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Hooper

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[54] **TWO STROKE INTERNAL COMBUSTION ENGINES**

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[73] Assignee: **John Edward Favill,** Sedgley, England; a part interest

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[52] **U.S. Cl.** ..... **123/73 PP,** 123/73 DA

[51] **Int. Cl.** **F02b 33/04**

[58] **Field of Search** ..... 123/73 PP, 73 DA, 123/73 R, 73 A; 148/6.8, 18

[56] **References Cited**

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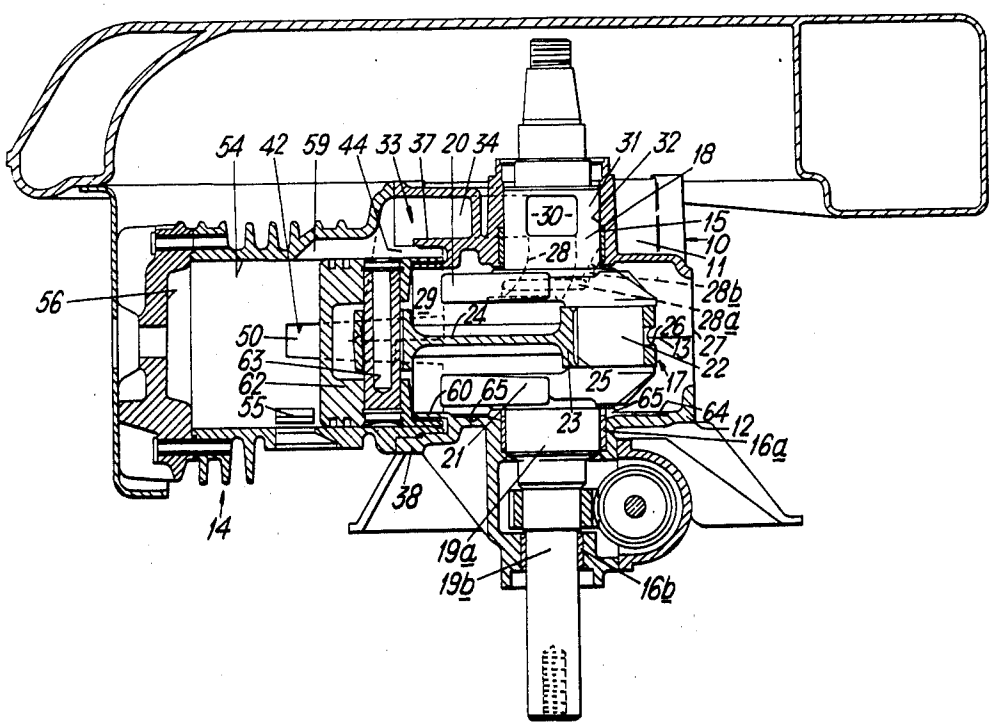
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Assistant Examiner—Michael Koczo, Jr.
Attorney—Kurt Kelman

[57] **ABSTRACT**

The specification discloses a two-stroke engine employing crankcase compression wherein a charge of lubricant and fuel passes through a first transfer passage in a stationary part of the engine. The transfer passages for the or each cylinder communicate at one only of the journals of the crankshaft and the second transfer passage is branched and leads to inlet parts located so as to give loop scavenging of the cylinder. The rotary axis of the crankshaft may be vertical and said journal the upper journal which is thus well lubricated since at least the majority of the cylinder charge is exposed to the journal bearing.

