Nov. 8, 1960 C. JANEWAY ET AL 2,959,164

INTERNAL COMBUSTION ENGINES

Filed July 16, 1958 3 Sheets-Sheet 1

FIG. 1

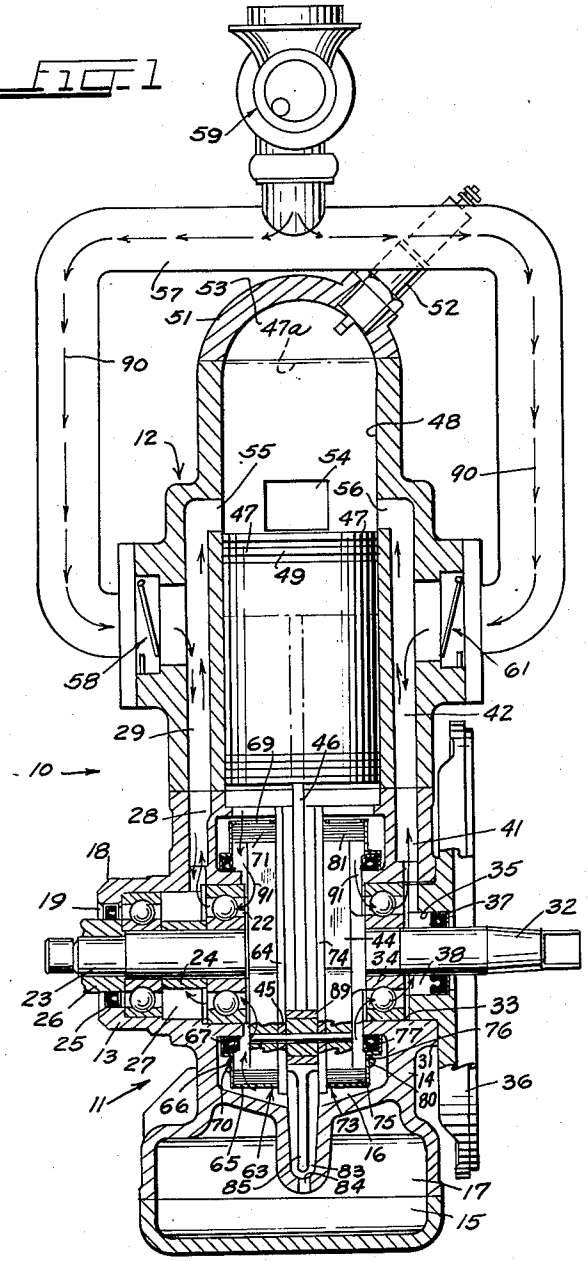
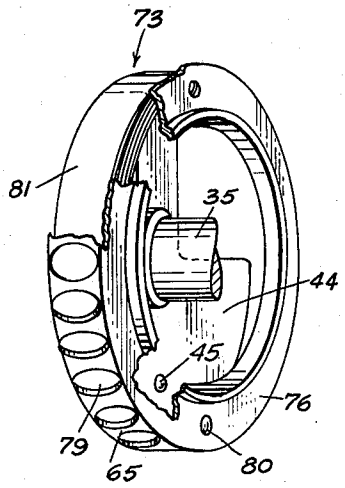


FIG. 2



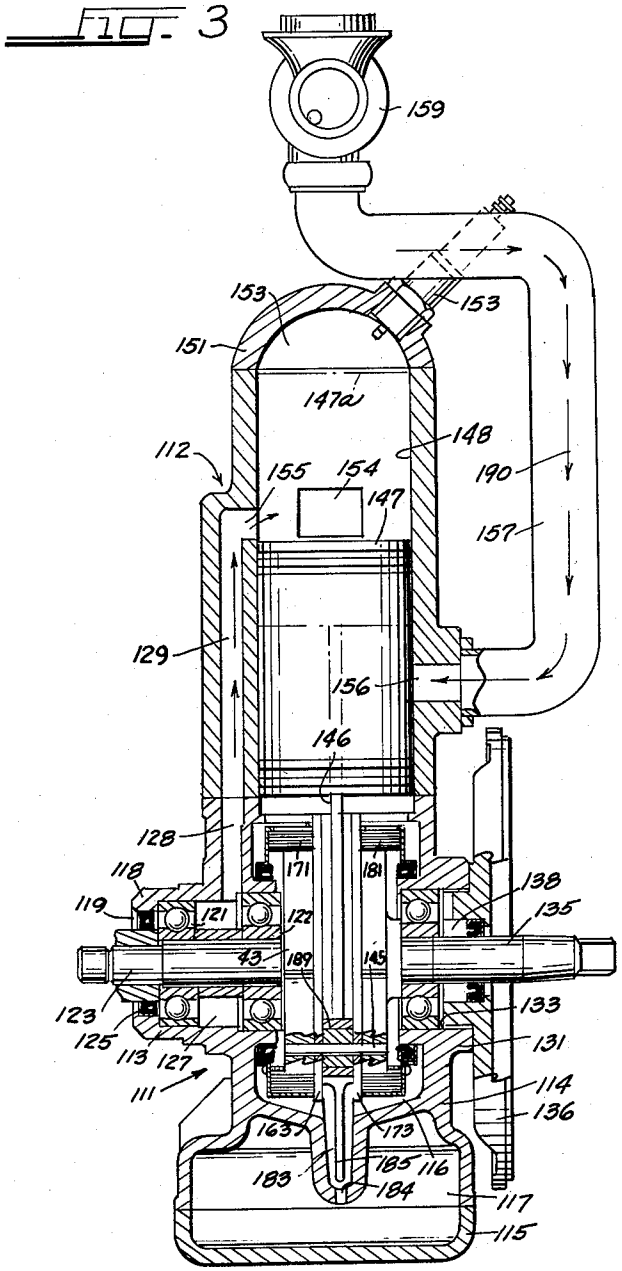
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FIG. 3



