Dec. 9, 1947. J. J. SERRELL ET AL 2,432,130

OIL CIRCULATING AND FEEDING SYSTEM

Filed July 4, 1942 3 Sheets-Sheet 1

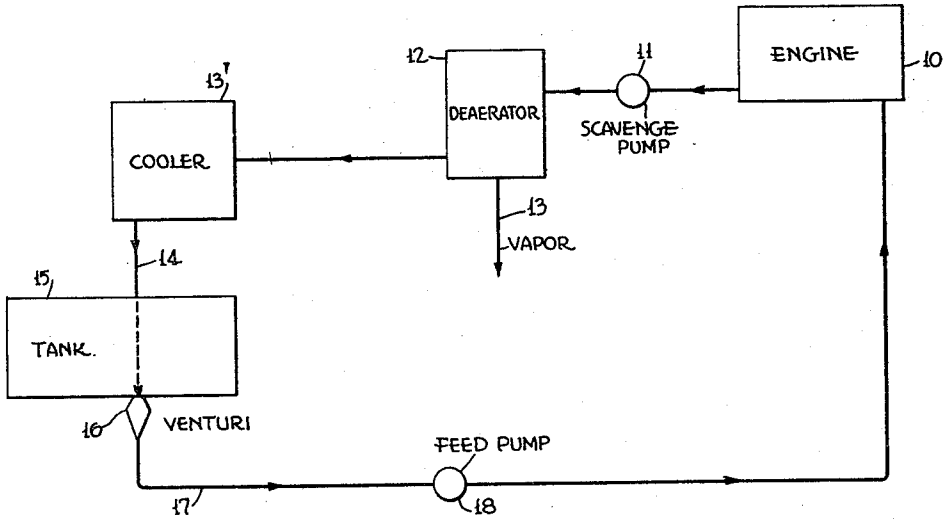


FIG. 1

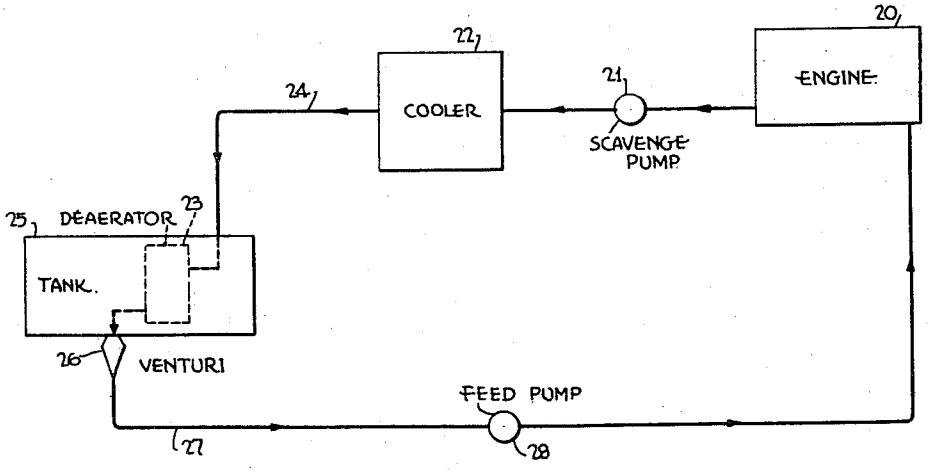


FIG. 2.