5 Claims, 3 Drawing Figures



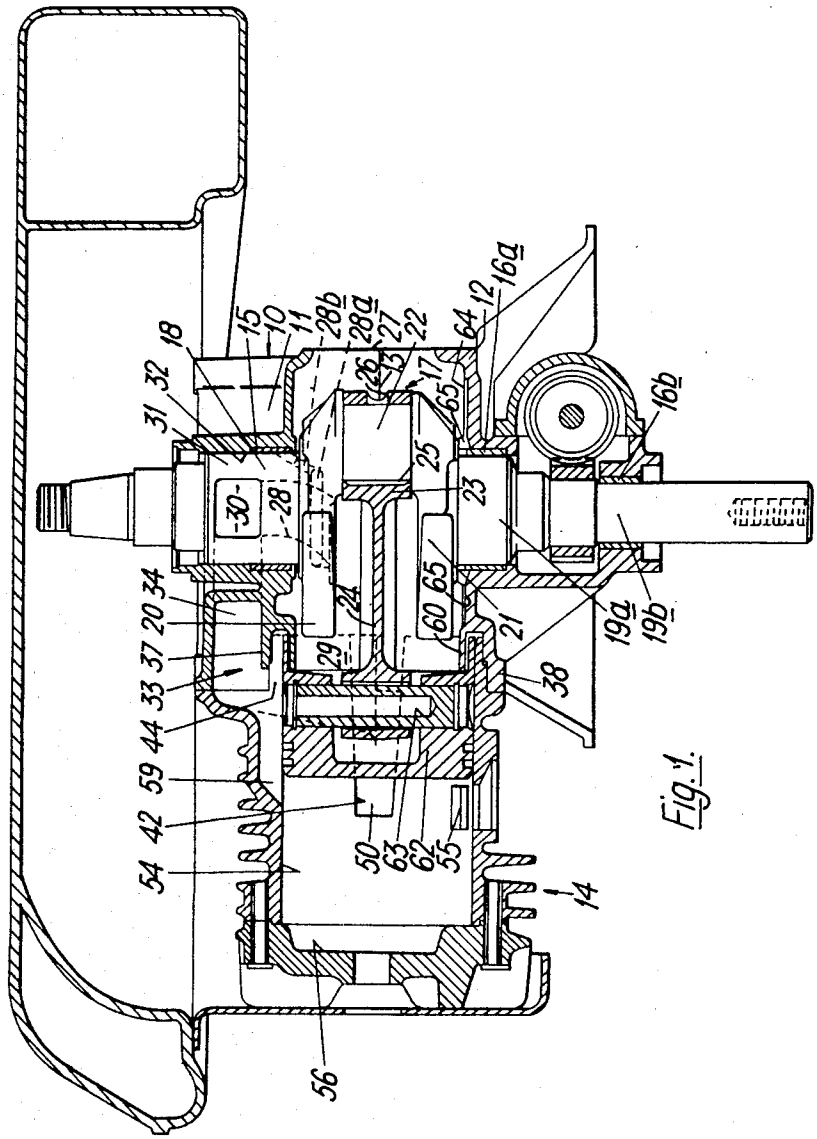

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11
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28a
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16a
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16b
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19a
19b
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Fig. 1.

