenge hoses 145a, 145b extend into the bearing housing 140 along channels in the outer periphery of the lower bearing housing interior, where they extend in opposite directions along the primary axis of the bearing housing 140 and pump shaft 112 (FIG. 1). By routing the scavenge hoses 145a, 145b in this fashion, the lubrication system 100 can operate at its design capacity regardless of whether the pump is subjected to movement or tilt; i.e., each of the suction ports 144a, 144b and hoses 145a, 146a and 145b, 146b are dimensioned to return 100 percent of the required system flow rate to one of the suction stages 150a or 150b of the recirculation pump 150. In one embodiment, the ports 144a, 144b and scavenge hoses 145a, 145b are so sized and positioned that the system in operations will continue to function at design capacity with a tilt of up to about ten degrees upwardly or downwardly along the primary axis of the bearing housing 140. In the embodiment shown in FIGS. 2 through 5, both return lines 146a, 146b are dimensioned for a total flow of 16.0 (60.6 liters) gallons per minute of an air and oil mixture. During level, stable operation, each scavenge return line 146a, 146b delivers about 8.0 gallons (30.3 liters) per minute to their respective suction stages 150a, 150b of the multiple stage recirculation pump 150. The lubricant entering the pump 150 is then directed via a discharge line 146 through an oil filter 147 and into the reservoir 120.

Clean and cooled lubricant is drawn from the reservoir 120 via a supply port 157 through a hose 157a to the supply stage 150c of the pump 150. During normal operation, the suction rate to the suction stage 150c is about 8.0 gallons (30.3 liters) per minute. As shown in FIG. 2, the supply stage 150c of the pump 150 discharges through a line 154 to a flow control device/flow switch 155 which directs 7.5 gallons (28.4 liters) per minute of lubricant through line 160 to the manifold 161 and about 0.5 gallons (1.9 liters) per minute back to the reservoir 120 via connection 156.
The supply manifold 161 comprises three branches 161a, 161b, and 161c interconnected to the ports 141a, 142a, and 143a for the bearings 141, 142, and 143. To ensure an even distribution of lubricant to each of the bearings 141, 142, 143, an orifice (not shown) is provided at the terminal ends of each of the ports 141a, 142a, and 143a internal to the bearing housing 140. Each of the orifices has a diameter sized to provide the required individual flow rate to each of the respective bearings 141, 142, and 143. The flow rate to the three bearings 141, 142, 143 is approximately a combined 7.5 gallons (28.4 liters) per minute. Simultaneously therewith, the pressure balance vent valve 123 directs approximately 8.5 gallons (32.2 liters) per minute of air through line 123a to the bearing housing 140 via port 144c.

The foregoing describes the normal operational process and flow paths of the system 100 of the present invention. The following describes an operation of the system 100 during faulted or failed conditions is necessary. With reference to FIG. 2, should the lubricant system 100 of the present invention fail for any number of reasons (power failure, mechanical seizure, line rupture, etc.), the system according to at least one exemplary embodiment of the present invention has incorporated failsafe provisions. Specifically, should forced circulation via the multiple stage pump 150 cease, a volume of lubricant in the external reservoir 120 would gravity drain through the vertically mounted check valve 122 into the bearing housing 140 via line 161.

This line 161 is sized such that the gravity feed to the bearing housing 140 is approximately one gallon (3.8 liters) per minute for a period of five minutes for a total of about five gallons (18.9 liters) of lubricant. The resulting volume of lubricant, in this embodiment, is sufficient to create a lubricant level in the bearing housing 140 such that the bearings 141, 142, 143 would receive sufficient “splash” lubrication to the running centrifugal pump. This failsafe provision will also activate during normal shutdown in order to provide a level of oil to the bearings for the next startup.

Further to the lubricant system 100 described herein, certain electric/electronic control and protection devices have been incorporated therein. For example, the oil filter 147 contains a switch contact (not shown) which activates in the event that the filter element becomes plugged and the flow is diverted through the bypass, thus triggering an alarm to notify the pump operator of the problem. This condition would cause the passive gravity feed provision to deliver flow to the bearing housing 140.

Although the present invention has been described with a preferred embodiment, it is to be understood that modifications and variations may be utilized without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the appended claims and their equivalents.

We claim:

1. A lubrication system for a centrifugal pump of the type having a bearing housing for maintaining the lubrication of a plurality of pump shaft rolling element bearings, comprising:
   (a) a lubricant reservoir forming a volume, and having at least one supply port for supplying lubricant to the bearing housing, and at least one return port for returning lubricant to the lubricant reservoir;
   (b) a lubrication recirculation pump having at least one supply stage and at least one suction stage;
   (c) a connector between the supply port of the reservoir and the suction stage of the lubrication recirculation pump for the supply of lubricant to the suction stage of the recirculation pump;
   (d) a connector for interconnecting the supply stage of the lubrication recirculation pump to the bearing housing for the delivery of lubricant to the bearing housing; and
   (e) a connector for interconnecting the bearing housing and the at least one suction stage of the lubrication recirculation pump for the return of lubricant to the lubrication recirculation pump.