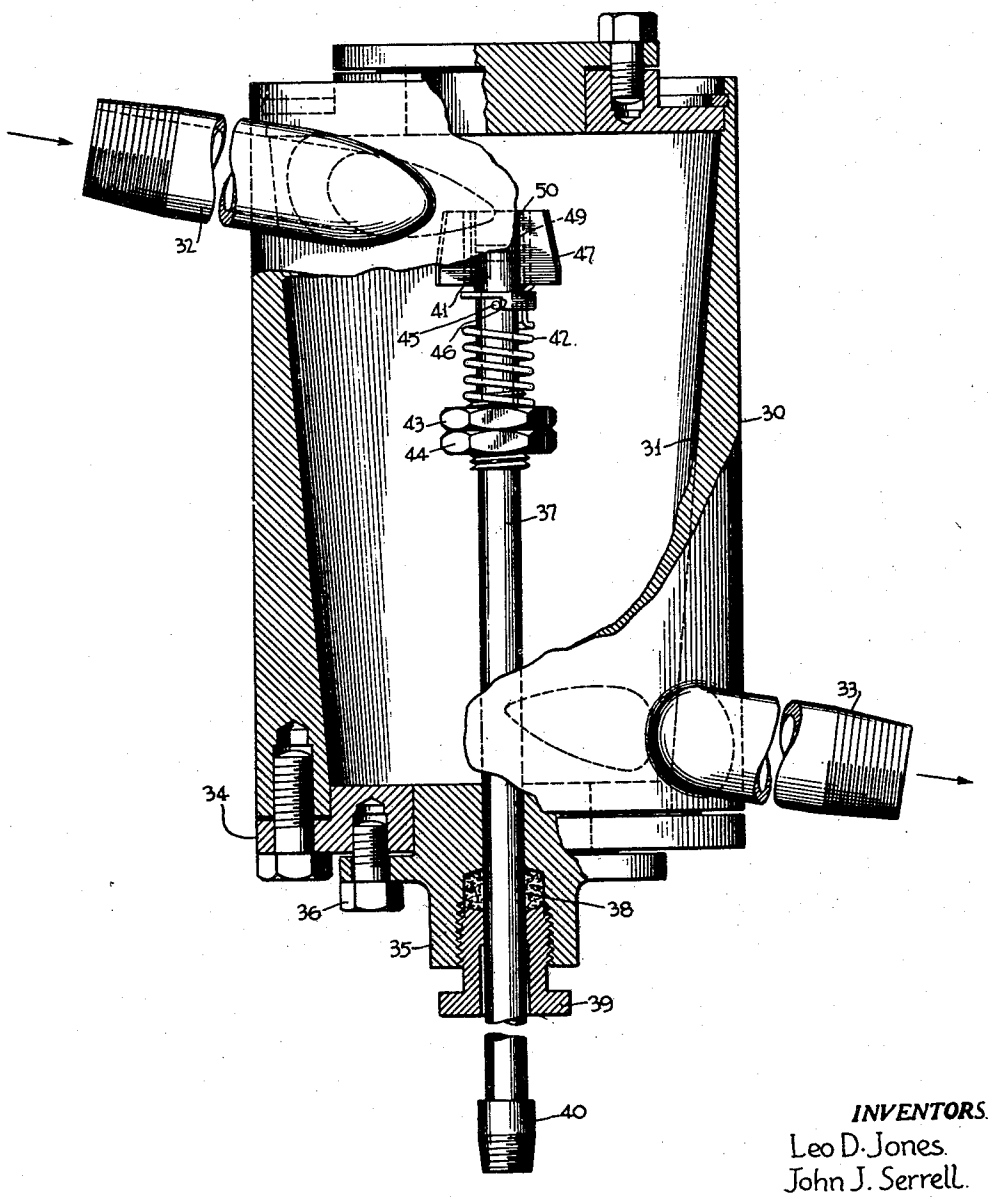
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OIL CIRCULATING AND FEEDING SYSTEM

Filed July 4, 1942 3 Sheets-Sheet 2

FIG. 3.