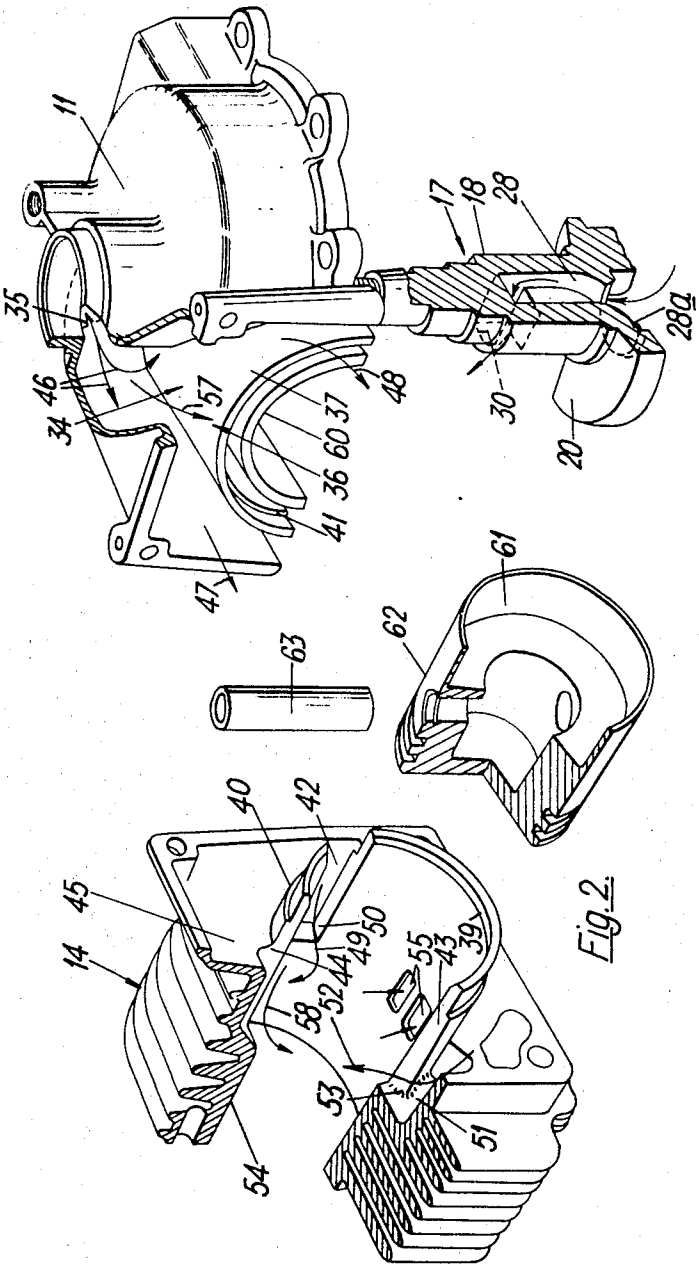

11
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28a
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Fig. 2.

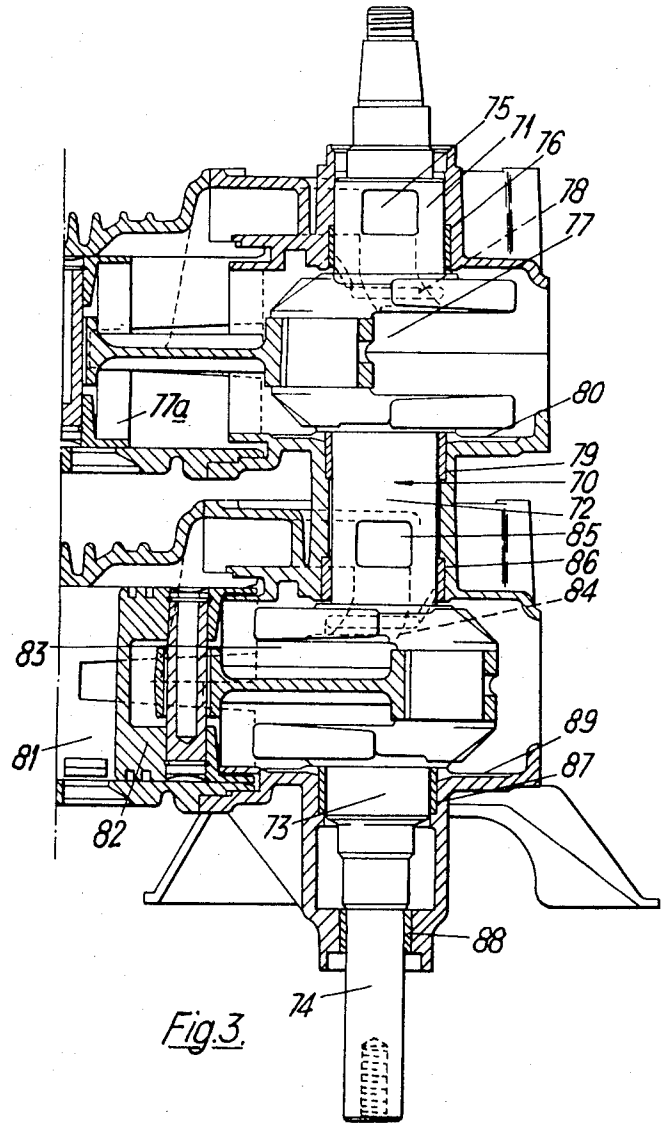


Fig.3.

TWO STROKE INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to two-stroke internal combustion engines employing crankcase compression.

2. Description of the Prior Art

Two-stroke engines are known of the kind employing crankcase compression, i.e. wherein, for the or each cylinder, a charge of air, lubricant and fuel vapour is compressed in a crank chamber of a crank-case by the piston in the cylinder approaching its bottom or inner dead centre position, the charge then passing through transfer passage means to emerge in the cylinder above the piston. The transfer passage means may comprise first transfer passage means formed in the crankshaft and second transfer passage means formed in the stationary part of the engine, i.e. the crankcase/cylinder block unit or assembly. In passing from the crank chamber to the cylinder a charge passes through the first and second transfer passage means in succession. Engines having the above features will hereinafter be referred to as being "of the kind described."

The invention is particularly useful when incorporated in an engine of the kind described which is designed to run with the rotary axis of its crankshaft vertical, e.g. an engine designed to drive a grass mower. In existing two-stroke engines arranged to run with the rotary axis of the crankshaft vertical difficulty has been encountered in lubricating the upper crankshaft bearing and it is an object of this invention to overcome this problem.

