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UNIFLOW SCAVENGING FOR ENGINES

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1. This invention relates to two stroke cycle internal combustion engines with uniflow scavenging. The invention may be employed in single or double acting engines having a single working piston in each cylinder or opposed pistons, and the invention may also be employed in free piston engines as well as engines having crank shafts at one or both ends of the working cylinder. The invention may, furthermore, be employed in engines with solid fuel injection or in engines supplied with a mixture of fuel and air. The invention may be used in engines with compression ignition or other ignition systems.

One object of the invention is to provide a simple, reliable and concentrated system of internal combustion engines particularly suitable for light and fast running engines. However, my invention may also be employed in connection with conventional engines running at moderate or low speed. A further object of the invention is to provide means for scavenging and charging fluid admission to the cylinder from two opposite sides of the cylinder in such manner that rotation of the scavenging fluid in the cylinder during the scavenging period is counteracted and so that the scavenging fluid and the combustion gases are mixed as little as possible during the scavenging period and an efficient scavenging of the cylinder with low pressure losses is obtained.

A further object of the invention is to provide a scavenging system causing each cylinder half to be filled up with scavenging fluid under the central portion of the periphery of said cylinder half so that peripheral combustion gas whirls are avoided as far as possible. A still further object of the invention is to provide a design in which the efficient scavenging system is obtained with means causing a strong whirling motion in the combustion chamber of the engine during the fuel injection so that favourable combustion conditions are obtained which, in two stroke cycle engines, is of outstanding importance for obtaining an efficient working process and a high mean pressure.

For these and other purposes I provide a two stroke cycle internal combustion engine with uniflow scavenging having a combustion cylinder, a plurality of substantially parallel passages leading into said cylinder at one end of the cylinder and directed substantially perpendicular to said cylinder, and an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the centre plane, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder. Further features of the invention are described in the following specification and the claims.

Some embodiments of two-stroke cycle internal combustion engines according to the invention are illustrated by way of example in the accompanying drawings, it being understood, however, that different modifications and other combinations of the illustrated elements may be carried out within the scope of the claims.

Fig. 1 is a transverse vertical section through one of the cylinders of an opposed piston engine according to the invention. Fig. 2 is a cross-section of a cylinder of said engine on line II—II in Fig. 1. Fig. 3 is a partial section illustrating the piston position in the engine according to Fig. 1 at the end of the compression stroke. Fig. 4 is a transverse vertical section of an opposed piston engine according to a slightly modified embodiment of the invention, and Fig. 5 illustrates the positions of the pistons of this engine at the end of the compression stroke. Figs. 6 and 7 are similar views of a further modification of an opposed piston engine according to the invention. Figs. 8 and 9 illustrate similar views of the engine cylinder and the piston of an engine having piston controlled scavenging openings at one end of the cylinder and an exhaust valve means at the other end of the cylinder. Fig. 10 is a section on line X—X in Figs. 6 and 8. Fig. 11 is a transverse vertical section of an engine according to a third embodiment of the invention, and Fig. 12 is a cross section of a cylinder of said engine on line XII—XII in Fig. 11. Figs. 13 and 14 are cross sections of cylinders according to still further embodiments of engines according to the invention.

The opposed piston engine according to Figs. 1-3 consists of any number of cylinders I, a lower crank case 2 and an upper crank case 3 in which crank shafts 4 and 5 are mounted in suitable bearings. The crank shafts may be connected with each other over a toothed gear transmission at one end of the engine or in any other way commonly used in connection with opposed piston engines. A connecting rod 6 connects the upper crank shaft 5 with an upper piston 7 which controls the scavenging openings of the cylinder, and a connecting rod 8 connects the lower crank shaft 4 with a lower piston 9 controlling the exhaust openings of the cylinder. Scavenging consequently takes places in a direction towards the lower piston. Preferably, therefore, said piston may be provided with cooling means, or, if both
pistons are cooled, with cooling means of greater cooling capacity than the cooling means of the upper piston.