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Dec. 9, 1947. J. J. SERRELL ET AL 2,432,130

OIL CIRCULATING AND FEEDING SYSTEM

Filed July 4, 1942 3 Sheets-Sheet 3

FIG.4

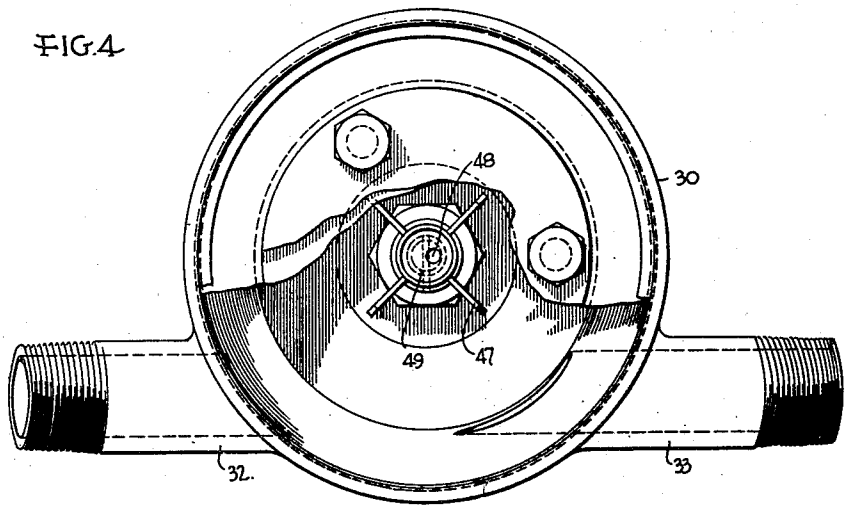
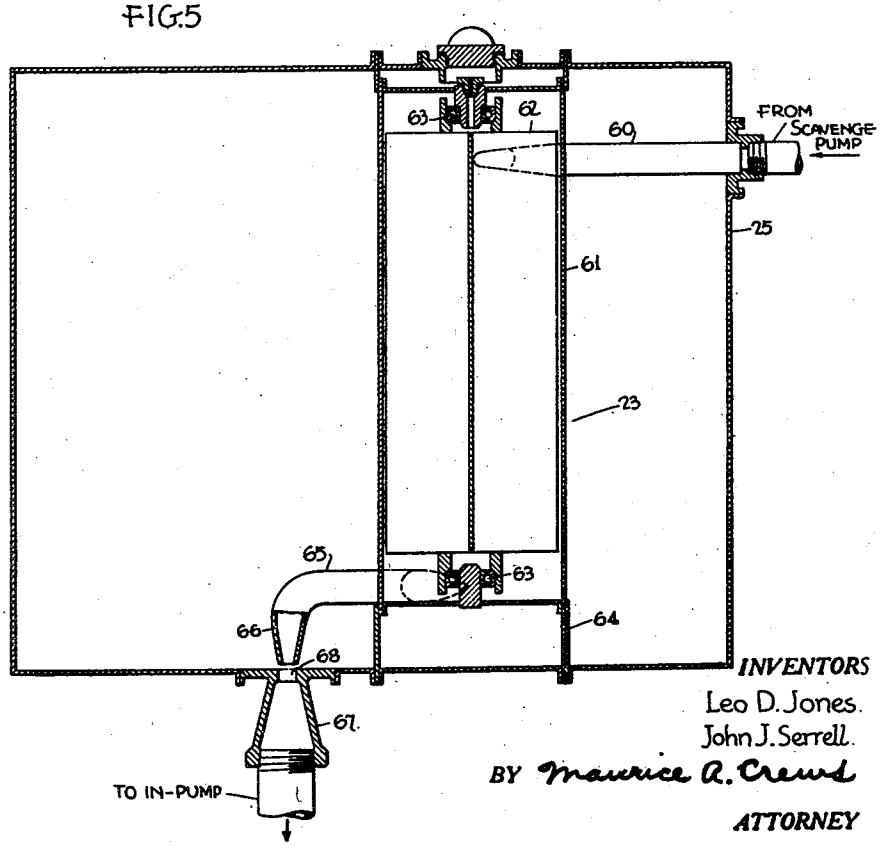


FIG.5



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Patented Dec. 9, 1947

2,432,130

UNITED STATES PATENT OFFICE

2,432,130

OIL CIRCULATING AND FEEDING SYSTEM

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Application July 4, 1942, Serial No. 449,830

9 Claims. (Cl. 184—6)

1

The present invention pertains to a centrifugal apparatus for deaerating liquids and to the combination of such an apparatus with other features of a lubrication system. While features of the invention may be used in a variety of applications, they will be described for purposes of illustration and convenience in their relation to the lubricating system of an aviation engine, since that is the purpose for which they were originally conceived.