SUMMARY OF THE INVENTION

According to the invention we provide an engine of the kind described wherein the first transfer passage means for the or each cylinder is a first transfer passage associated with the cylinder and arranged to communicate with the second transfer passage means at a location at or adjacent to one only of the journal bearings of the crankshaft and the second transfer passage means for the or each cylinder comprises a branched passage leading from said location to inlet port means in the cylinder wall, the branched passage and the inlet port means being so located and shaped as to give in conjunction with exhaust port means, loop scavenging of the cylinder as hereinafter defined.

By loop scavenging we mean that a fresh charge enters the cylinder from spaced inlet ports in two directions which converge towards part of the cylinder wall opposite to the exhaust port means, the latter being located between inlet port means, the fresh charge being deflected by said cylinder wall towards the cylinder head and by the cylinder head to expel the spent charge from the exhaust port means.

For the or each cylinder there may be only two inlet ports (each of which may be divided) arranged as described if the ports can be of adequate size without causing the pressure caused by the piston side loads to be greater than is desirable. If necessary there can be a third inlet port located at a position diametrically opposite to the exhaust port means but so as not to interfere with the loop scavenging, the streams of charge from the other two inlet ports impinging on the cylinder wall at a position nearer to the cylinder head than the third inlet port.

In a single cylinder engine there will be but a single location where the first transfer passage communicates with the second transfer passage means whereas in a two or multicylinder engine there will be two or more, separate, first transfer passages each such passage being associated with a different one of the cylinders. The first transfer passages will communicate at different locations at or adjacent different journal bearings with different second transfer passage means. That is to say the first and second transfer passage means for each cylinder are completely separate from the transfer passage means for the or each other cylinder and each cylinder is fed from its own crank chamber. The charge for each cylinder thus passes from a crank chamber associated with the cylinder along a first transfer passage and then along a branched second transfer passage to enter the cylinder at spaced inlet ports so arranged in relation to an exhaust port or ports as to give loop scavenging.

We have found that the volume provided by the or each second transfer passage damps out variations in the inlet pressure of the charge and thus gives the engine very good torque characteristics over the lower part of its speed range.

Since the charge includes a lubricant, the charge passing through the or each first transfer passage will lubricate the journal bearing of the crankshaft in which, or adjacent to which, the first transfer passage communicates with second transfer passage means. The or each first transfer passage can open into a journal so that an interrupted bearing surface is provided on the journal but it is preferred that the first transfer passage communicates with the second transfer passage means adjacent to a journal having a continuous bearing surface but so that lubricant from the charge does pass into and lubricate the journal bearing surface.

With the rotary axis of the crankshaft is vertical, the journal or journals at or adjacent to which the first transfer passage or passages communicate with the second transfer passage means will be those associated with the upper bearing or bearings and the oil will drain down to form a pool around the lower or lowermost bearing and grooves or passages will be provided to lead the oil from the pool into the bearing itself. Difficulty has been experienced in existing single cylinder, two-stroke engines with a vertical crankshaft in lubricating the upper crankshaft bearing. The present invention overcomes this difficulty and we have found that a single cylinder engine embodying the invention and arranged with the rotary axis of the crankshaft vertical and employing plain crankshaft bearings can be run successfully on a petrol/oil mixture with an oil consumption of 20 ml./B.H.P./hr. For comparison the aforementioned existing engines require a petrol/oil mixture of 16 parts of petrol to 1 part of oil to give effective lubrication and, despite the use of a needle bearing for the upper crankshaft frame, has an oil consumption in excess of 50 ml./B.H.P./hr.. If needle, ball or roller crankshaft bearings are used in engines embodying the invention the specific oil consumption can be reduced further but it is one of the advantages of the invention that plain crankshaft bearings can be used.

The journal of the or each bearing which is lubricated by lubricant deposited from the charge is preferably arranged below the location at which the first transfer passage communicates with the second transfer pas-

sage means so that oil from the charge passes down by gravity into the journal bearing. This arrangement enables plain crankshaft bearings to be used for all the journals. The or each first transfer passage may include an annular groove within the crankshaft and arranged about the rotary axis thereof and an oil conduit extending from the groove to the surface of the journal adjacent to which the first transfer passage communicates with the second transfer passage means. The groove collects oil from the charge and centrifugal force causes the oil to pass along the conduit to the journal bearing surface. This arrangement assists in providing adequate lubrication for each bearing which is lubricated from the charge.

