Oct. 25, 1938. J. B. WATSON 2,134,161

LUBRICATING SYSTEM WITH TWO PUMPS

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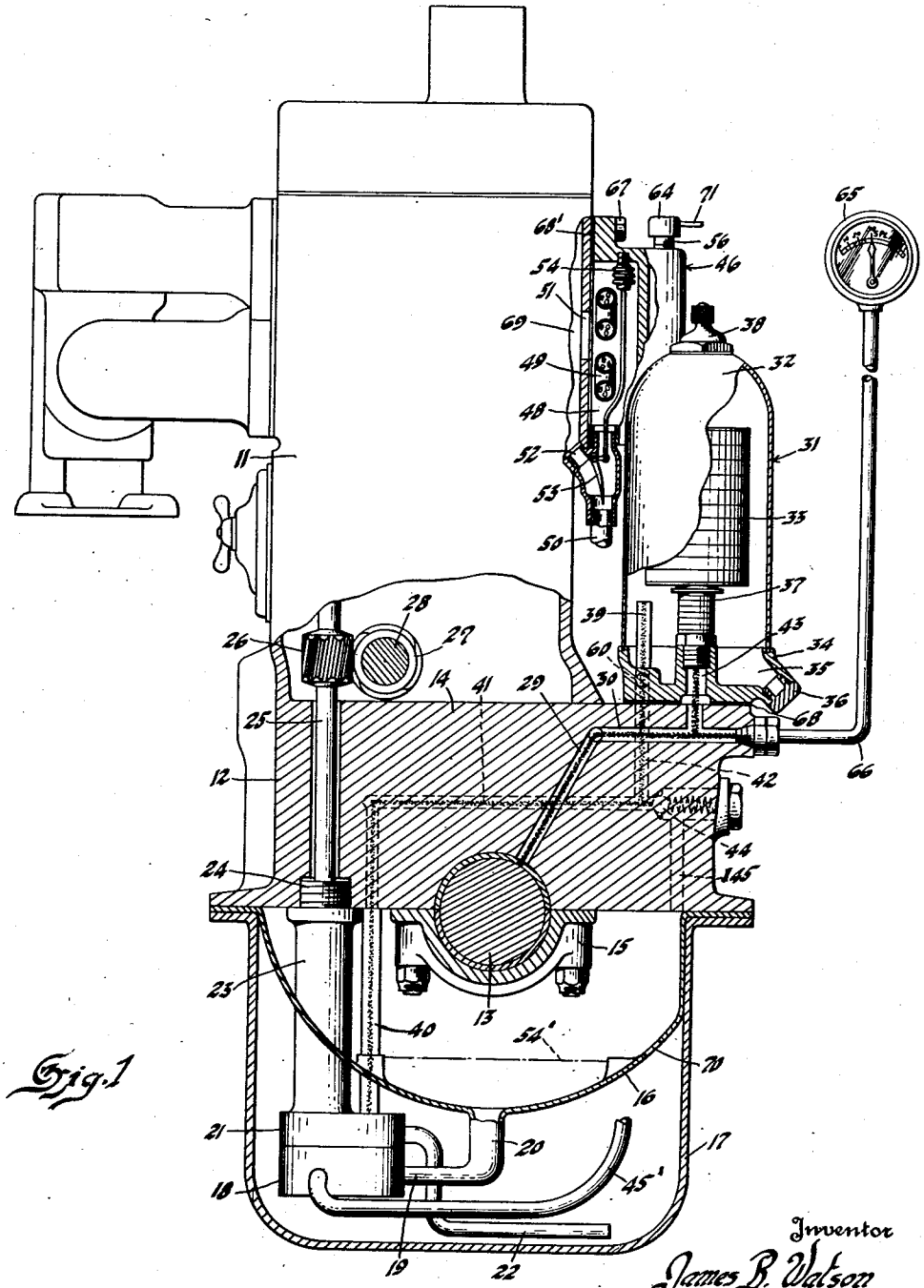


Fig. 1

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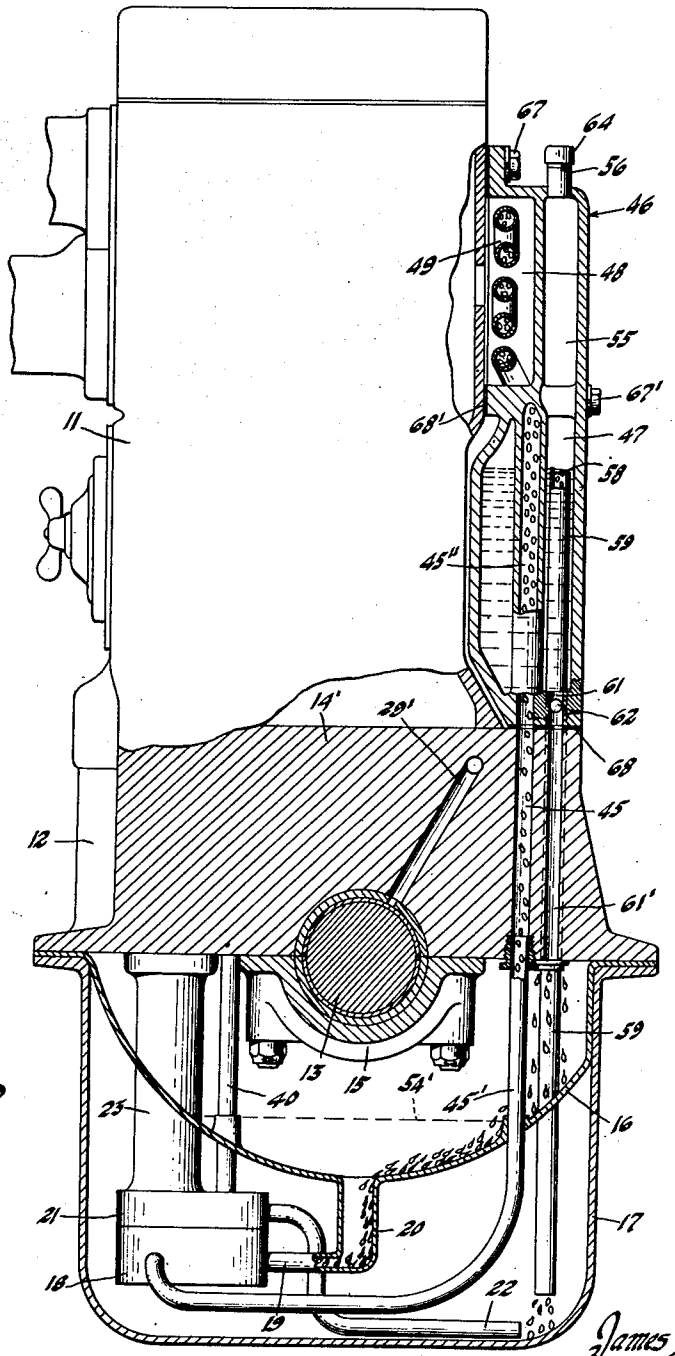