The lubricating system of an airplane engine consists of an oil storage tank, a conduit from the storage tank to the engine, a feed pump on or in the engine for pumping oil to the various parts of the engine to lubricate it, a sump in the engine into which the oil drains from the various parts of the engine, a scavenge pump for pumping oil from the sump, a conduit from the scavenge pump to an oil cooler, an oil cooler and a conduit back to the oil storage tank. The system may include additional items such as a relief valve to by-pass oil around the cooler under certain conditions, a thermostatic valve for accomplishing this same purpose, and/or a centrifugal separator for purifying the oil after use, but the elements discussed above are the essential ones, insofar as the system of the present invention is concerned.

The scavenge pump ordinarily has a displacement from two to three times as great as the oil feed rate of the feed pump in the case of radial engines, and in the case of in-line engines, there are usually two scavenge pumps, one at each end of the crank-cases, each of these pumps having a displacement at least twice as great as that of the feed pump. This relationship of capacities between the scavenge pump or pumps and feed pump is necessary to insure the continuous removal of all of the oil which drains into the sump. A necessary incident to this relationship, however, is the fact that vapor from the crankcase is pumped by the scavenge pump or pumps together with the oil through the oil cooler and into the storage tank. The pumping of this vapor through the oil cooler increases the drop in pressure through the cooler and the load on the scavenge pump or pumps, and complicates the problem of cooling the oil. The pressure drop through the cooler causes finer dispersion of the vapor and thus aggravates the foaming problem to be discussed hereinafter.

The vapor carried into the oil stream through the scavenge pump also complicates the problem of introducing the oil into the storage tank. If the oil containing this vapor is introduced

2

beneath the surface of the oil already in the tank, the vapor passes upwardly through the body of oil and causes a foam. If, on the other hand, the oil containing the vapor is introduced above the level of the oil in the storage tank, the resulting splashing also causes foam.

The presence of the vapor in the oil from the scavenge pump adds to the difficulty of solving two other problems. The first of these is the feed of oil to the feed pump when flying at high elevation. The main difficulty here is the lack of atmospheric pressure to force oil from the storage tank to the inlet of the feed pump. This difficulty is aggravated by the air bubbles entrained in the oil, since these air bubbles seriously impair flow of oil to the feed pump at high elevations. Another problem is that of feed of oil to the feed pump in maneuvers which cause a negative "G" in the plane, such as flying inverted and performing outside loops. Here again the natural problem caused by these maneuvers is accentuated by the presence of the vapor in the oil.

The present invention includes features for solution of each of the above-discussed problems. It includes a system in which the oil is fed, under pressure derived from the energy imparted to it by the scavenge pump, from that pump to a point adjacent the zone of discharge of oil from the oil storage tank. A Venturi connection is provided at this point, with the result that the oil passing from the motor is passed toward the suction side of the feed pump under energy derived from the scavenge pump, while additional oil is sucked from the oil storage tank toward the feed pump under the impelling effect of said Venturi connection.

In the preferred form of the invention, the oil is subjected to treatment in a centrifugal deaerator to remove most of the vapors sucked into the oil by the scavenge pump, during its passage from the scavenge pump to the Venturi connection referred to above. The centrifugal deaerator may be mounted in advance of an oil cooler interposed between the scavenge pump and the oil storage tank, or it may be mounted beyond the oil cooler in the line of flow of the oil, as for example, by being mounted in the oil storage tank itself. If mounted in advance of the cooler, the operation of the cooler is rendered more efficient by removal of the vapor at this point, and the emulsifying action to which the oil and air are subjected in passing through the cooler is also avoided.