Each engine cylinder is provided with two diametrically opposed supply conduits 10 directed perpendicularly to the longitudinal central plane of the engine for supplying charging and scavenging air from a not illustrated source of compressed air of any conventional design known in the art. The air flowing through the only conduits 10 is admitted to the combustion cylinder through two galleries forming a number of substantially parallel scavenging air passages 11, 12, 13 disposed in pairs on each side of the axial longitudinal central plane of the engine. As obvious from Fig. 2 this arrangement results in a completely symmetrical arrangement of the scavenging air passages and the scavenging air supply conduits with reference to the axial longitudinal central plane of the engine as well as to a plane through the cylinder axis perpendicular to said plane, and the scavenging air is distributed in a very uniform manner over the cylinder halves on each side of said axial longitudinal central plane. The illustrated arrangement of the scavenging air supply conduits and the scavenging air passages offers a possibility to reduce the distance between adjacent cylinders in multiple cylinder engines so that the total length of the engine is reduced and crank shafts and other parts of the engine become lighter. The scavenging air passages 11 disposed at the extreme sides of each scavenging air supply conduit 10 are confined at the outside by walls 14 making a sharp turn of almost 90° just before the opening into the cylinder and forming guide surfaces 15 directed substantially towards the centre of the cylinder. Said guide surfaces 15 counteract the tendency of the air streams through the scavenging air passages 11 to continue within the cylinder in a peripheral direction and to produce a rotation of the scavenging air around the cylinder axis. The top of the piston 7 controlling the scavenging openings is shaped in a manner contributing to the counteraction of the rotation of the scavenging air around the cylinder axis during the scavenging period. For this purpose and in order to provide a compression chamber shape suitable for the combustion process the top of the piston 7 is provided with a ridge 16 having a flat end surface and side surfaces confined by curved surfaces 17. As obvious from Fig. 2, said curved surfaces 17 are symmetrical with reference to the axial longitudinal central plane of the engine and the portions of the surfaces 17 situated near the piston periphery form guide surfaces cooperating with the scavenging air passages 12 during the scavenging period deflecting a portion of the scavenging air stream entering through the passages 12 towards the cylinder axis thus counteracting the formation of peripheral streams from said passages having a tendency to cause rotation of the scavenging air in the cylinder during the scavenging period. The guide surfaces 17 also assist in deflecting a portion of the scavenging air axially before it reaches the centre of the cylinder so that a conglomeration of scavenging air in the central portion of the cylinder is counteracted. The described simple and symmetrical piston shape is also advantageous with regard to the strength of the piston and from the manufacturing standpoint.

The engine illustrated in Figs. 1–3 is a Diesel engine with solid injection at two points of each engine cylinder 1 opposite each other. Fuel in-
Figs. 1-3 illustrated in Figs. 6, 7 and 10 the upper piston only is provided with a ridge 2 running straight across the top of the piston in the direction of the longitudinal centre plane of the engine. The peripheral portions of the side surfaces of the ridge 22 are decorated with the guide surfaces 15 to counteract the formation of peripheral air streams in the cylinder from the sidemost passages 11 leading from the two air supply conduits to the interior of the cylinder. At the end of the compression stroke the ridge 22 together with the flat end surface of the piston forms a narrow slit or gap 33 from which air is expelled so that a whirling action is obtained in the combustion chamber at the end of the compression stroke, as indicated by the arrows 34 and 35 in Fig. 7.

Figs. 8, 9 and 10 illustrate the employment of the invention in connection with an engine having a single working piston 36 operating in a cylinder 37 and controlling scavenging openings 38 in said cylinder to which scavenging air is supplied from two directions as obvious from Fig. 10. The cylinder 37 is provided with an outlet valve means such as a mushroom valve 38 in the end of the cylinder opposite the scavenging openings but may naturally be provided with a piston valve of the same or less diameter than the cylinder diameter. Furthermore, the cylinder is provided with fuel injection valves or ignition means or the like 40. The piston 38 is provided with a ridge 41 at the side surfaces of which help to guide the scavenging air in the same way as the ridge 22 according to Figs. 6, 7 and 10. At the end of the compression stroke a narrow slit or gap 44 is formed between the end surface of the ridge 41 and the cylinder head 43 and the valve 38. Air jets 45 expelled from said gap produce together with fuel jets 46 a whirling action at the end of the compression stroke.

In the embodiment of the invention illustrated in Figs. 11 and 12 scavenging air is supplied to the engine cylinder through two scavenging air supply conduits 47 directed towards each other and inclined away from the piston 1 controlling the scavenging openings. Said piston may preferably have a bevelled portion as indicated at 48. Oppositely directed scavenging air streams enter the cylinder through the passages 49, 50, 51 from both sides of the axial longitudinal centre plane of the engine. The passages 49, 50 and 51 are inclined downwards towards the lower piston so that the scavenging air at the entrance into the cylinder already has an axial component movement. In order to counteract the tendency of forming scavenging air streams in the cylinder tending to rotate the scavenging air the outer walls 52 of the sidemost scavenging air passages 49 leading from the supply conduits 47 to the cylinder just before the opening into the cylinder make a sharp turn of almost 90°. The guide surfaces 53 deflect the air towards the cylinder axis and counteract the formation of peripheral scavenging air streams in the cylinder. In similar manner the outer walls 54 of the passages 50 just before the openings into the cylinder make a turn towards the cylinder axis in order to prevent that scavenging air entering through said passages shall get a chance to cause rotation of the scavenging air in the cylinder during the scavenging period. In the embodiments according to Figs. 11 and 12 the upper piston 7 and the lower piston 8 have both substantially flat end surfaces but naturally the pistons may be formed in similar manner as the pistons described in connection with the embodiments according to Figs. 1 and 10 or in any other suitable way.