Fig. 2

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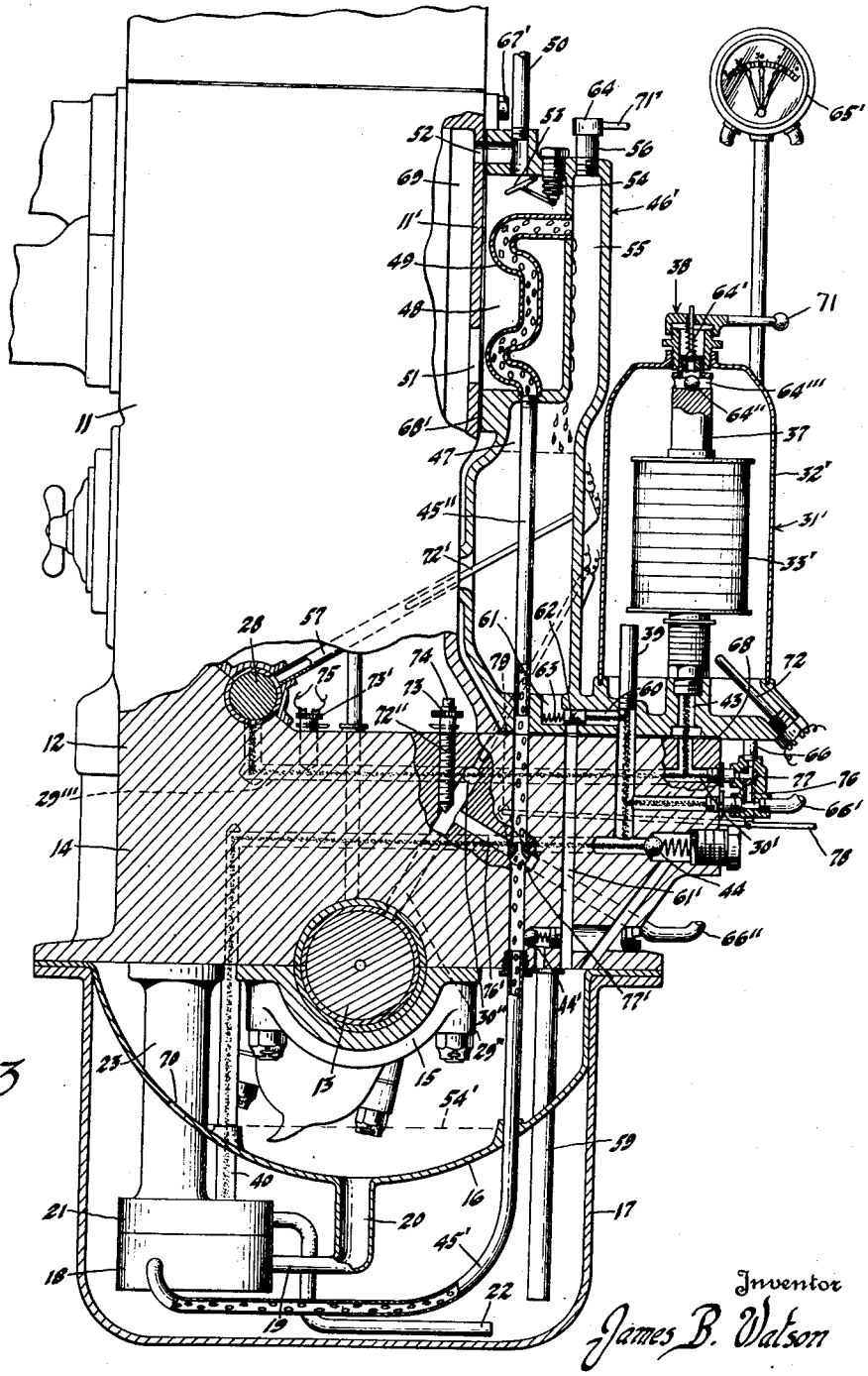


Fig. 3

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UNITED STATES PATENT OFFICE

2,134,161

LUBRICATING SYSTEM WITH TWO PUMPS

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Application May 20, 1929, Serial No. 364,473

53 Claims. (Cl. 184—6)

Being directed to the improvement of engine lubricating means and methods, this invention includes provision for "splash" lubrication through a warming-up period, the interval of splash lubrication being automatically terminated in favor of gravity or other lubrication through suitable conduits; and preferred embodiments of this invention may include a so-called low-pressure lubricating system and/or a high-pressure lubricating system, one or both of said systems being provided with means for a conditional or emergency return of lubricant into a so-called "splash" pan,—disposed within or below a crank case and below some or all of the lubricated bearings.