In the preferred form of the invention, the centrifugal deaerator consists of a non-rotating

tank around the interior surface of which the oil flows in a rotating motion during its passage from entrance to exit of the tank in a longitudinal direction. This tank is preferably provided with a valve controlling discharge of gas or vapor from a central portion of the tank, after removal of this gas or vapor under the influence of centrifugal force, and the opening and closing of this valve are controlled by the thickness of the layer of liquid passing along the interior wall of the deaerator. Thus, when the wall of liquid exceeds a predetermined thickness, the actuating mechanism moves the deaerator valve to a position preventing discharge of gas from the tank, and when this wall recedes again to a permissible thickness, the valve is again opened and discharge of gas resumed.

A better understanding of the details of the invention will be had by reference to the following description in the light of the attached drawing, in which,

Figure 1 is a flow sheet illustrating the arrangement of the deaerator and venturi in accordance with one form of the invention,

Figure 2 is a similar view illustrating an arrangement involving an alternative,

Figure 3 is a cross sectional view through a preferred form of deaerating apparatus,

Figure 4 is a plan view of the apparatus of Figure 3 with parts broken away to illustrate a valve detail, and

Figure 5 is a diagrammatic view of a simplified form of deaerator mounted directly in the oil storage tank, this view containing also a detailed illustration of the Venturi connection for assisting in feed of oil to the suction side of the feed pump.

Referring to the drawing by reference characters, it will be seen that Figure 1 illustrates an arrangement in which the oil is sucked from the engine 10 by a scavenge pump 11, which is shown for the purposes of convenience as separate from the engine 10, although it is ordinarily directly associated with the engine. From the scavenge pump 11, the mixture of oil and gas passes to the centrifugal deaerator 12, from which vapor is discharged at 13, while the oil is passed, under energy derived from the scavenge pump, through a cooler 13'.

Oil from the cooler 13' is then passed through conduit 14, which may include a portion passing directly through oil storage tank 15 to a Venturi connection 16.

The Venturi connection 16 communicates with the main body of oil in the storage tank 15 adjacent the zone of discharge of oil from the main body thereof in said tank, and thus provides suction for impelling oil from the main body thereof in said tank, together with oil from the conduit 14, through the conduit 17 to the feed pump 18 by which this oil is returned to the engine 10 for re-use.

It will be seen that, in such a system, by centrifugally deaerating the oil and returning this centrifugally deaerated oil to the engine, the disadvantage of feeding large quantities of gas, together with the oil, to the engine, is avoided. It will also be seen that, by passing the oil from the tank 15 to the feed pump 18 under the suction effect of the Venturi connection 16, disadvantages previously encountered in connection with feed of oil from the storage tank to the engine are avoided.

Figure 2 of the drawing illustrates a somewhat modified arrangement in which the deaerator is mounted between the cooler and the Venturi connection, instead of being mounted in advance of the cooler. As here illustrated, the deaerator may be mounted directly within the oil storage tank. In this embodiment of the invention oil from the engine 20 is passed by scavenge pump 21 through cooler 22 to the deaerator 23, through conduit 24. Oil from the rotating body thereof in the deaerator 23 is passed, under energy derived from the scavenge pump, through Venturi connection 26, and in passing through this connection, it sucks oil from the tank 25 through the conduit 27 to the feed pump 28. Since the general principles of this form of the invention are similar to those of that described above in connection with Figure 1, further explanation is deemed unnecessary.

Figures 3 and 4 illustrate a preferred form of deaerator for use in the system of either of Figures 1 and 2. As here illustrated, the deaerator consists of a tank 30 provided with an interior surface 31 which is preferably circular, and which may be cylindrical or frusto-conical as shown. This tank is provided with an inlet connection 32 for injecting oil tangentially into the tank along the surface 31 in a direction having a longitudinal component toward the tangential outlet 33 which receives the oil after the gas has been separated by centrifugal force due to rotating movement of the oil during passage along surface 31 from entrance to exit.