Conventional plain bearings may be used for the crankshaft. Alternatively the bearings can be made from a hypereutectic, silicon-aluminium alloy. Such an alloy is at present used for making cylinder blocks for engines. When the bores in such blocks are bored and honed the aluminium is spread over the surface and the latter then etched to expose the silicon particles and leave oil-retaining hollows between the latter. Such a technique could be used in making engines embodying the invention not only for the cylinder bore but also for the journal bearings. Thus the crankshaft/cylinder block unit or assembly could be die cast from such an alloy and the cylinder bore and crankshaft bearings bored, honed and etched as described to provide lubricant retaining bearing surfaces. In such an engine the piston and crankshaft would be of iron which runs on the silicon particles exposed by the etching and lubricated by oil retained in the hollows. Alternatively either only the crankshaft journal bearings or only the cylinder bore may be formed in this way.

It is preferred that the exhaust port means shall be directed downwardly. Where an engine incorporating this feature of the invention is used on a grass mower then the silencer which is connected to the exhaust port means may be arranged below the deck of the mower, i.e. below the hood covering the mower blades.

Preferably there are for the or each cylinder, during the major portion of the time during which transfer of the charge from the crank chamber to the cylinder occurs, two paths for the charge from the chamber into the second transfer passage means and the second of said paths comprising one or more small clearances between a part or parts of the crankshaft and/or piston on the one hand and a stationary part or parts of the engine on the other, the relation between the restrictions offered to gas flow by the two paths being such that the major part of the charge flows through the first transfer passage during transfer of the charge from the crank chamber to the cylinder.

By use of this arrangement, it is possible to make the crankcase and cylinder block from diecastings and it is not necessary for the second transfer passage means to be absolutely isolated in a gas tight manner from the crank chamber except through the auxiliary transfer ports. This arrangement makes for ease of manufacture and the main transfer passages may be open channels in the walls of the cylinder.

In connection with the use of such a manufacturing technique and small clearances reference should be had to U.S. Ser. No. 3,374,776 issued on Mar. 26, 1968 to The Villiers Engineering Co. Limited.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in detail by way of example with reference to the accompanying drawings in which:

FIG. 1 is a vertical section through a single-cylinder engine embodying the invention and designed to run with the axis of its crankshaft vertical;

FIG. 2 is an exploded perspective view of part of the engine of FIG. 1 showing the flow of charge therethrough; and

FIG. 3 is a vertical part-section similar to FIG. 1 of a twin cylinder engine embodying the invention.

Referring now to FIGS. 1 and 2, the engine comprises a crankcase 10 which is formed of two parts 11 and 12 which meet in the horizontal plane 13. The crankcase parts are die cast and then machined. The engine also includes a cylinder block 14 which is diecast and then machined. Mounted in plain bearings 15, 16*a* and 16*b* is a crankshaft indicated generally at 17 and having journals 18, 19*a* and 19*b*. The crankshaft is formed with two webs 20 and 21 between which is a big end journal 22 on which is mounted a big end 23 of a connecting rod 24. The big end 23 includes a half bearing 25 and the big end cap is apertured at 26. The crankcase has an opening 27 to which may be bolted a carburetor (not shown) arranged to deliver a mixture of petrol and oil through a reed valve (not shown) and sufficient of the oil from the mixture passes through the aperture 26 to lubricate the big end bearing 25.

Formed in the web 20 and the journal 18 is a first transfer passage 28 which leads from a crank chamber 29 formed in the crankcase to an opening 30 in the journal 18 but above the plain bearing 15. The portion of the journal in which the opening 30 is formed is relieved slightly relative to the remaining portion of the journal which engages the bearing 15 so that there is an oil film between the portion 31 in which the opening is formed and the inner surface 32 of the bearing spigot on the crankcase.

An annular groove 28*a* is formed in the passage 28 and an oil conduit 28*b* extends from the groove to the surface of the journal 18 within the bearing 15 to assist in lubricating the bearing assembly as described below.

The opening 30 is located at the junction of the first transfer passage 28 and a second transfer passage indicated generally at 33. The second transfer passage has a portion 34 in the crankcase part 11 and which terminates in an opening 35 in the surface 32, the openings 30 and 35 coming into communication during rotation of the crankshaft 17.