It is the further object of this invention to utilize a plurality of pumps, preferably provided with a common drive, in advancing oil through conduits comprised in separate systems of the general character referred to,—one of said pumps, hereinafter referred to as a "scavenger" pump, having its inlet connected with the mentioned splash pan, and the other of said pumps, hereinafter referred to as a "pressure" pump, having its inlet disposed below the normal level of oil within a suitable reservoir; and said reservoir may take the form of an additional pan, secured below said splash pan and adapted to receive oil pumped therefrom into a higher reservoir comprised in said low-pressure system.

Each of the mentioned systems may include not only a lower reservoir (such as one of the mentioned pans) but an upper reservoir maintained under a predetermined pressure; each of said systems may include either a means for controlling the temperature of the oil pumped from a lower reservoir or means for controlling the composition of oil so pumped, in advance of the delivery of the pumped oil toward bearings to be lubricated thereby; and preferred embodiments of this invention may include a low-pressure system in which oil is heated or cooled to a temperature favorable to the filtration, delivery and utilization thereof in said high-pressure system and means whereby, upon the failure of such delivery or the pumping of an excess of oil by either of the mentioned pumps, splash lubrication may be automatically restored or excess restored.

Other objects of this invention, including the provision of an externally carried unit and including also various optional details hereinafter referred to, may be best appreciated from the following description of an illustrative embodiment thereof, taken in connection with the appended claims and the accompanying drawings.

Fig. 1 is a somewhat diagrammatic transverse sectional view of an engine in which an embodiment of this invention is included,—parts being shown in elevation, and other parts being broken away or omitted, in order the better to show a high-pressure system in which oil, as withdrawn from a lower pan or reservoir, is normally advanced through a filter and thence into pressure conduits,—provision being made for a return of excess oil past a relief valve into a splash pan and stippling being arbitrarily employed to distinguish high-pressure conduits.

Fig. 2 is a view similar to Fig. 1, but taken in another vertical plane and showing parts of low-pressure conduits through which oil and/or a stream of oil and bubbles may be advanced from a splash pan sump through a temperature controlling coil into an elevated reservoir,—from which an excess of pumped oil may normally overflow into a reservoir below said splash pan. Parts are broken away to different levels.

Fig. 3 is an idealized and condensed view intended diagrammatically to illustrate all essential features presented in Figs. 1 and 2, together with some optional features of the present invention.

Referring first to Fig. 1, an engine comprising a block 11 and a crank case 12 is shown as including also a main crank shaft 13, supported by means comprising webs 14, 14' (which may be integral with casing 12) and semi-cylindrical bearings 15; and said crank case is shown as supporting also both an inner or "splash" pan 16 and an outer pan 17,—each of said pans being adapted to serve at times as an oil reservoir.

The crank case 12 may additionally support one or more pumps, such as a so-called "scavenger" pump 18, adapted to receive oil through an intake conduit 19 (connected with a sump 20, which is adapted to receive drainage from the splash pan 16) and a so-called "pressure" pump 21, provided with an intake 22, so positioned as to withdraw oil from the pan or reservoir 17. Both of said pumps may be supported by means such as a hollow cylindrical element 23, shown as threaded at 24 into the crank case web 14 and as providing bearings for a substantially vertical drive shaft 25. This drive shaft is shown as carrying a gear 26, engaged by a worm 27 upon a horizontal shaft 28,—which may be a usual cam shaft, or the like; but it should be understood that the manner of supporting and driving the mentioned pump or pumps is relatively immaterial to the present invention.

Pressure conduits 29, 29', in preference to being

directly connected with pump 21, are herein connected by conduit 30 with an oil reservoir comprised in a unit or assembly 31,—said reservoir preferably enclosing a filter. For example, a transparent receptacular element 32, enclosing a cylindrical or other filter assembly 33 may be retained upon a casting 34 (preferably providing a sediment trap 35, having an outlet opening 36) by means including a partly tubular laterally apertured filter-carrying outlet element 37 and an upper clamping element or pressure-determining organization 38; and a pipe 39, extending upward to a predetermined level in element 32, is shown as connected with feed conduits or passages 40, 41, 42, communicating with the pressure pump 21.

It will be obvious that any clogging of the filter 33, or its equivalent, during a continued delivery of oil by means such as the pump 21 might result in an undue rise in pressure within the pipe 39 and conduits 40—42, and in an undesirable drop in pressure within the oil delivery conduits 29, 30, etc.,—with which an outlet passage 43 connects the interior of the filter-supporting tubular element 37; and, accordingly, in case a filtering or other composition-control unit is interposed in the general manner described, means such as an adjustable pressure-relief valve 44, conditionally permitting a return of pumped oil through a by-pass 145, may be employed to relieve pressure and incidentally to restore splash lubrication whenever the pressures in the respective conduits mentioned fall outside of a predetermined range.