The tank 30 is provided with an end plate 34, which is removably mounted to permit access to the interior of the tank. This end plate is provided with a central opening to receive a housing 35 for a packing gland, this housing being secured to the end plate by bolts 36. A hollow tube 37 is slidably mounted in a central bore of the housing 35, the upper end of this tube extending to a position within the tank 30, and this position being adjustable by longitudinal movement of the tube.

A packing gland 38 surrounds the tube 37 within the bore of the housing 35, and the prevention of leakage and longitudinal securement of the tube in the desired position are both accomplished by tightening of the gland nut 39.

Tube 37 is provided with a nipple 40 at its lower end for connection to other piping, and this piping may extend through the outer surface of the tank 25 in case the deaerator is mounted within that tank as illustrated in Figure 2 of the drawing. A valve 41 is secured in sliding relationship upon the upper end of the tube 37, and the upper end of the valve is urged downwardly and held in contact with the upper end of the tube 37 by the spring 42. The lower end of the spring 42 is secured in position longitudinally with respect to the tube 37 by the nut 43, which may be locked by nut 44, both of these nuts being threaded to the tube 37. These nuts provide a method of securing the spring in position longitudinally, and also a method of altering the tension on the spring, as will be evident from inspection of the drawing. A stop pin 45 is secured to the tube 37 adjacent the bottom of the valve 41, and this stop pin coacts with an abutting surface 46 of the lower end of the valve to secure the valve in open position under the influence of the spring 42 until accumulation of a predetermined thickness of an annular layer of liquid along the interior of the wall 31, as will be evident from further discussion of details by which this result is accomplished. A plurality of wings 47 extend outwardly from the cylindrically extending portion of the outer surface of the valve 41, and this valve is also pro-

vided with a cylindrically extending portion 50 above the upper end of the tube 37, in order to minimize leakage of oil into the tube 37 by splashing. When the abutment 46 is in contact with the pin 45, an opening 48 in the upper, otherwise closed, end 49 of the valve 41 registers with an opening in the upper end of the tube 37 to permit discharge of gas through these registering openings and the tube 37. When the abutment 46 is moved in a counterclockwise direction away from the pin 45, on the other hand, these openings are brought out of registry with each other, with the result that the valve connection and possibility of discharge of gas through the tube 37 is closed, much after the fashion of a talcum powder can.

In the operation of the above apparatus, the mixture of air and oil enters through the tangential inlet pipe 32. The mixture flows around the inner wall 31 of the tank 30, during its passage from the inlet 32 to the outlet 33, and this rotating flow causes separation of air toward the center of the tank under the influence of centrifugal force. After being relieved of its air in this manner, the oil leaves the tank through the tangential outlet 33. The air flows through the hole 48 and registering hole in the top of tube 37, and escapes from the apparatus through this tube. So long as the valve is maintained in open position by the action of the spring 42 in holding the abutment 46 against the pin 45, the air will discharge rapidly through the valve and tube 37. During this operation, the thickness of the body of oil rotating within the surface 31 during its passage longitudinally along that surface will gradually increase until the inner surface of this layer strikes the wings 47 and causes these wings to move in a counter-clockwise direction against the influence of the spring 42. This rotary movement of the wings 47 under the impelling effect of the rotation of the body of oil within the tank causes the opening 48 to be moved out of registry with the coacting opening in the otherwise closed upper end of the tube 37, and prevents further discharge of air so long as this condition continues to prevail. As the operation continues after this condition is reached, the pressure in the central part of the tank 30 will increase, due to the fact that the released air cannot be discharged through the tube 37, and this increase in pressure will cause an increase in the amount of oil discharged through tangential outlet 33, with the result that the amount of discharge will ultimately exceed the amount of feed, and the inner surface of the stratum of oil within the surface 31 will again recede. When this happens, the spring 42 will again return the valve to open position, with the result that the air can again be discharged through tube 37.