The crankcase 10 presents to the cylinder block 14 a cylindrical wall indicated generally at 36, part 37 of the wall being formed integrally with the crankcase part 11 and part 38 of the wall being formed integrally with the crankcase part 12. The cylinder block 14 is provided with a hollow skirt 39 which fits within the cylindrical wall 36, the skirt being stepped at 40 to engage a step 41 within the wall 36. The skirt 39 is provided with three slots 42, 43 and 44. A hollow flange 45 extends from one side of the cylinder block 14 and forms, as it were, a lid for the portion 34 of the second transfer passage 33.

The second transfer passage is branched by the wall part 37 and the skirt 39 so that, as will be described below, a charge flowing into the portion 34 through the opening 35 and indicated by the arrows 46 will branch

as indicated by the arrows **47** and **48.** The part of the charge indicated by the arrow **47** will then flow into the space within the hollow flange **45** and around the skirt to enter the cylinder as indicated by the arrow **49** through an inlet port **50** constituted by the end of the slot **42** remote from the free end of the skirt **39.** The part of the charge indicated by the arrow **48** will flow into a space **51** within the cylinder block and will enter the cylinder as indicated by the arrow **52** through an inlet port **53** constituted by the end of the slot **43** remote from the free end of the skirt **39.** The inlet ports **50** and **53** and the slots **42** and **43** are so arranged that the charge entering the cylinder from the inlet ports **50** and **53** impinges upon a part **54** of the cylinder wall opposite to exhaust ports **55** and is deflected by said wall portion against the cylinder head **56** and thence towards the exhaust ports **55.** This arrangement gives loop scavenging. Some of the charge as indicated by the arrow **57** flows into the cylinder through the slot **44** as indicated by the arrow **58.** The purpose of the slot **44** is to enable the size of the slots **42** and **43** to be reduced sufficiently to prevent the cylinder wall being damaged by side loads imposed upon it by the piston. In certain circumstances the slot **44** can be dispensed with and all the charge can enter the cylinder through the inlet ports **50** and **53** to give loop scavenging as described above. Where the slot **44** is provided the upper end thereof forms a third inlet port **59.**

Formed within the cylindrical wall **36** is a cylindrical spigot **60** and this is arranged to co-operate with the skirt **61** of a piston **62** secured to the connecting rod **25** by a gudgeon pin **63** in a conventional manner. When the piston **62** is in its lower or inner dead centre positions as shown in FIG. **1** there is a slight radial clearance between the spigot **60** and the skirt **61** for a purpose which will hereinafter be described.

The operation of the engine which has been described is as follows. As the piston **62** moves towards its upper or outer dead centre position it creates a partial vacuum in the crank chamber **29** and draws a charge of petrol, oil and air in through the opening **27** through the reed valve and carburetor not shown. As the piston moves to its lower or inner dead centre position as shown in FIG. **1** the charge is compressed underneath the piston and cannot escape from the crank chamber **29** due to the operation of the reed valve and the majority of the charge will pass through the first transfer passage **28.** Some of the charge, a minor part thereof, will pass through the clearance between the spigot **60** and the skirt **61.** The part of the charge which passes into the passage **28** will pass through the opening **30** and the opening **35** into the portion **34** of the second transfer passage. From the portion **34** the charge will split into three streams as indicated by the arrows **47, 48** and **57** respectively and will enter the cylinder above the piston as indicated by the arrows **49, 52** and **58** respectively. The piston **62** will then move upwardly and compress the charge which will be exploded by a sparking plug in the conventional manner and the piston **62** will then move to its inner dead centre position to cause a further charge to enter the cylinder and to expel the spent charge through the exhaust ports **55.** As the new charge enters the cylinder as indicated by the arrows **49** and **52** it will impinge upon the wall portion **54** of the cylinder and will effect loop scavenging as described above i.e. by being deflected upwardly towards the cylinder head **56** and by the cylinder head towards the exhaust ports **55.** The portion of the charge entering through the inlet port **59** as indicated by the arrow **58** will assist in the scavenge operation but will not itself effect loop scavenging.