Referring more particularly to Fig. 2, and to the desirability of bringing oil to a standard temperature in advance of its filtration and/or delivery under high pressure, it will be seen that oil withdrawn from splash pan 16, or its equivalent, through the sump 20 and the scavenger pump 18 is intended to be advanced (as, by way of an interior riser 45 and conduits 45', 45'', comprised in the mentioned low-pressure system and communicating with the outlet of said scavenger pump) through a thermal-control or other conditioning unit 46 and/or a bubble-separating upper reservoir or low-pressure chamber 47, and thus indirectly into the lower pan or receptacle 17.

As may be seen from a comparison of Figs. 1 and 2, any thermal control-unit 46, or the like, as introduced into either or both of the mentioned circuits, may include an open-sided chamber 48, so positioned as normally to receive heat through an adjacent wall of the engine block 11; and said chamber may contain, in addition to a coil 49 with which the conduit 45'' communicates, cooling water admitted, in any desired proportion or at any desired rate, through a pipe 50,—which may communicate with a usual or special radiator or a part thereof; and the relative advance of cooled or heated water, if and as provided for, through the chamber 48 and any suitable opening 51 (which may communicate, as may also an alternative opening 52, with the cooling water passages of the engine block 11) may be varied, according to the thermal effect desired, by means such as a valve 53,—subject to manual manipulation or to control by a thermostatic element 54, or omitted under standardized conditions.

Subject to a slight fluctuation as a result of the reciprocation of pistons (not shown) and the operation of pumps, the pressure in one or both of pans 16, 17 may go but little below atmospheric, and the splash pan 16, or its equivalent, may initially contain oil up to a level such as that indicated by the line 54'. In Figure 2, a dump valve is assumed to have opened, upon a cessation of pumping. Operation of the scavenger pump 18 through a warming-up period may have promptly so lowered the said oil level in pan 16 as to discontinue splash lubrication and shortly thereafter advanced a mixture of oil and bubbles through a thermal-control unit of the described character,—the presence of the bubbles in the oil being highly favorable to a prompt transfer of heat to or from the oil; and the elevated separatory reservoir 47, into which the heated or cooled stream referred to may be permitted to splash, is shown as providing an upper space or compartment 55, having an outlet 56 for separated air,—presumably contaminated with fuel vapors, water, and products of combustion. Any desired proportion of the separated oil may be permitted to exit, as by way of low-pressure conduits 57 or other suitable conduits, toward bearings to be lubricated; but the major part, or any desired part, of the separated oil may be permitted continuously to overflow a dam or ledge 58 in such manner as promptly to descend, by way of a vertical or other conduit 59, into one of the mentioned pans (and preferably into lower pan 17 or an equivalent tempered-oil reservoir).

The illustrated interior disposition of conduits obviates tinkering; it also obviates clutter and affords assurance that any cooling system for the engine will tend to cool the oil; and, whether or not any low-pressure or high-pressure oil conduits 57 are directly connected therewith, the elevated separatory reservoir 47 (like the elevated filtration reservoir 32) may ordinarily remain filled to a high level during normal or "dry-sump" running periods,—wherein the pump 18 (preferably not pump 21) may pump streams of bubbles. It will thus be seen that, in any case, the described initial "splash" and/or low-pressure system may incidentally serve to bring the oil delivered by the scavenger pump 18 to a temperature suitable to its use and/or its advance through the filter 33 and into the high-pressure conduits 29, leading to engine bearings—such as those of the shaft 13—draining into the pan 16; and that the described low-pressure system may deliver oil into any desired warmed-oil conduits 57, conducting any desired proportion of a warmer and therefore more fluent oil (largely freed of vapors) to the mentioned bearings or to other bearings,—which may also drain into the splash pan 16, or its equivalent. After the engine is stopped, any oil in the pressure receptacle or filtration reservoir 32 may gradually advance, by gravity or otherwise, through the pressure conduits 29; and, if desired, means may be provided to assure a return, upon such stopping of the engine, of any oil then contained within the separatory chamber 47.

For example, as best shown in diagrammatic Fig. 3 (to which mentioned characters, in some cases primed, are applied, notwithstanding arbitrary differences in configuration and arrangement) a transverse passage 60, communicating with the inlet conduit 42 of the filtering or other composition control-unit 31' and with vertical or other drain passages 61, 61' below chamber 47, may be so controlled (as, by a laterally movable valve element 62, shown as provided with a compression spring 63 normally closing the upper end of the passage 61') that whenever pressure pump 21 ceases to operate, a resultant drop in

pressure within the conduit 42 may enable the spring 63 laterally to advance the valve element 62 in such manner as to empty the chamber 47 through the passages 61 and 61',—preferably delivering into splash pan 16.

It will be seen that not only drainage of oil from bearings such as those of the shaft 13, fed through high-pressure conduits 29, 29', and drainage from bearings such as those of shaft 28, shown as fed through a low-pressure conduit 57, but also the oil conditionally returned past either or both of the valves 44 and 62 may thus be permitted to accumulate in the inner or splash pan 16,—thereby assuring restoration of the initial oil level 54', in readiness for a restarting of the engine. Upon such restarting, even though the accumulated oil be undesirably viscous by reason of its low temperature, not only are interior parts adequately lubricated by splash but the oil, warmed by friction and by exposure of extensive surfaces, may be further thermally conditioned during its advance through the mentioned low-pressure system; and the indicated operation of the high-pressure system, described as including the pressure pump 21 and the composition-control unit 31', may thereafter assure an optimum delivery of the desired quantities of fresh or reconditioned oil at the desired temperatures and pressures to the respective bearings.