2. The lubrication system of claim 1 wherein the lubricant reservoir is configured for mounting above the bearing housing.

3. The lubrication system of claim 1 wherein the lubricant reservoir further comprises at least one internal baffle, the internal baffle separating the volume of the reservoir into lubricant supply and lubricant return portions.

4. The lubrication system of claim 1 wherein the external lubrication system further comprises an auxiliary lubrication mechanism, the mechanism comprising:
   (a) a check valve mounted at a predetermined height within the reservoir;
   (b) a discharge port proximate the bottom of the reservoir; and
   (c) wherein the check valve is configured to permit a predetermined quantity of lubricant to flow through the discharge port to the bearing housing.

5. The lubrication system of claim 1 wherein the external lubrication system further comprises a pressure balancing air vent valve proximate the top of the reservoir, the pressure balancing air vent valve configured for interconnection with the bearing housing.

6. The lubrication system of claim 1 further comprising a supply manifold through which the supply stage of the lubrication recirculation pump delivers lubricant to the bearing housing.

7. The lubrication system of claim 6 wherein the supply manifold comprises a plurality of discharge branches configured for interconnection with bearing housing proximate each of the plurality of pump shaft rolling element bearings.

8. The lubrication system of claim 1 further comprising a lubricant filter positioned upstream of the return port of the reservoir.

9. The lubrication system of claim 1 wherein:
   (a) the multiple stage pump comprises at least two suction stages; and
   (b) wherein a return line is configured to interconnect each of the at least two suction stages to the bearing housing for the return of lubricant from the bearing housing to the at least two suction stages.

10. The lubrication system of claim 9 wherein each of the return lines further interconnect to a scavange hose, each scavange hose configured to scavange lubricant at spaced points within the bearing housing.

11. A centrifugal pump, comprising:
   (a) a pump shaft rotatably supported by a plurality of rolling element bearings;
   (b) a bearing housing for maintaining the lubrication of the plurality of pump shaft rolling element bearings;
   (c) a lubrication system, comprising:
(i) a lubricant reservoir forming a volume, at least one supply port for supplying lubricant to the bearing housing, and at least one return port for returning lubricant to the lubricant reservoir;
(ii) a lubricant recirculation pump having at least one supply stage and at least one suction stage;
(iii) a connection between the supply port of the reservoir and the suction stage of the lubricant recirculation pump for the supply of lubricant to the suction stage of the recirculation pump;
(iv) a connection between the supply stage of the lubricant recirculation pump and the bearing housing for the delivery of lubricant to the bearing housing; and
(v) a connection between the bearing housing and the at least one suction stage of the lubricant recirculation pump for the return of lubricant to the lubricant recirculation pump.

12. The lubrication system of claim 11 wherein the lubricant reservoir is configured for mounting above the bearing housing.

13. The pump of claim 12 wherein the lubricant reservoir further comprises at least one internal baffle, the internal baffle separating the volume of the reservoir into lubricant supply and lubricant return portions.

14. The pump of claim 12 wherein the external lubricant reservoir further comprises an auxiliary lubrication mechanism, the mechanism comprising:
(a) a check valve mounted at a predetermined height within the reservoir;
(b) a discharge port proximate the bottom of the reservoir; and
(c) wherein the check valve is configured to permit a predetermined quantity of lubricant to flow through the discharge port to the bearing housing.

15. The pump of claim 12 wherein the external lubricant reservoir further comprises a pressure balancing air vent valve proximate the top of the reservoir, the pressure balancing air vent valve interconnected to the bearing housing.

16. The pump of claim 12 further comprising a supply manifold through which the supply stage of the lubricant recirculation pump delivers lubricant to the bearing housing.

17. The pump of claim 16 wherein the supply manifold comprises a plurality of discharge branches interconnected to the bearing housing proximate each of the plurality of pump shaft rolling element bearings.

18. The pump of claim 12 further comprising a lubricant filter positioned upstream of the return port of the reservoir.

19. The pump of claim 12 wherein:
(a) the multiple stage pump comprises at least two suction stages; and
(b) wherein a return line interconnects each of the at least two suction stages to the bearing housing for the return of lubricant from the bearing housing to the at least two suction stages.

20. The pump of claim 19 wherein each of the return lines further interconnect to a scavenge hose, each scavenge hose configured to scavenge lubricant at spaced points within the bearing housing.