The lubrication of the engine takes places as follows. The big end bearing **25** is lubricated as has been described by virtue of sufficient of the oil from the petrol/oil mixture passing through the aperture **26.** Of the mixture passing through the first transfer passage **28,** the oil in some of the mixture will become left in the annular groove **28*a*** and will pass along the oil conduit **28*b*** to the external surface of the journal **18** and will thus lubricate the surface of the journal **18** running within its bearing **15.** Moreover, the mixture can enter the slight clearance between the journal portion **31** and the surface **32** from the opening **30,** and the oil will tend to engage said surface due to centrifugal action and the oil will run down the surface **32** and will lubricate the bearing surfaces of the journal **18** and the bearing **15.** Such surfaces are therefore lubricated partly by oil flowing downwardly from the opening **30** and partly through oil expelled by centrifugal force from the groove **28*a*** along the conduit **28*b***.

The lubrication of the lower crankshaft bearings is obtained by the formation of a pool of oil on the lower surface **64** of the crankcase part **12** and the introduction of the oil via grooves **65** into the bearing **16*a***. Some of the oil will also flow downwardly from the bearing **16*a*** to lubricate the bearing **16*b***.

Engines are known, particularly for motorized grass mowers arranged with the rotary axis of the crankshaft vertical as shown in FIG. **1,** but there has, in existing engines, been a considerable difficulty in obtaining adequate lubrication of the upper bearing of the crankshaft. As mentioned above, known engines run on a petrol to oil ratio of 16:1 even when needle or roller bearings are used. We have found that using plain bearings for all the bearings **15, 16,** and **16*a***, an engine embodying the invention and as shown in FIGS. **1** and **2** can be run on a mixture of petrol and oil and in which the petrol to oil ratio is 25:1. It is preferred to use plain bearings for simplicity and cheapness but if desired roller or needle or similar bearings could be used, particularly for the lower crankshaft bearings and this would enable the ratio of oil to petrol in the mixture to be reduced still further.

As has been mentioned above, the major portion of the charge compressed in the crankcase **29** by the piston **62** as it moves to its inner dead centre position passes along the first transfer passage **28** and from thence into the second transfer passage **33** which is branched as described above. A minor portion of the charge, however, flows through the clearance between the spigot **60** and the skirt **61** directly into the slots **42, 43** and **44** and thus into the cylinder above the piston. The clearance is made sufficiently small between the skirt **61** and the spigot **60** to ensure that the major part of the charge flows through the transfer passage **28** but by providing a clearance and therefore not making a crank chamber **29** air-tight except of course for the first transfer passage **28,** it is possible to manufacture the crankcase part and the piston by die casting. It is within the scope of the invention, however, to provide an engine made on more conventional lines wherein the crank chamber **29** is substantially air-tight except for the normal leakage which takes place between the piston and the cylinder wall.

The drawings show the bearings **15**, **16***a* and **16***b* as being normal plain bearings. It is within the scope of the invention, however, to die cast the crankcase parts **11** and **12** from a hyper-eutectic silicon-aluminium alloy and to form the bearings directly in the crankcase parts. This will be done by first boring out and honing the bearings and then etching the surfaces thereof to expose the silicon and form lubricant-retaining pockets in the aluminium around the exposed silicon particles. In such a construction the crankshaft would be of iron or the journals in the bearings of the silicon-aluminium alloy would be iron plated. A similar method of construction could be used for the cylinder block **14** and the cylinder formed therein by honing and then etching and in this case the piston would be of iron or would be plated.

It will be seen that as thus far described the invention provides a single cylinder engine which may run with the rotary axis of the crankshaft vertical and in which the upper bearing is very adequately lubricated with a comparatively low proportion of oil in the petrol/oil mixture. The invention may also be used, however, in an engine in which the rotary axis of the crankshaft is horizontal and in such case the bearings such as **16***a* and **16***b* would be formed by needle, roller or similar bearings.

The invention is also applicable to a multi-cylinder engine and a partial section of a two-cylinder engine is shown in FIG. **3**. Referring to this figure, the engine comprises a crankshaft indicated generally at **70** which has an upper journal **71** an intermediate journal **72** and lower journals **73** and **74**. All the journals run in plain bearings. The journal **71** has an opening **75** therein above the plain bearing **76** and charge displaced from a crank chamber **77** by a piston **77***a* flows through a passage **78** and from the opening **75** into the cylinder in a manner similar to that described in relation to FIG. **1**. The lower bearing **79** is lubricated by a pool of oil collecting on the lower surface **80** of the crank chamber **77** in a manner similar to that described in relation to FIG. **1**.