In connection with described features, any usual or preferred means may be employed for oil replenishment and/or crankcase ventilation; the capacity of scavenger pump 18 may exceed that of pump 21; and, as suggested in Fig. 3, in case an admixture of oil and "air" is permitted to enter the filter receptacle 32', or its equivalent, the clamping element or organization 38 may be provided with means assuring a predetermined "air" pressure within said receptacle; but, in view of the provision of valve 44, there is no actual necessity for delivering air in admixture with the oil advanced through conduit 40 by pump 21; and therefore no need for automatically controlling any exit for air entrapped to provide elastic pressure.

Upper reservoirs 32 and 47 may be sufficiently capacious to receive, during normal running, all the oil in both systems, said oil filling pan 16 to the level of line 54' during periods of rest; but, to emphasize an optional feature, pressure-controlled valve organizations are suggested at 64 and at 64', Fig. 3,—the latter being shown as associated with a level-controlled and upwardly-seated valve 64'', above lateral openings 64''', provided in the partly-tubular element 37. Although even the valve organization 64 is superfluous in case the low-pressure system is to operate under gravity, either or both of said organizations may comprise or serve as a cap which is removable for oil replenishment; either may be subject to remote or automatic control; and a glance at dash instruments during normal running may reliably reveal both the condition and the quantity of the oil in the pressure system or in both systems.

It will be obvious that a pressure gauge or gauges 65, 65' may be connected with any of the mentioned conduits,—as by means of elbow-fittings 66, 66', shown as respectively communicating with filter outlet and inlet passages provided in the crankcase casting. The gauge 65 will be seen to read in pounds or other units only up to a specific pressure (30 lbs. above atmospheric) at which splash lubrication may be automatically assured by automatic opening of the valve 44. No claims are herein drawn to the special novel gauges as illustrated at 65'; but it is believed to be highly advantageous to so connect gauge or gauges 65, 65' as to facilitate attachment and removal of unit 31 or 31',—without necessitating any disconnection of said gauge or gauges.

Low-pressure chambers 47, 48 and/or 55, in addition to conduits and passages such as 49, 60 and/or 61, may be provided directly in the casting 34,—shown as comprising sediment trap 35 and the body of the conditioning unit 46; and the entire unit 31, 31', with some or all of the mentioned chambers, conduits and/or passages and parts supported thereby may be normally retained by means such as screws or bolts 67, 67', suitably apertured rubber or like gaskets 68' being interposed.

The heat-exchange chamber 48 may be referred to as a five-walled chamber for the reason that one lateral wall thereof is shown as omitted, being provided for by a surface 11' of the engine block 11; and it will be seen that desired thermal effects upon the oil traversing coil 49 may be obtained by varying the advance of cooling water, as delivered by pipe 50,—advancing the same into a passage or passages 69, in a jacket provided by said block, either directly, by opening 52, or wholly or partly by way of chamber 48 and opening 51. The latter path is taken in case the oil tends to exceed a predetermined temperature range subsequently to an initial warming-up period, within which a splash lubrication may be gradually discontinued; but the provision of any overflow openings 70 in pan 16, the provision of a relief valve 44' in the low-pressure system, and also the provision of remote-manipulation arms 71, 71' on pressure control valves 64', 64, are among the features that should be regarded as entirely optional. Optional also is the use of any self-limiting or directly withdrawable electric or other thermal control elements 72, 72', 72'', provided in low-pressure or high pressure conduits (as, at 57 and 29'') leading to bearing elements, or provided in upper or lower filtering or receptacular elements,—as may be desired, in some seasons or in some climates, to effect a local and preliminary warming of certain portions of the oil even before the engine is started. Again, the use of any desired pointer-carrying or other feed-equalizing pressure varying-valve elements in the various conduits should be regarded as optional. Such elements are shown as special screws 73, 73',—adapted simultaneously or otherwise to vary a "choke" effect in separate and presumably parallel conduits of the general character shown at 29'' and 29''' as connected with conduit 30' through a longitudinal conduit 30''. The valves 73, 73', or equivalent "choke" elements, may occupy interior positions to obviate risk of unauthorized readjustment; and these valve elements themselves may be capable of being used as heaters or as coolers or in effecting tests or in effecting a control through automatic response to pressures and/or temperatures developed in the respective conduits which they control. For these reasons, the heads of the valve screws are shown as small gears; a pressure- or fluid-transmitting pipe is suggested at 74; and a thermal-couple or heating connection is shown at 75.

In order to apply exceptionally high pressures to "thick" oil, as at starting, it is additionally suggested in Fig. 3 that a by-pass or by-passes 76, 76' controlled by a suitable valve or valves 77, 77'

manipulable by rods, or a single rod 78 may be provided in such manner as to be available in giving a brief "double-pressure" effect,—subject to either manual or automatic control; either or both of the oil-conditioning devices 31', 46' may be so by-passed, automatically or at will. Valuable reverse-flow effects, adapted to clean the filter 33' or to correct other stoppage, may be thus obtained; a left-hand shift of the arm 79 of valve 77' may momentarily or permanently admit some bubbles from conduit 45' to receptacle 32', for a pressure effect; and, in any case, the use of special gauge 65', wherein a separate Bourdon tube may be connected with each of the pipes or elbows 66, 66', 66'', obviously favors economy of instruments and of space.

Although the foregoing description has included mention of various alternative and/or optional features, it should be understood not only that some of the mentioned features might be independently employed but that numerous further modifications might easily be devised,—all within the scope of the present invention.