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INTERNAL COMBUSTION ENGINES

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FIG. 5

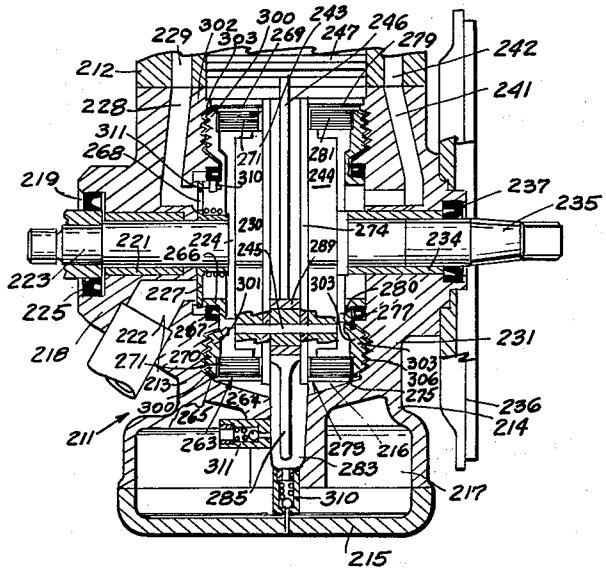
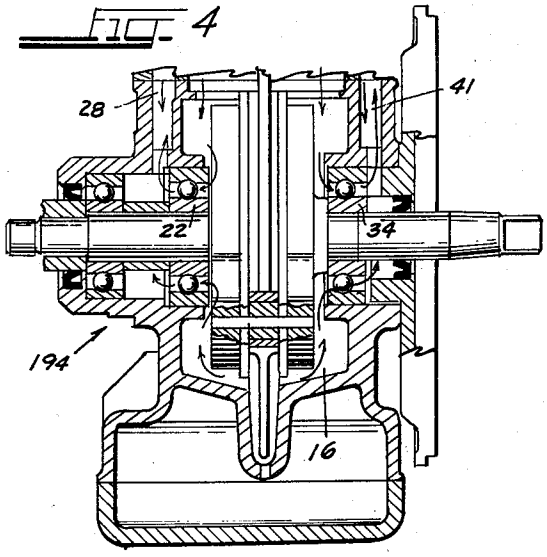


FIG. 4



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United States Patent Office

2,959,164

Patented Nov. 8, 1960

2,959,164

INTERNAL COMBUSTION ENGINES

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Filed July 16, 1958, Ser. No. 748,931

6 Claims. (Cl. 123—73)

This invention relates to two-cycle internal combustion engines. More particularly, the invention relates to a method and apparatus for lubricating and fueling internal combustion engines of the two-cycle variety.

The lubrication of two-cycle internal combustion engines presents a number of difficulties and problems. The most commonly used lubrication arrangements, in engines of this kind, rely upon the admixture of a lubricant with the fuel for the engine. In arrangements of this kind, the lubricant passes into the firing chamber of the engine, where it is expected that the lubricant will be burned along with the fuel. Frequently, however, portions of the lubricant are not completely burned, with the result that carbon deposits are formed within the combustion chamber. These carbon deposits frequently interfere with proper operation of the engine, particularly where the deposits form upon and adjacent to the electrodes and other elements of the spark plugs. These carbon deposits often make it necessary to dismantle the engine at relatively frequent intervals in order to permit removal of the carbon deposits.

An important advance in the field of lubrication of two-cycle internal combustion engines is presented in the copending application of William P. Dalrymple, Serial No. 372,825, filed August 7, 1953, now Patent No. 2,893,362. The invention described in the Dalrymple application includes a lubricating system, for two-cycle internal combustion engines, which does not require mixing of lubricant with the fuel. Instead, in the Dalrymple invention, a separate supply of lubricant is maintained in a crankcase associated with the engine and is delivered directly from the crankcase to the moving parts of the engine. An important feature of the Dalrymple engine is a rotary oil separator which is interposed between the firing chamber of the engine and the crankcase. This rotary separator is effective to remove entrained oil or other lubricant from the fuel and air mixture before that mixture is supplied to the firing chamber of the engine. Thus, the Dalrymple invention affords a substantial advance in the art of two-cycle engines in that it provides for effective and economical lubrication of the engine without requiring the mixing of a lubricant with the fuel supplied to the engine.

The present invention is in some respects complementary to that of the Dalrymple application, and may be combined with the Dalrymple invention to afford even more efficient lubrication of a two-cycle engine without requiring the admixture of lubricant and fuel. Accordingly, a primary object of the invention is to afford improved lubrication in a two-cycle internal combustion engine of the kind having separate fuel and lubricant supplies. Furthermore, it should be noted that this attribute of the invention extends to two-cycle engines which are substantially different from the aforementioned Dalrymple engine.

In two-cycle engines of the kind having separate fuel and lubricant supplies, some of the lubricant may nonetheless become entrained with the fuel and air mixture to be supplied to the combustion chamber of the engine. Accordingly, another important object of the present invention is to remove this entrained oil or other lubricant more efficiently and effectively than has heretofore been possible. Another, and related object of the invention, is to prevent dilution of the lubricant supply with fuel from the fuel and air mixture.

Another factor of substantial importance in connection with internal combustion engines relates to fuel economy. Fuel economy is to a substantial extent dependent upon the extent to which the liquid fuel, usually gasoline, is effectively vaporized before it is introduced into the combustion chamber of the engine. Accordingly, an additional object of the invention is to atomize or vaporize the fuel in the fuel-air mixture more effectively and efficiently than has heretofore been possible in two-cycle engines of relatively simple construction. Another object of the invention is to achieve the aforementioned atomization of the fuel in an apparatus which is also effective to remove entrained oil or other lubricants from the fuel-air mixture.

Another problem with which the present invention is concerned relates to the bearings of a two-cycle internal combustion engine. As in any engine or similar device, the bearings may tend to overheat in operation, particularly if not properly lubricated. A further object of the invention, therefore, is to provide for lubrication and cooling of the bearings as a part of the normal operation of the engine and without requiring separate special apparatus for this purpose. A related and more specific object of the invention is to cool and lubricate the bearings in a two-cycle internal combustion engine by means which also tend to reduce the amount of lubricant delivered to the combustion chamber of the engine.