The lower cylinder **81** has a piston **82** therein which compresses a charge in a crank chamber **83** and causes the charge to flow out through a first transfer passage **84** to an opening **85** in the journal **70**. The bearing **86** is lubricated by oil deposited from the opening **85** as described above and also by an annular groove and conduits similar to the groove **28***a* and **28***b* of FIG. **1**. The bearings **87** and **88** for the journals **73** and **74** are lubricated from oil which collects on the lower surface **89** of the crank chamber **83** in a manner described in relation to FIG. **1**.

It will be seen from FIG. **3** that each of the upper bearings **76** and **86** is lubricated by oil deposited from the first transfer passages **78** and **84** and that the lower bearings **79** and **87** and **88** are lubricated by oil collecting in the lower surfaces of the crank chambers. It will be noted that in this two cylinder engine each piston is associated with a separate crank chamber and the invention can be applied to an engine having more than two cylinders and again each cylinder and piston therein will be associated with a separate crank chamber. The arrangement shown in FIG. **3** can be used, for example, in an outboard marine engine. It is believed that it will be apparent that the general operation of each cylinder of the engine of FIG. **3** will be similar to the single cylinder of FIG. **1**. The arrangement shown in FIG. **3** may also be used in an engine having the rotary axis of its crankshaft horizontal in which case the bearings **79**, **87** and **88** would be replaced by roller, needle or similar bearings. It will be seen that the invention provides an improved two-stroke engine which may be run with the axis of the crankshaft vertical and in which adequate lubrication can be obtained thus overcoming problems previously encountered in this type of engine.

If desired a further oil conduit may be drilled from the annular groove **28***a* to direct oil to the big end journal **22** or a further annular groove could be provided, similar to the groove **28***a*, and having an oil conduit leading to the big end.

I claim:

1. A two-stroke engine comprising: a stationary part including a crankcase and a cylinder block, a cylinder arranged horizontally in the cylinder block and a crank chamber in the crankcase; means to supply a fuel and lubricant mixture to said crank chamber; inlet and exhaust port means in the cylinder wall; a crankshaft rotatably mounted with its rotary axis vertical in the crankcase and having upper and lower journals received respectively in upper and lower journal bearings in the crankcase; a piston slidable in the cylinder between top and bottom dead centre positions; a connecting rod connecting the piston to the crankshaft; first and second transfer passage means associated with the cylinder, the first transfer passage means being formed in the crankshaft and extending between the crank chamber and a location adjacent to said upper journal bearing only and the second transfer passage means comprising a branched passage extending from said location to the inlet port means for providing, in conjunction with the exhaust port means, loop scavenging of the cylinder; and means to lead lubricant from the lower surface of the crankchamber to the lower journal bearing.

2. An engine according to claim **1** wherein said location is adjacent to and above said upper crankshaft journal.

3. An engine according to claim **1** wherein the exhaust port means is directed downwardly.

4. A two-stroke engine comprising: a stationary part including a crankcase and a cylinder block, at least two cylinders arranged horizontally in the cylinder block, one above the other, and a number of separate crank chambers in the crankcase, the number of such chambers being equal to the number of cylinders and each chamber being associated with a different cylinder; means to supply a fuel and lubricant mixture to said crank chambers; inlet and exhaust port means in the wall of each cylinder; a crankshaft rotatably mounted with its rotary axis vertical in the crankcase and having an upper journal bearing adjacent its upper end, a lower journal bearing adjacent its lower end and a number of intermediate journal bearings equal in number to one less than the number of cylinders, each intermediate journnal bearing interposed between two adjacent crank chambers; a piston slidable in each cylinder between top and bottom dead centre positions; a connecting rod connecting each piston to the crankshaft; separate first and second transfer passage means associated with each cylinder, each first passage means being formed in the crankshaft and extending only between the crank chamber associated with the cylinder and a location adjacent to the journal bearing adjacent the

upper end of said crank chamber, and each second transfer passage means comprising a branched passage extending from said location to the inlet port means of the associated cylinder for providing, in conjunction with the exhaust port means of the cylinder, loop scavenging of the latter; and means to lead lubricant from the lower surface of the lowermost crank chamber to the lower journal bearing.

5. An engine according to claim **4** wherein each said location is adjacent to and above the journal bearing adjacent the upper end of said crank chamber.

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