I claim:

1. In means for lubricating an engine comprising bearings within a crankcase: a splash pan below said crankcase; a high-pressure system comprising a filter and conduits leading therefrom to some of said bearings; a heat-exchanging chamber; a bubble-separating chamber; means for advancing a stream of oil and bubbles through said heat-exchanging chamber into said bubble-separating chamber; and means for advancing the separated oil from said last mentioned chamber into said high-pressure system.

2. An organization of the general character defined in claim 1, which also includes means for a return of oil into said splash pan in case of deviation from a predetermined pressure range in said pressure system.

3. In means for lubricating an engine comprising bearings within a crankcase: means for an initial splash lubrication of said bearings; a low-pressure circulatory system for oil initially employed in such splash lubrication; and a high-pressure circulatory system into which said low-pressure circulatory system normally delivers such oil.

4. An organization of the general character defined in claim 3, in which one of said circulatory systems includes means for bringing the circulated oil to an optimum temperature.

5. An organization of the general character defined in claim 3, in which one of said circulatory systems includes a thermal-control unit and the other of said circulatory systems includes a composition-control unit.

6. In an internal combustion engine, a receptacle from which lubricant is adapted to be splashed by moving parts of the engine, means to withdraw lubricant from the receptacle, a receptacle into which the mentioned means is adapted to discharge lubricant, means to withdraw lubricant from the second-mentioned receptacle and advance it to the bearings, and conditionally operating means by which lubricant withdrawn from the first mentioned receptacle by the first mentioned means may be returned directly to the first mentioned receptacle and by which lubricant withdrawn from the second mentioned receptacle may be advanced to the first mentioned receptacle instead of to bearings.

7. In an internal combustion engine, a high pressure lubricating system, a low pressure lubricating system, means for advancing lubricant through each of the systems to bearings, a reservoir from which lubricant is adapted to be splashed by moving parts of the engine, a reservoir in one of the systems located above the level of the first mentioned reservoir, a passage connecting the two reservoirs and a valve in the passage operated by a decrease in the pressure in the system in which the second mentioned reservoir is not located to drain lubricant from the second mentioned reservoir to the first mentioned reservoir when operation of the engine ceases.

8. In a lubricating system, upper and lower reservoirs, means to withdraw lubricant from the lower reservoir and deliver it to the upper reservoir, and means operative to retain lubricant in the upper reservoir during operation of the first mentioned means and to permit return thereof to the lower reservoir when the first mentioned means ceases operating.

9. In a lubricating system, a circuit including a reservoir from which lubricant is adapted to be splashed onto bearings, a circuit to which lubricant is adapted to be delivered from the first mentioned circuit and from which lubricant is adapted to be delivered to bearings, and means whereby lubricant from the first mentioned circuit may be returned to the reservoir instead of being delivered to the second mentioned circuit.

10. In a lubricating system, a circuit including a reservoir from which lubricant is adapted to be splashed onto bearings, a circuit to which lubricant is adapted to be delivered from the first mentioned circuit and from which lubricant is adapted to be delivered to bearings, and means whereby lubricant from the second mentioned circuit may be returned to the reservoir instead of being delivered to the bearings.

11. In an internal combustion engine, a reservoir in which lubricant is adapted to accumulate while the engine is not operating, parts which move during the normal operation of the engine and are adapted initially to agitate the lubricant in the reservoir and supply lubricant to parts to be lubricated by splash, a second reservoir, a pump adapted to withdraw lubricant from the first-mentioned reservoir and deliver it to the second-mentioned reservoir after the lubricant has become sufficiently fluid and a pump adapted to withdraw lubricant from the second-mentioned reservoir and deliver it to parts to be lubricated.

12. The invention claimed in claim 11 plus an oil temperature regulator in the circuit between the first and second-mentioned reservoirs.

13. The invention claimed in claim 11 plus a filter in the circuit between the second-mentioned reservoir and the parts to be lubricated.

14. The invention claimed in claim 11 plus an oil temperature regulator in the circuit between the first and second-mentioned reservoirs and an oil filter in the circuit between the second-mentioned reservoir and the parts to be lubricated.

15. The invention claimed in claim 11 in which the first-mentioned pump is adapted to remove lubricant from the first-mentioned reservoir at such a rate as to render the splash system substantially ineffective during normal operation of the engine.

16. Engine lubricating means comprising: oil conduits; means for advancing a stream of admixed oil and bubbles; and means for utilizing said bubbles in conditioning said oil and in producing a desired pressure within said conduits.

17. In an engine, a reservoir from which lubricant may be splashed onto bearings, a lubricant temperature regulator, a chamber in which gase-

ous bodies may be separated from lubricant, means which during its normal operation renders the splash system ineffective for withdrawing lubricant and gaseous bodies from the reservoir and advancing a stream of lubricant and gaseous bubbles through the regulator into the chamber, a second reservoir, means for conducting lubricant from the chamber to the second reservoir, means for separating solids from the lubricant, and means for withdrawing lubricant from the second reservoir and advancing it through the last mentioned means to bearings of the engine.

18. In an engine, two reservoirs, a lubricant temperature regulator, means for withdrawing lubricant and enough gaseous bodies to expedite considerably transfer of heat to or from the lubricant from one of the reservoirs and advancing the mixture through the regulator toward the other reservoir, and means for withdrawing lubricant from the last mentioned reservoir and advancing it toward bearings of the engine.