Yet another object of the invention is to provide a new and improved two-cycle internal combustion engine which is highly effective and efficient in operation, yet which is of relatively simple and economical construction.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show a preferred embodiment of the present invention and the principles thereof and what is now considered to be the best mode for applying those principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a partially sectional elevation view of a single cylinder two-cycle internal combustion engine constructed in accordance with one embodiment of the invention;

Fig. 2 is a perspective view of a rotary separator member incorporated in the engine of Fig. 1;

Fig. 3 is a sectional elevation view, similar to Fig. 1, of a two-cycle internal combustion engine constructed in accordance with another embodiment of the invention;

Fig. 4 is a sectional elevation view of the crankcase of a two-cycle internal combustion engine constructed in accordance with a somewhat different embodiment of the invention;

Fig. 5 is a sectional elevation view of the crankcase portion of a two-cycle internal combustion engine constructed in accordance with yet another embodiment of the invention.

The two-cycle internal combustion engine 10 is shown in partially section elevation in Fig. 1, which comprises one embodiment of the present invention, includes a

crankcase 11 upon which a cylinder 12 is mounted. The crankcase 11 includes two housing sections 13 and 14 which are located upon the left and right hand sides of the crankcase as seen in Fig. 1. The two housing sections 13 and 14 are joined to each other and to a base section 15 by suitable mounting means, such as bolts or the like (not shown). Suitable gaskets are interposed between the three sections of the crankcase housing to seal the crankcase or lubrication chamber 16 and the oil or other lubricant reservoir 17.

The crankcase housing section 13 is provided with a projection portion or boss 18 having an internal opening 19 within which a pair of bearings 21 and 22 are mounted. Preferably, the bearings 21 and 22 are of the anti-friction type and may constitute suitable roller bearings or, as illustrated, ball bearings. The crankshaft 23 of the engine 10 is journaled in the bearings 21 and 22, and a sleeve 24 is mounted on the shaft 23 between the bearings to maintain the bearings in spaced-apart relation on the shaft. A conventional packing or seal 25 is mounted upon a sleeve 26 on the outboard portion of the crankshaft 23 and serves to seal off the crankcase chamber 16 and to prevent leakage, past the bearings 21 and 22, to the surrounding air. The space or chamber 27 separating the two bearings 21 and 22 communicates with a transfer passage 28 in the upper portion of the crankcase housing section 13. The transfer passage 28, in turn, is connected to a transfer passage 29 in the cylinder 12 of the engine, for a purpose set forth in detail hereinafter.

The crankcase housing section 14 is provided with a projection portion or boss 31 which is similar to but somewhat smaller than the boss 18. The two bosses 18 and 31 are aligned with each other along a common axis 32 which comprises the axis of the crankshaft of the engine 10. The boss 31 is provided with an aperture or bore 33 within which a bearing 34 is mounted. Like the bearings 21 and 22, the bearing 34 is preferably of the anti-friction type and may comprise either a roller bearing or, as illustrated, a ball bearing. In the illustrated embodiment of the invention, a crankshaft extension 35 is journaled in the bearing 34, being disposed in coaxial alignment with the crankshaft 23. Preferably, a flywheel 36 is mounted upon the crankshaft extension 35. A conventional packing member or seal 37 is mounted on the shaft 35 in engagement with the shaft and the flywheel 36 to afford a seal for the crankcase chamber 16 and prevent leakage from the crankcase chamber along the shaft extension 35. An open chamber or passageway 38 encompasses the shaft 35 intermediate the bearing 34 and the seal 37. This chamber 38 communicates with a transfer passage 41 in the upper portion of the crankcase housing section 14. The transfer passage 41, in turn, is connected to a second transfer passage 42 in the cylinder portion 12 of the engine.

A pair of crank arms 43 and 44 are mounted upon the crankshaft 23 and the crankshaft extension 35, respectively. The two crank arms 43 and 44 are interconnected by a crank pin 45 upon which the lower end of a connecting rod 46 is mounted. The crank arms 43 and 44 are provided with suitable counter-weights in accordance with the usual practice. The connecting rod 46, at its upper end, is pivotally connected to a piston 47 which is disposed within the internal bore 48 of the cylinder 12. The piston 47 is of conventional construction and may be provided with a plurality of piston rings 49 which engage the inner wall of the cylinder to afford a seal between the cylinder and the piston. The upper portion of the bore 48 is closed by the usual domed cylinder head 51 which may be bolted or otherwise suitably secured to the upper end of the cylinder 12. A spark plug 52 is mounted within an aperture in the cylinder head 51 and extends therethrough into the combustion chamber 53 defined by the cylinder head 51 and the upper portion of the cylinder 12.

In Fig. 1, the cylinder 47 is shown in solid lines at its lowermost position of movement within the cylinder bore 48, this position corresponding to the beginning of a compression stroke of the engine. The piston is also shown in dash outline at 47A at the uppermost limit of its travel within the cylinder, the position 47A corresponding to the end of the compression stroke. With the piston in the position shown in solid lines, at the beginning of the compression stroke, three ports 54, 55 and 56 are exposed within the cylinder. When the piston is in the position indicated by dash outline 47A, on the other hand, the skirt or body portion of the piston covers all three of the ports 54–56. Indeed, the ports 54–56 are closed during the major portion of the operating cycle of the engine, since upward movement of the piston starts to close the ports almost immediately as the piston leaves its bottom dead center position.

The port 55 is connected to the transfer passage 29 and thus to the crankcase transfer passage 28. In addition, the intake port 55 is also connected to a fuel conduit or manifold 57 through a moving-vane check valve 58. The manifold 57, in turn, communicates with the carburetor 59 of the engine. The carburetor may be of any conventional type and therefore need not be described in detail in this specification.

The port 56 is also an intake port for the engine and is connected to the transfer passageways 42 and 41. In addition, the intake port 56 is connected to the manifold 57 through a second check valve 61. It should be understood that the vane-type check valves 58 and 61 shown in Fig. 1 are illustrative only and that any other suitable check valve construction may be employed if desired.

The port 54 comprises an exhaust port for the engine, and may be connected to any suitable exhaust conduit.