The above description of the operation of the centrifugal deaerating apparatus is somewhat idealized for the sake of simplicity of explanation. As a matter of fact, in the actual operation of the apparatus, the valve may not be moved completely either to absolutely closed or absolutely open position, after the operation is well under way. This valve moves to an intermediate position after a condition fairly close to equilibrium is established between the effect of the spring 42 in moving the valve to open position and the effect of wings 47 in moving it to closed position. As a matter of practical operation, however, the effect of the valve in permitting discharge of gas, but preventing discharge of liquid through tube 37 by preventing accumulation of too deep a stratum of liquid within the tank is the same, regardless of

whether the valve actuating mechanism effects actual successive closing and opening of the valve, or merely the attainment of an equilibrium condition which builds up a pressure within the center of the tank sufficient to bring the rate of discharge of oil through conduit 33 to the approximate rate of feed thereof through the conduit 33.

Figure 5 of the drawing illustrates a centrifugal deaerating apparatus especially adapted to be mounted within the oil storage tank, as illustrated in Figure 2 of the drawing. As here illustrated, the oil from the scavenge pump enters the tank 25 through an inlet connection 60 and is discharged tangentially along the inner wall of the cylinder 61 of the centrifugal deaerating apparatus 23. A plurality of wings 62 may be mounted for free movement in a rotary direction with respect to the cylinder 61 by means of bearing connections 63 through which these wings are secured in position relative to the supports 64 by which the cylinder 61 is held in position in the tank 25. Oil which passes tangentially into the interior of the cylinder 61 flows in a rotary motion around that cylinder during its passage downwardly along the cylinder from the inlet connection 60 to the outlet connection 65 through which it is tangentially discharged from the cylinder. During this movement, the wings 62 tend to stabilize the rotary movement of the oil within the cylinder 61. In being discharged tangentially from the lower end of the cylinder 61, the oil is impelled through the outlet connection 65 under energy initially derived from the scavenge pump. The outlet connection 65 conducts the oil to a portion of the tank 25 adjacent the zone of discharge of oil from that tank, and this connection is restricted, as illustrated at 66, in the form of the contracting end of a Venturi throat. The expanding end 67 of the venturi may constitute an extension on the outlet from the tank 25, and space is provided as indicated at 68 between the outlet end 66 of connection 65 and the inlet end of connection 67, in order to permit oil to be sucked through this Venturi connection from the main body of the storage tank, and passed to feed pump 28 along with oil being recirculated from cylinder 61 to this feed pump. This connection is illustrated diagrammatically in Figure 2 of the drawing, and a similar arrangement with respect to the flow diagram of Figure 1 of the drawing is also illustrated in connection with that embodiment of the invention in that figure. As discussed above, by sucking the oil from the oil storage tank in this manner, and by deaerating the oil before recycling it, difficulties in feed of oil to the motor due to causes discussed above are largely eliminated.

Various modifications are possible within the scope of the invention, and we do not therefore wish to be limited except by the scope of the following claims.

We claim:

1. In an oil circulating and feeding system for motors, the combination comprising, a scavenge pump for removing oil from the motor, a centrifugal gas separator in the line of flow of oil from the scavenge pump, means for conducting oil under energy derived from said scavenge pump to a point adjacent the zone of discharge of oil from an oil storage tank, a Venturi connection between said conducting means and said storage tank adjacent said zone of discharge, a feed pump for impelling oil to said motor, and a conduit connecting said feed pump with said Venturi connection.