19. In an engine, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, a lubricant temperature regulator, means for drawing lubricant and enough gaseous bodies to expedite considerably transfer of heat to or from the lubricant out of the first mentioned reservoir and advancing the mixture through the regulator toward the second reservoir, and means for drawing lubricant out of the last mentioned reservoir and advancing it toward bearings of the engine.

20. In an engine, two lubricant reservoirs, means for withdrawing lubricant from one of the reservoirs and advancing it toward the other reservoir, a lubricant conditioning element, means for withdrawing lubricant from the last mentioned reservoir and advancing it through the lubricant conditioning element toward bearings of the engine, and means whereby the lubricant may be returned to one of the reservoirs instead of being delivered to the bearings.

21. In an engine, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, means for withdrawing lubricant from the first mentioned reservoir and advancing it to the second reservoir and thence to bearings, and means whereby the lubricant may be returned to the first mentioned reservoir instead of being delivered to the bearings.

22. In an engine, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, means for withdrawing lubricant from the first mentioned reservoir and delivering it to the second reservoir, a third reservoir, means for conducting lubricant from the second reservoir to the third reservoir, means for withdrawing lubricant from the third reservoir and advancing it toward bearings and means whereby the lubricant may be returned to the first mentioned reservoir instead of being delivered to the bearings.

23. In a lubricating system, a low pressure lubricating circuit, including bearings and a lubricant pump, a high pressure lubricating circuit including bearings and a lubricant pump, means establishing communication between the two circuits, and a lubricant reservoir in one of the circuits so located that lubricant may be splashed therefrom onto one of the bearings.

24. In a lubricating system, a low pressure lubricating circuit, including bearings and a lubricating pump, a high pressure lubricating circuit including bearings and a lubricating pump, means establishing communication between the two circuits, a lubricant reservoir in one of the circuits so located that lubricant may be splashed therefrom onto one of the bearings, and means rendering the effectiveness of the splash system dependent upon the effectiveness of the pressure system.

25. The invention claimed in claim 18 plus means between the regulator and the last mentioned reservoir for separating gaseous bodies from the lubricant.

26. The invention claimed in claim 19 plus means between the regulator and the last mentioned reservoir for separating gaseous bodies from the lubricant.

27. A lubricating system for an internal combustion engine and including a crankcase adapted for storing a supply of lubricant, a splash pan, means circulating lubricant through said lubricating system under pressure, and means responsive to a predetermined fall of pressure in said lubricating system for draining a portion of said lubricant into said splash pan.

28. In an engine a lubricating system including a crankcase adapted for storing a supply of lubricant, a splash pan adapted for storing lubricant during idle periods of the engine for use in lubricating moving parts of the engine during the initial operation of the engine, said lubricating system including a pump and lubricant conducting portions for conducting lubricant under pressure to engine parts to be lubricated, and valve means intermediate said pump and conducting portions responsive to engine operation for placing the pressure side of said pump in communication with the system during engine operation and for diverting lubricant from said lubricating system to said splash pan on stopping the engine.

29. In an engine lubricating system, a splash pan, a lubricant supply means through which a lubricant may be conducted under pressure to engine parts to be lubricated, a lubricant reservoir separate from said lubricant supply means and having an inlet and outlet, and valve means actuated in response to a fall in pressure in said lubricant supply means for opening said reservoir outlet whereby to drain the contents thereof into said splash pan when the engine stops.

30. In the lubrication art, the operations of introducing enough gaseous bubbles into lubricant to expedite considerably the transfer of heat to or from it and passing the mixture through a heat exchange element before applying it to the parts to be lubricated.

31. In the lubrication art, the operations of introducing enough bubbles of air into lubricant to expedite considerably the transfer of heat to or from it, passing the mixture through a heat exchange element, separating the air from the lubricant, and, thereafter, applying the lubricant to the parts to be lubricated.

32. In a lubricating system, a heat exchanger, means for introducing enough bubbles of air into lubricant to expedite considerably the transfer of heat to or from it and advancing the mixture through the heat exchanger, and means for separating the air from the lubricant before the lubricant is advanced to the parts to be lubricated.

33. In a lubricating system, a heat exchanger, and a pump which sucks lubricant and enough air to expedite considerably the transfer of heat to or from the lubricant and advances the mixture through the heat exchanger.

34. In a lubricating system, a heat exchanger, means for introducing enough bubbles of air into

lubricant to expedite considerably the transfer of heat to or from it and advancing the mixture through the heat exchanger, and means for advancing the lubricant to parts to be lubricated after it has passed through the heat exchanger.

35. In a lubricating system, a heat exchanger, means for introducing enough bubbles of air into lubricant to expedite considerably the transfer of heat to or from it and advancing the mixture through the heat exchanger, and means for separating the air from the lubricant and, thereafter, advancing the lubricant to parts to be lubricated.

36. In a lubricating system, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, means for withdrawing lubricant from the first-mentioned reservoir and advancing it to the second reservoir and thence to bearings, means whereby lubricant may be returned to the first-mentioned reservoir instead of being delivered to the bearings, and a valve actuated by the pressure of lubricant in the system controlling the last-mentioned means.

37. In a lubricating system, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, means for withdrawing lubricant from the first-mentioned reservoir and advancing it to the second reservoir, means for advancing lubricant from the second reservoir to bearings, means whereby lubricant may be returned to the first-mentioned reservoir instead of being delivered to the bearings, and a valve actuated by the pressure of the lubricant in the system between the second-specified means and the bearings controlling the last-specified means.

38. A lubricating system for an internal combustion engine including a crankcase adapted for storing a supply of lubricant, a splash pan, and means actuated in response to a predetermined pressure drop in said lubricating system for replenishing the supply of lubricant in said splash pan.