The lubrication system of the internal combustion engine 10 is in many respects substantially similar to that described and claimed in the aforementioned application of William P. Dalrymple. A first rotary separator 63 is mounted upon the crankshaft 23 for rotation therewith. The rotary separator 63 comprises an imperforate disc or plate 64. A rim or flange member 65 is secured to the plate 64, and an extension portion 66 of the flange 65 supports a conventional line-type sealing member 67 in sealing engagement with an internal extension portion 68 of the crankcase housing boss 18. The flange or rim member 65 is provided with a plurality of apertures 69, as best shown in Fig. 2. The rotary separator 63 is mounted on the shaft 23 for rotation therewith, as by a series of screws 70 which secure the flange member 65 to the crank arm 43 and its associated counterweight.

The rotary separator 63 further includes a lubricant separation barrier 71. The barrier 71 may be formed from felt, sintered metal, or other porous material, as described in the aforementioned Dalrymple application. Preferably, however, the barrier is constructed from a plurality of layers of extremely fine mesh material in the manner described and claimed in the copending application of Max W. Kistler, Serial No. 748,930, filed concurrently herewith. Typically, the barrier may be constructed from approximately 30 layers of standard 100 mesh copper or other corrosion-resistant screen with the individual layers in random alignment with respect to each other. By reference to Fig. 1, it is seen that the barrier 71 of the oil separator 63 is effectively interposed between the bearing 22 and the crankcase or lubrication chamber 16. Consequently, the only path of communication from the transfer passage 28 into the crankcase chamber 16 extends through the bearing 22 and also through the barrier portion 71 of the rotary oil separator 63.

A second similar rotary oil separator 73 is mounted upon the extension crankshaft 35. The separator 73 comprises a face disc or plate 74, a flange member 75 having an extension portion 76, and a line-type seal 77 which is mounted upon the flange extension 76 and which engages an internal portion 78 of the boss 31 on the

crankcase housing section 14. The oil separator flange 75 is provided with a series of peripheral openings 79. The separator is suitably mounted for rotation with the shaft 35, as by the screws 80. Moreover, the oil separator includes a porous barrier layer 81 which is substantially similar to the barrier 71 in the separator 63. Thus, the oil separator 73 is interposed between the crankcase chamber 16 and the transfer passage 41, so that the only path of communication between the transfer passage and the crankcase chamber is through the bearing 34 and the barrier portion 81 of the rotary separator.

At the base of the crankcase chamber 16 the bottom wall of the crankcase chamber is extended downwardly to form a lubricant well 83. Communication between the well 83 and the oil reservoir 17 is provided by a small aperture 84, preferably located at the base of the sump. A finger member 85 is mounted upon the collar 89 of the connecting rod 46 in position to dip into the well 83 to pick up oil from the well and supply it to the operative parts of the engine.

The engine 10 may initially be set in motion by a conventional form of starter, including manually operable means. In the ensuing description of operation of the engine, it is assumed that rotation of the engine is commenced with the piston 47 located at the lowermost point on its reciprocatory path of motion, as shown in the solid lines of Fig. 1.

Starting from the assumed position, rotation of the crankshaft 23, 35 drives the piston 47 upwardly through the cylinder bore 48 to the position illustrated in dash outline at 47A. As the piston moves upwardly within the cylinder 12, it effectively closes the ports 54—56 and therefore seals off the two transfer passages 29 and 42 from the upper portion of the cylinder. After the ports 55 and 56 have been closed by the upward movement of the piston, there is no effective interconnection between the crankcase chamber 16 and the cylinder bore 48. Consequently, the continued upward movement of the piston 47 is effective to reduce the pressure within the crankcase chamber 16. In this connection, it is preferred that the internal volume of the crankcase be held to a minimum to assure substantial pressure changes therein during operation of the engine.

The reduction of pressure within the crankcase chamber 16 is effective to open the two check valves 58 and 61, since the crankcase chamber is connected to the check valves by means of the two transfer passages 28, 29 and 41, 42. Accordingly, a mixture of air and fuel is drawn from the carburetor 59 through the manifold 57 and into the transfer passages. The movement of this fuel and air mixture is indicated by the arrows 90. Moreover, and as also indicated by the arrows 90, a portion of the fuel and air mixture is drawn into the crankcase chamber 16, passing through the bearings 22 and 34 and through the oil separator barriers 71 and 81.

When the piston 47 reaches the top of its stroke, as indicated at 47A, and starts downwardly again, a build-up of pressure within the crankcase chamber 16 is initiated. As the pressure increases within the crankcase chamber, a corresponding increase in pressure takes place in the transfer passages, which are in communication with the crankcase chamber. Consequently, the check valves 58 and 61 are closed, cutting off communication between the transfer passages and the manifold 57.

As the downward movement of the piston continues, the intake ports 55 and 56 are exposed. Because a substantial pressure has in the meantime been built up within the crankcase chamber 16, and in the transfer passages 28, 29 and 41, 42, a charge of the air and fuel mixture is forced from the transfer passages into the upper portion of the cylinder bore 48. At least some of this fuel mixture is that which has previously been drawn into the crankcase chamber 16. As indicated by the arrows 91, the fuel mixture is forced back out through the barriers 71 and 81 in the rotary oil separators, through the bearings 22 and 34, into the transfer passages, and thence into the cylinder bore 48 of the engine.

On its second upward stroke, the piston 47 performs substantially the same functions as described hereinbefore. That is, the piston effectively closes the ports 54—56. The closing of the ports 55 and 56 is effective to cause a second charge of fuel and air mixture to be drawn into the transfer passages and, at least in part, into the crankcase of the engine, as described hereinabove. Moreover, on this upward stroke, the piston 47 compresses the fuel mixture present in the upper portion of the cylinder bore 48. The compressed mixture is ignited, shortly after the piston passes the top dead center position 47A, driving the piston downwardly in a power stroke. The downward power stroke is substantially the same as the downward stroke described hereinabove. It should be noted that, in the course of the downward stroke, the exhaust opening 54 is first exposed, so that a substantial portion of the residue from the burned fuel and air mixture passes out through the exhaust port before the intake ports 55 and 56 are opened.