2. In an oil circulating and feeding system for

motors, the combination comprising, scavenge pump means for removing oil from the motor, an oil storage tank, a feed pump for feeding oil to the motor, means for conducting oil under energy derived from said scavenge pump to the suction side of said feed pump, means for directing oil flowing from said storage tank to the feed pump to and through a zone of confluence with oil flowing from said scavenge pump to said feed pump, said zone of confluence comprising an ejector connection for assisting in removal of oil from said storage tank, and thereby supplying oil to said feed pump under energy derived from said scavenge pump, while supplementing said oil supply with oil from said storage tank, said scavenge pump being driven by a source of power independent of that produced by the impelling of oil by said feed pump.

3. In an oil circulating and feeding system for motors, the combination comprising, a scavenge pump for removing oil from the motor, an oil cooler in the line of flow of oil from the scavenge pump, a centrifugal gas separator in the line of flow of oil from the scavenge pump and said oil cooler, said centrifugal gas separator being located beyond said oil cooler in the direction of flow of oil from said scavenge pump, means for conducting oil under energy derived from said scavenge pump to a point adjacent the zone of discharge of oil from an oil storage tank, a Venturi connection between said conducting means and said storage tank adjacent said zone of discharge, a feed pump for impelling oil to said motor, and a conduit connecting said feed pump with said Venturi connection.

4. In an oil circulating and feeding system for motors, the combination comprising, a scavenge pump for removing oil from the motor, a centrifugal gas separator in the line of flow of oil from the scavenge pump, an oil cooler in the line of flow of oil from said scavenge pump and said centrifugal gas separator, said oil cooler being located beyond said centrifugal gas separator in the line of flow of oil from said scavenge pump, means for conducting oil under energy derived from said scavenge pump through said oil cooler and to a point adjacent the zone of discharge of oil from an oil storage tank, a Venturi connection between said conducting means and said storage tank adjacent said zone of discharge, a feed pump for impelling oil to said motor, and a conduit connecting said feed pump with said Venturi connection.

5. An oil circulating and feeding system as defined in claim 3, in which said centrifugal gas separator is mounted directly in the oil storage tank.

6. An oil circulating and feeding system as defined in claim 3, in which said centrifugal gas separator comprises a stationary tank through which the oil is passed in a rotating motion, said stationary tank being mounted directly in the oil storage tank, and having an outlet for gas removed from the main body of the oil which is connected to the main storage space of said tank.

7. In an oil circulating and feeding system for motors, the combination comprising, a scavenge pump for removing oil from the motor, means for conducting oil under energy derived from said scavenge pump to a point adjacent the zone of discharge of oil from an oil storage tank, a Venturi connection between said conducting means and said storage tank adjacent said zone of discharge, a feed pump for impelling oil to said motor, and a conduit connecting said feed pump with said Venturi connection.

8. In an oil circulating and feeding system for motors, the combination comprising, scavenge pump means for removing oil from the motor, a gas separator in the line of flow of oil from said scavenge pump designed to receive and discharge said oil under pressure derived from the energy of said scavenge pump, an oil storage tank, a feed pump for feeding oil to the motor, means for conducting oil under energy derived from said scavenge pump to and through said gas separator and from said gas separator to and through a zone of confluence with oil flowing from said storage tank to said feed pump, said zone of confluence comprising an ejector connection for assisting in removal of oil from said storage tank, and thereby supplying deaerated oil to said feed pump under energy derived from said scavenge pump, while supplementing said oil supply with oil from said storage tank.

9. In an oil circulating and feeding system for motors, the combination comprising, scavenge pump means for removing oil from the motor, a gas separator in the line of flow of oil from said scavenge pump designed to receive and discharge said oil under pressure derived from the energy of said scavenge pump, an oil cooler in the line of flow of oil from said gas separator also designed to receive and discharge said oil under pressure, an oil storage tank, a feed pump for feeding oil to the motor, and means for conducting oil under energy derived from said scavenge pump to and through said gas separator and oil cooler and to said feed pump through a zone of confluence with oil from said storage tank, said zone of confluence comprising an ejector connection for assisting in removal of oil from said storage tank, and thereby supplying oil to said feed pump under energy derived from said scavenge pump, while supplementing said oil supply with oil from said storage tank.

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