39. In a lubricating system for an internal combustion engine consisting of means for conducting a lubricant under pressure to engine parts to be lubricated, splash lubricating means adapted for operation during the initial engine operation, and means responsive to the engine operation for selectively effecting flow of lubricant to the lubricant conducting means during engine operation and to said splash lubricating means on stopping the engine.

40. In a lubricating system for an internal combustion engine consisting of means for conducting a lubricant under pressure to engine parts to be lubricated, splash lubricating means adapted for operation during the initial engine operation, and valve means automatically responsive to lubricant pressure for selectively effecting flow of lubricant to the lubricant conducting means during engine operation and to said splash lubricating means on stopping the engine.

41. In an engine, a lubricating system including a crankcase adapted for storing a supply of lubricant and a lubricant conducting means for conveying lubricant to engine parts to be lubricated, a splash pan, means circulating lubricant through the lubricant conducting means under pressure, and means for draining lubricant from said conducting means into said splash pan on stopping the engine, whereby to provide a supply of lubricant for splashing during the initial operation of the engine.

42. In an engine, a lubricating system including a crankcase adapted for storing a supply of lubricant, a splash pan adapted for storing lubricant during idle periods of the engine for use in lubricating moving parts of the engine during the initial operation of the engine, means circulating lubricant through said lubricating system under pressure during engine operation, and means responsive to fall of pressure in said lubricating system for replenishing said splash pan with lubricant.

43. In an engine, a lubricating system including a crankcase adapted for storing a supply of lubricant, a splash pan adapted for storing lubricant during idle periods of the engine for use in lubricating moving parts of the engine during the initial operation of the engine, and valve means associated with said lubricating system and responsive to engine operation for diverting lubricant from said lubricating system to said splash pan on stopping the engine.

44. An engine having a crankshaft, a lubricating system therefor including a crankcase for storing a supply of lubricant and means for circulating lubricant through said system under pressure, a splash pan underlying said crankshaft and adapted for storing lubricant during idle periods of the engine for use in lubricating moving parts of the engine during initial operation of the engine, and means responsive to the fall of pressure in said lubricating system for replenishing said splash pan with lubricant when the engine stops.

45. A lubricating system for engines having a crankcase for storing lubricant, a splash pan adapted to store lubricant for use in lubricating engine parts during initial engine operation, and means responsive to the lubricant pressure produced in said system by engine operation for replenishing the supply of lubricant in said splash pan when a predetermined minimum pressure is reached in said lubricating system.

46. A lubricating system for engines having a crankcase for storing lubricant, a splash pan adapted to store lubricant for use in lubricating engine parts during initial engine operation, lubricant conducting means communicating with said system and terminating in relation to said splash pan to deposit lubricant in said splash pan, and valve means controlling lubricant flow through said conducting means, said valve means responsive to the lubricant pressure produced in said system by engine operation for opening said lubricant conducting means when a predetermined minimum pressure is reached in said lubricating system whereby to replenish the lubricant supply in said splash pan.

47. In an engine, a lubricating system including a crankcase adapted for storing a supply of lubricant and a lubricant conducting means for conveying lubricant to engine parts to be lubricated, a splash pan adapted for storing lubricant during idle periods of the engine for use in lubricating moving parts of the engine during the initial operation of the engine, means inducing a flow of lubricant through said lubricant conducting means, and means operable to drain lubricant from said lubricant conducting means on stopping the engine for replenishing said splash pan with lubricant.

48. In an engine lubricating system, a splash pan, a lubricant supply means through which a lubricant may be conducted under pressure to engine parts to be lubricated, a lubricant reservoir separate from said lubricant supply means and having an inlet and outlet, and valve means

actuated in response to a predetermined pressure drop in said lubricant supply means for opening said reservoir outlet whereby to drain the contents thereof into said splash pan.

49. In an engine lubricating system including lubricant conducting means, a lubricant reservoir separate from said lubricant conducting means, a splash pan adapted for storing lubricant to be splashed on engine parts to be lubricated during the initial operation of the engine, and means for draining the contents of the reservoir into said splash pan on stopping the engine.

50. In an engine lubricating system including lubricant conducting means, a splash pan adapted for storing lubricant to be splashed on engine parts to be lubricated during the initial operation of the engine, and means separate from the lubricant conducting means for refilling said splash pan with lubricant on stopping the engine.

51. In an engine, a reservoir from which lubricant may be splashed onto bearings, a second reservoir, means for drawing lubricant out of the first-mentioned reservoir and advancing it toward the second reservoir, means for drawing lubricant out of the second reservoir and advancing it toward bearings of the engine, a lubricant conditioning element through which lubricant passes on its way from the second reservoir toward bearings and means whereby the lubricant may be returned to the first-mentioned reservoir instead of being delivered to the bearings.

52. The method of bringing a liquid to a desired temperature condition which consists of introducing into the liquid enough gaseous bubbles to expedite considerably the transfer of heat to or from the liquid and advancing the mixture of liquid and gaseous bubbles bodily through a heat exchanger in heat exchanging relation with a hotter or colder medium.

53. In apparatus for bringing a liquid to a desired temperature condition, a heat exchanger with a passage in it through which liquid is constrained to flow in a confined stream, and means for introducing into the liquid enough gaseous bubbles to expedite considerably the transfer of heat to or from the liquid and advancing the mixture of liquid and gaseous bubbles bodily through the mentioned passage in the heat exchanger in heat exchanging relation with a hotter or colder medium.

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