From the foregoing description, it is apparent that the fuel and air mixture flows substantially continuously through the two bearings 22 and 34, first in one direction and then in another. Furthermore, a substantial amount of the fuel and air mixture circulates in and around the bearing 21. This movement of the fuel and air mixture through the bearings is effective to cool the bearings, thereby materially prolonging their operating life. At the same time, oil particles and unvaporized fuel particles present in the stream of fuel and air passing through and around the bearings tend to settle out in the bearing races. In this manner, undesired relatively heavy fractions of the fuel, oil particles, and other unvaporized portions of the fuel-air mixture are prevented from reaching the combustion chamber 53 of the engine. As a consequence, combustion is more complete within the chamber 53 than would otherwise be the case and undersirable carbon deposits are accordingly reduced. It is thus seen that the bearings themselves are in effect utilized as separators for removing at least some oil and unvaporized fuel particles from the train of fuel delivered to the combustion chamber of the engine.

The above-described separator action achieved by passing the fuel mixture through the races of the bearings also affords another advantage in operation of the engine 10. The separator action thus afforded provides a continuing though minute supply of oil for the bearings themselves. Consequently, the bearings are continuously lubricated during operation of the engine, without any need for providing separate lubrication means. Moreover, it should be noted that the cooling and lubricating operation effected by passing the fuel mixture through the bearings both tend to vary in accordance with the load placed upon the engine. When the engine is operated under heavy load, substantially greater quantities of fuel mixture are passed through the bearings than is the case when the engine is operated under light load. Consequently, maximum cooling and lubrication are provided when they are both most needed, during operation of the engine under relatively heavy loads.

Another important aspect of operation of the engine 10 relates to the dual use of the separators 63 and 73. As pointed out hereinabove, at least a substantial portion of the fuel and air mixture passes through the separators twice, once during that portion of the operating cycle in which the fuel mixture is drawn into the crank case chamber 16 and again during the succeeding portion of the operation cycle in which the mixture forced outwardly of the crankcase chamber and back into the transfer passages of the engine. This two-way flow of the fuel mixture, with respect to the rotary separators, affords substantial benefits in the operation of the engine 10.

In the first place, as the fuel mixture passes into the crankcase chamber 16 through the rotary separator bar-

riers 71 and 81, it affords a cleaning action which tends to pick up separated oil which may be contained in the separator barriers, returning this oil to the crankcase chamber and hence to the well or sump 83. The continuous cleaning action afforded for the barrier portions of the rotary oil separators may increase the efficiency of the separators to an appreciable extent.

A second benefit derived by the dual passing of the fuel mixture through the oil separators relates to dilution of the lubricant contained in the well 83 and in the reservoir 17 with fuel from the fuel mixture. Because the fuel mixture has access to the crankcase chamber 16 only by passing through the rotary separators, the possibility of condensation of a portion of the fuel is substantially reduced. This advantage is derived from the fact that the rapidly turning rotary separators tend to atomize the fuel particles in the air-fuel mixture and hence reduce the possibility of condensation, even when the engine is relatively cold.

The operating economy of the engine 10 is also improved by virtue of the two-way flow of the fuel mixture through the rotary separators 63 and 73. The atomizing effect of the separators upon the fuel particles is utilized not once, but twice. As a consequence, a better admixture of the fuel and air particles is achieved, resulting in more even combustion and in better utilization of the heavy fractions of the liquid fuel particles for heat energy.

The internal combustion engine 110 illustrated in Fig. 3 is in most respects substantially similar to the engine 10 of Figs. 1 and 2. Thus, the engine 110 comprises a crankcase portion 111 upon which a cylinder section 112 is mounted. As before, the crankcase 111 may comprise individual sections 113 and 114 sealed to each other and to a base section 115 to define a crankcase chamber 116 and an oil reservoir 117. The crankcase section 113 is provided with a boss portion 118 having an internal bore 119 within which a pair of bearings 121 and 122 are mounted. A crankshaft 123 is journaled in the bearings 121 and 122. The bore 119, as before, is sealed by means of a conventional packing or line seal 125. Moreover, and as in the first embodiment, the chamber 127 separating the two bearings communicates with a transfer passage 129 in the cylinder of the engine by means of a relatively short transfer passage 128.

The crankshaft section 114 is provided with a boss 131 having an internal bore 133 within which a bearing 134 is mounted. A flywheel 136 is mounted upon a crankshaft extension 135 which is journaled in the bearing 134. In this instance, however, there is no transfer passage connected with the chamber 138 between the flywheel and the bearing 134.

As before, a pair of crank arms 43 and 44 are mounted upon the shaft sections 23 and 35 respectively. The two crank arms are connected by a crank pin 145 upon which the lower end of a connecting rod 146 is mounted in the usual manner.

The upper end of the connecting rod 146 is connected to a piston 147 which reciprocates within the bore 148 of the cylinder 112. The piston 147 reciprocates between a bottom dead center position, shown in solid lines, and a top dead center position indicated by the dash outline 147A.

The upper portion or combustion chamber 153 of the cylinder 112 is enclosed by a cylinder head 151 in which a conventional spark plug 152 is mounted. In this instance, the cylinder is provided with one inlet port 115 which communicates with the transfer passage 128, 129. An exhaust port 154 is also provided in the upper portion of the cylinder 112. The fueling arrangement in this embodiment of the invention, however, is somewhat different than that in the engine 10 of Fig. 1. Thus, in the engine 110, the carburetor 159 is connected to an inlet port 156 in the lower portion of the cylinder 112 by means of a single conduit 157, there being no requirement for a gate valve in the fuel conduit in this instance.

The engine 110 further includes a pair of rotary oil separators 163 and 173, which are mounted upon the shaft members 23 and 35, respectively, and which are substantially similar in construction to the previously described oil separators 63 and 73. The oil separators 163 and 173 are preferably provided with multiple-layer metal mesh or other porous barriers 171 and 181, respectively, corresponding to the barriers 71 and 81. Moreover, and as before, a finger 185 is mounted upon the connecting rod collar 189 and extends outwardly thereof to pass through an oil well 183 at the base of the crankcase chamber 116. A relatively small opening 184 provides for communication between the well 183 and the main oil reservoir, chamber 117.

Operation of the internal combustion engine 110 is substantially similar to that of the engine 10, except that two-way flow through the lubricant separators 163 and 173 is not employed. Thus, on the initial upstroke of the piston 147, moving toward the position 147A, the upper intake port 155 is first covered by the piston, together with the exhaust port 154. When the port 155 is covered, and as the piston continues its upper movement, the pressure within the lubrication chamber 116 is reduced. Consequently, when the continued movement of the piston subsequently opens the port 156 into direct communication with the crankcase chamber 116, the reduced pressure in the crankcase chamber causes a charge of mixed fuel and air to be drawn from carburetor 159 through the conduit 157 into the crankcase chamber. This air-fuel mixture flows generally along the lines indicated by the arrows 190, and a portion of the mixture passes through the barriers 171 and 181 in the rotary oil separators.

In the initial portion of its downstroke, the piston 147 closes the port 156, preventing the application of excessive back pressure to the carburetor 159. The downward movement of the piston increases the pressure within the crankcase chamber 116 and forces more and more of the fuel and air mixture through the rotary separators. Near the end of its downward stroke, the piston 147 passes the port 155, opening the intake port into the upper portion of the cylinder bore 148. When the port 155 is effectively opened by the downward movement of the piston, the combustion chamber of the engine is at a substantially lower pressure than the crankcase chamber 116. Consequently, a charge of mixed air and fuel is forced outwardly through the bearing 122, through the transfer passage 128, 129, and out through the port 155 into the upper portion of the cylinder 112. It is thus seen that the bearing 122 is lubricated and cooled in substantially the same manner as described hereinbefore in connection with engine 10 of Fig. 1. Accordingly, substantially the same advantages are afforded, in the engine 110, as in the previously described embodiment, with respect to cooling of this bearing and lubrication thereof, and also with respect to additional separator action in the bearing. Moreover, the continual fluctuations in pressure within the crankcase chamber 116 caused the air and fuel mixture to circulate in and around the bearings 121 and 134 to afford lubrication and cooling of these bearings as well.

Fig. 4 illustrates a slightly modified crankcase construction for the engine 10 of Fig. 1, the crankcase in this instance being designated by the reference numeral 194. Because the crankcase 194 is in most respects substantially similar to the initially described crankcase 11, and may be used in conjunction with the cylinder 12 (Fig. 1) without substantial modification of the cylinder structure, the component parts of the crankcase 194 have been designated, in Fig. 4, by the same reference numerals as have been employed for corresponding parts in Fig. 1. Moreover, in view of the substantial identity between most of the parts no ad-

ditional description of the individual components is deemed necessary. The principal modification presented by the crankcase structure 194 of Fig. 4 is in the elimination of the rotary separators 63 and 73 from the first described embodiment of the invention. Thus, Fig. 4 illustrates the application of one aspect of the invention to a two-cycle internal combustion engine in which no rotary filters are employed.

In operation, moreover, the crankcase 194 shown in Fig. 4 functions in substantially the same manner as the corresponding crankcase section 11 of Fig. 1. That is, on each downward movement of the piston connected to the connecting rod 46, a charge of mixed fuel and air is drawn through the transfer passages 28 and 41 into the crankcase chamber 16. In passing into the crankcase chamber 16, the mixture of air and fuel is required to pass through the bearings 22 and 34. As the fuel-air mixture passes through the bearings, unvaporized liquid particles of the fuel tend to be separated out, thereby preventing their delivery to the combustion chamber of the engine. By the same token, some of these relatively heavy particles are effectively atomized as they pass through the rotating bearings, and are thus put into a form more readily adapted to complete combustion.

On the downward or decompression stroke of the piston, the fuel and air mixture within the crankcase chamber 16 is compressed, as described hereinabove in connection with Fig. 1. Of course, a certain amount of oil is mixed with the fuel within the crankcase chamber 16, since the finger 85 continuously impels oil upwardly into the chamber and onto the operating parts of the engine. Near the end of the downward stroke of the piston, the transfer passages 28 and 41 are effectively opened into the upper end of the cylinder of the engine. Accordingly, a charge of mixed fuel and air, together with a small quantity of oil, is drawn outwardly of the crankcase chamber 16 and through the transfer passages into the cylinder of the engine. As this mixture passes through the bearings 22 and 34, at least a portion of the oil entrained therein is separated and remains in the bearings. In this manner, and as in the embodiment of Fig. 1, the bearings 31 and 34 are directly lubricated and cooled by passing the fuel mixture therethrough. By the same token, some of the fuel mixture circulates in and around the bearing 21, affording a substantial cooling and lubricating action for this bearing as well.

Fig. 4 may also be considered to illustrate the application of certain features of the invention to an internal combustion engine in which a separate lubricant supply is not afforded. Thus, it is apparent that the cooling and atomizing action of the stream of fuel and air in passing through the crankshaft bearings, is not dependent upon the particular direct lubricating arrangement illustrated in Figs. 1 and 4. Instead, this feature of the invention may also be advantageously employed in conjunction with virtually any lubrication arrangement, and still affords substantial advantages with respect to cooling of the bearings and also with regard to improved atomization of the fuel in the air-fuel mixture.

Fig. 5 illustrates yet another embodiment of the invention, in which the carburetor is connected to the crankcase of a two-cycle internal combustion engine. Moreover, in this embodiment of the invention, that feature of the invention relating to two-directional flow through a rotary oil separator is employed independently of passage of the air-fuel mixture through or over the engine bearings. The crankcase structure 211 shown in Fig. 5 may be utilized with a cylinder corresponding to the cylinder structure 12 of Fig. 1, except that the carburetor connections comprising the check valves 58 and 61 are not employed in this instance; consequently, only the lower part of the cylinder portion 212 of the engine has been shown in the drawing.

The crankcase structure 211 may be constructed in three sections, these being the left and right hand sections 213 and 214 and the base section 215. As before, the several sections of the crankcase housing may be joined together by any suitable means, and the upper portion of the crankcase may be bolted or otherwise secured to the lower portion of the cylinder 212. As before, the crankcase housing sections define a crankcase or lubrication chamber 216 and an oil reservoir 217.

The crankcase housing section 213 is provided with a relatively large boss or external projection 218 having an internal bore 219 within which a sleeve bearing 221 is mounted. The crankshaft 223 of the engine is journaled in the bearing 221, a conventional line bearing seal 225 being provided as in the previously described embodiments. The boss 218 is also provided with an additional passageway 222 which communicates with the crankcase chamber 216 of the engine. A collar 224 is fixedly mounted on the shaft 223 in spaced relation to the opening of the conduit or passage 222 into the chamber 216. Between the collar 224 and passage 222 there is mounted a valve plate 227 having an aperture 268. The valve plate 227 is freely movable, in an axial direction, with respect to the shaft 223, but is prevented from rotational movement with respect to the shaft by means described hereinafter. A biasing spring 230 engages the collar 224 and the valve plate 227. Spring 230 exerts a biasing force on the valve plate 227, urging it toward the outlet opening of the passageway 222.

The crankcase housing section 224 is provided with a boss 231 within which a second sleeve bearing 234 is mounted, the boss being provided with a suitable aperture 233 for receiving the bearing 234. A crankshaft extension 235 is journaled within the bearing 234. As before, a flywheel 236 may be mounted upon the shaft extension 235 and a conventional packing 237 may be associated with the flywheel and the shaft to prevent leakage along the shaft.

As in the crankcase 11 described hereinabove in connection with Fig. 1, the crankcase 211 is provided with two transfer passages 228 and 241. The transfer passage 228 communicates with a corresponding transfer passage 229 in the cylinder section 212 of the engine. Similarly, the transfer passage 241 is connected to a cylinder transfer passage 242. The passages 229 and 242 correspond to the passages 29 and 42 in the first-described embodiment of the invention, except that they communicate only with the upper portion of the engine cylinder and are not connected to a fuel manifold as in the engine of Fig. 1. Moreover, it should be noted that the transfer passages 229 and 241 extend into the interior of the crankcase housing but do not pass through the bearing for the shaft 223, 235.

As in the first-described embodiment, the engine is provided with a pair of rotary centrifugal oil separator devices 263 and 273. The rotary separator 263 comprises a plate 264 which may be affixed to the crank arm 243 mounted upon the crankshaft 223. In fact, the plate 264 may be formed integrally with the crank arm and its associated counterweight. In addition, the separator 263 includes a flange member 265 which is affixed to the plate 264 or which may be otherwise mounted upon the crank arm 243 or the counterweight for the arm. For example, the flange portion of the separator may be secured to the crank arm and counterweight by one or more screws 270. A line-type sealing member 267 is mounted upon the crankcase housing section 213 and engages an end portion 266 of the separator flange 265 to provide at least a partial seal between the housing and the separator. As before, the flange member 265 is provided with a series of peripheral openings 269. A metal mesh or other porous separator barrier 271 is interposed between the openings 269 and the interior of the oil separator 263.

In this instance, however, an additional seal is provided between the oil separator 263 and the housing 213 to

seal the passages 222 and 228 from the crankcase or lubrication chamber 216. This additional seal is a labyrinth seal of a rather unusual kind. It comprises a plurality of annular V-shaped lands 300 which are formed in the surface of a portion 301 of the flange member 265 which faces an interior wall 302 of the crankcase housing section 213. The crankcase wall 302 is provided with a corresponding plurality of annular V-shaped grooves 303 which are disposed in interfitting relation with respect to the lands 300. Thus, in order for any liquid to pass between the crankcase chamber 216 and the fuel intake passage 222, without passing through the separator barrier 271, it is necessary for the liquid to traverse a narrow elongated passage formed by the lands 300 and the grooves 303. This construction affords substantially improved sealing characteristics, when the shaft 223 is rotated, as compared with a conventional line seal device. Moreover, the labyrinth seal afforded by the lands 300 and the grooves 303 remains substantially constant in its sealing characteristics over an extended period of operation. This labyrinth seal is described in greater detail and claimed in the co-pending application of Henry A. Sherwood, Serial Number 749,016, filed concurrently herewith. A pin 310 on the flange member 265 engages in a slotted extension 311 of the valve plate 227 to constrain the valve plate to rotate with rotation of the shaft 223.

The oil separation device 273 is substantially similar to the separator 263. Thus, it comprises a face plate 274 which is affixed to and which may comprise an integral part of a counterweighted crank arm 244. A flange member 275, similar to the flange member 265, is included in the separator and may be affixed to the crank arm by suitable means such as one or more screws 280. A line type sealing member 277 is mounted on the housing section 214 and engages an extension portion 276 of the flange member 275. The flange member 275 is provided with a series of peripheral openings 279 backed by a multiple layer metal mesh barrier 281. Moreover, the flange 275 of the separator is preferably provided with a plurality of annular V-shaped lands 305 which extend into interfitting relation with a corresponding plurality of annular V-shaped grooves 306 in the wall of the crankcase housing 214. The lands and grooves 305 and 306 form a second labyrinth seal which in this instance seals the chamber 216 from the opening leading into the transfer passage 214.

As before, a crank pin 245 connects the two crank arms 243 and 244 and a collar 289 is employed to connect the crank pin with a connecting rod 246. A finger 285 may be provided on the collar 289 to impel oil or other lubricant from a well 283 upwardly onto the operating parts of the engine.

The construction of the well 283 is somewhat different in this instance. The well is connected to the oil reservoir 217 by means of a pair of check valves 310 and 311, the valve 310 being located in the base of the well and the valve 311 being located a short distance up the side of the well. The two check valves are utilized to maintain a constant level of oil or other lubricant within the well 283 as described and claimed in the aforementioned Sherwood application. It should be noted that this oil level control arrangement may also be employed in any of the previously described embodiments of the invention.

The apparatus of Fig. 5 is illustrated in a position corresponding to the location of the piston 247 connected to the rod 246 at its bottom dead center location. The opening 268 in the valve plate 227 faces the end of the transfer passage 228, so that a fuel mixture may be fed through this transfer passage, as well as the transfer passage 241, into the firing chamber of the engine.

Rotation of the crankshaft 223, 235 causes the valve plate 227 to rotate, closing the inlet port to the transfer passage 228. Continued rotation of the shaft, which corresponds to upward movement of the piston 247, causes a reduction in pressure within the chamber 216. As before, the cylinder intake ports connected to the transfer passages 228, 229 and 241, 242 are closed as the piston moves upwardly. As the piston approaches its top dead center position, the port 268 in the valve plate 227 is brought into conjunction with the fuel conduit 222. Consequently, and because the pressure within the chamber 216 is relatively low, a charge of fuel-air mixture is drawn into the lubrication chamber, passing through the separator barrier 271 in a first direction.

Subsequently, continued rotation of the shaft closes the outlet port of the fuel conduit 222 and brings the piston of the engine downwardly toward the lubrication chamber 216. Pressure is built up within the chamber 216 and, when the ports at the ends of the transfer passages 229 and 242 are opened, a charge of fuel and air passes through the two oil separator barriers 271 and 281 and into the firing chamber of the engine. It is thus seen that the operating cycle in this embodiment of the invention is similar, insofar as the separators are concerned, to the embodiments described hereinabove.

In the embodiment of Fig. 5, only a relatively small quantity of the fuel-air mixture passes through the barrier 281 in one direction, this being the direction leading from the transfer passage 241 into the chamber 216. In many instances, however, even this small quantity may be of substantial assistance in cleaning the rotary separator 273. Moreover, all of the fuel must pass through one or the other of the two separators twice in order to reach the firing chamber of the engine, thereby taking full advantage of the atomizing effect of the engines. Of course, a second fuel inlet similar to the inlet 222 may be incorporated in the right hand side of the crankcase as desired, in which case a second valve is required to prevent exerting a back pressure on the carburetor.

From the foregoing description, it is apparent that the present invention provides for improved lubrication in a two-cycle internal combustion engine, and for highly effective removal of entrained oil or other lubricant from the fuel mixture supplied to the engine cylinder. The invention effectively prevents excessive dilution of the lubricant supply and at the same time is advantageous with regard to fuel economy in operation of the engine. The invention is effective to cool and lubricate the bearings of the engine. Moreover, all of these advantages are achieved with engine structures which are simple and economical in construction.

Hence, while preferred embodiments of the invention have been illustrated and described, it is to be understood that these are capable of variation and modification, and we therefore do not wish to be limited to the precise details set forth, but desire to avail ourselves of such changes and alterations as fall within the purview of the following claims.

We claim:

1. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase defining a chamber for containing lubricant therein; a piston disposed within said cylinder and reciprocally movable therein; at least one bearing mounted in said housing; a shaft, journalled in said bearing and extending into said crankcase; means connecting said shaft to said piston to translate reciprocating movement of said piston into rotary movement of said shaft; means for introducing a charge of fuel-air mixture into said crankcase to entrain lubricant in said mixture; and means for passing at least a part of said mixture through said bearing and into said cylinder to cool and lubricate said bearing and to atomize fuel and lubricant particles in said mixture.

2. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase defining a chamber for containing lubricant therein; a piston disposed within said cylinder and reciprocally movable therein; at least one bearing mounted in said housing; a shaft, journalled in said bearings and extending into

said crankcase, means connecting said shaft to said piston to translate reciprocating movement of said piston into rotary movement of said shaft; means for introducing a fuel-air mixture into said crankcase to entrain lubricant in said mixture, including means for passing said mixture through said bearing in a first direction to cool and clean said bearing; and means for passing said mixture back through said bearing in the opposite direction and into said cylinder to cool and lubricate said bearing and to atomize fuel and lubricant particles in said mixture.

3. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase defining a chamber for containing lubricant therein; a piston disposed within said cylinder and reciprocally movable therein; at least one anti-friction bearing mounted in said housing; a shaft, journalled in said bearing and extending into said crankcase; a means connecting said shaft to said piston to translate reciprocating movement of said piston into rotary movement of said shaft; a carburetor; conduit means, connecting said carburetor with said crankcase, for passing a fuel-air mixture through said bearing and into said crankcase to cool said bearing and entrain lubricant particles in said mixture, said conduit means including a check valve to prevent back feed of said mixture to said carburetor; and further conduit means for passing said mixture back through said bearing, bypassing said valve, into said cylinder, to cool and lubricate said mixture and to atomize fuel and lubricant particles therein.

4. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase; a rotatable shaft, extending into said crankcase, and driven by said piston; a rotary through-type oil separator mounted on said shaft within said crankcase; means for introducing a fuel-air mixture into said crankcase by passing said mixture through said separator in a first direction to clean said separator and atomize fuel particles therein; and means for passing said mixture back through said separator and into said cylinder to remove entrained lubricant from said mixture and atomize fuel and lubricant particles therein.

5. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase; a rotatable shaft, extending into said crankcase, and driven by said piston; a rotary through-type oil separator mounted on said shaft within said crankcase; a carburetor; conduit means, connecting said carburetor with said crankcase, for passing a fuel-air mixture through said separator and into said crankcase to clean said separator, said conduit means including valve means to prevent back feed of said mixture to said carburetor; and further conduit means for passing said mixture back through said separator and into said cylinder.

6. A two-cycle internal combustion engine comprising: a motor housing including a cylinder and a crankcase; a piston disposed within said cylinder for reciprocal movement therein; at least one anti-friction bearing mounted in said housing; a shaft journalled in said bearing and extending into said crankcase; a rotary through-type separator mounted on said shaft within said crankcase; means connecting said shaft to said piston to rotate said shaft in response to reciprocal movement of said piston; conduit means, including at least one valve, for passing a fuel-air mixture through said bearing and said separator, in a first direction, into said crankcase to cool said bearing, clean said separator, and atomize fuel particles in said mixture; and further conduit means for passing said mixture back through said bearing and said separator into said cylinder to remove entrained lubricant therefrom, atomize fuel and lubricant particles therein, and further cool and lubricate said bearing.

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