Fig. 13 is a cross section through the scavenging opening zone of a cylinder of an engine with uniflow scavenging which may otherwise be carried out as illustrated in Figs. 6, 8 or 11 or in any other way. Scavenging air is supplied from two sides of the longitudinal central plane of the engine through supply conduits 55 and 56. Air supplied through the conduit 55 flows during the scavenging period through the scavenging passages 57, 58, 59 and the substantially opposed scavenging passages 60, 61, 62 of the one cylinder half 63 whereas scavenging air supplied through the conduit 56 and the scavenging passages 64-66 enters the cylinder and fills up the other cylinder half 70. Guide surfaces 71, 72, 73, 74 then assist in counteracting the formation of peripheral scavenging air streams in the cylinder during the scavenging period. At least the piston controlling the scavenging openings may be provided with a ridge 75 as indicated by the chain dotted lines in Fig. 13 and/or with a ridge 76 which is also indicated by chain dotted lines. In the latter case and generally in engines with very large cylinder diameters fuel injection valves or ignition means may be provided in axial planes indicated by the lines 77 and 78.

Fig. 14 is a cross section through the scavenging opening zone of a cylinder of an engine with uniflow scavenging which may otherwise be carried out for instance as illustrated in Figs. 1, 4, 6, 8 and 11 or in any other suitable way. The two scavenging air conduits 79 and 80 communicate with a number of parallel and opposed scavenging passages 81-86 and 87-92, respectively, through which scavenging air is admitted into the cylinder. The scavenging air streams through the passages 81-83 and 87-92 meet in the cylinder and fill one half of the cylinder to the central peripheral portion 93 of said cylinder half and are then deflected axially for driving the combustion gases towards the combustion gas outlet. In the same way the scavenging air streams entering the cylinder through the passages 84-86 and 89-92 fill up the other half of the cylinder onto the peripheral portion 94.

The embodiments above described and illustrated in the drawings should only be considered as examples and the invention may be modified and the different elements combined in several different ways within the scope of the claims. For instance, in engines supplied with a mixture of fuel and air through the supply conduits 87, 81, 85, 86, 79, 80 the fuel injection valves 16 may be replaced by spark plugs.

What I claim is:

1. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a plurality of substantially parallel passages leading into said cylinder at one end of the cylinder and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder.

2. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a reciprocating working piston in said cylinder, a crank shaft connected with said working piston, a plurality of substantially parallel passages leading into said cylinder at one end of...
the cylinder and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, two opposed scavenging fluid supply conduits disposed one on each side of an axial longitudinal centre plane of the engine and communicating with said passages through which scavenging fluid is admitted into the combustion cylinder in two opposed stream bundles deflected into an axial stream within the cylinder, and an outlet at the opposite end of the cylinder.

3. A two stroke cycle internal combustion engine according to claim 2 in which each scavenging fluid supply conduit is divided in two branches leading to groups of parallel passages.

4. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, scavenging openings in said cylinder at one end of the cylinder, a plurality of substantially parallel passages leading to said scavenging openings and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, a reciprocating working piston in the cylinder controlling the admission through the scavenging openings, a ridge extending substantially diametrically over the top of said piston, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder.

5. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a reciprocating working piston in said cylinder, a plurality of substantially parallel passages leading into said cylinder at one end of the cylinder and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, a reciprocating working piston in the cylinder controlling the admission through the scavenging openings, a ridge extending substantially diametrically over the top of said piston and having an end surface which at the end of the compression stroke of the engine forms a narrow slit or gap with adjacent portions of an axial centre plane, a scavenging opening chamber at that moment in two spaces and setting up fluid jets projecting from said slit or gap, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder.

6. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a reciprocating working piston in said cylinder, scavenging openings in the cylinder at one end of the cylinder, a plurality of substantially parallel passages leading to said scavenging openings and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, a ridge extending substantially diametrically over the top of said piston perpendicularly to said passages, guide surfaces on each side of said ridge for axially deflecting a portion of the fluid entering the cylinder through the passages, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder.

7. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a plurality of substantially parallel passages leading into said cylinder at one end of the cylinder and directed substantially perpendicularly towards an axial centre plane of the cylinder and disposed on each side of said axial centre plane and distributed over the whole length of a cylinder diameter included in the axial centre plane, walls confining the outside of said side most passages making a sharp almost 90° turn towards the cylinder centre just before the inlet into the cylinder and forming guide surfaces for countering the formation for tangential fluid streams in the cylinder during the scavenging period, means for supplying scavenging fluid to the passages, and an outlet at the opposite end of the cylinder.

8. A two stroke cycle internal combustion engine according to claim 7 in which the second sidemost passages are confined by walls of which the most tangentially disposed makes a sharp turn just before reaching the opening into the cylinder for preventing the formation of tangential fluid streams in the cylinder.
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9. Pistons and dividing the combustion chamber in two spaces at the end of the compression stroke, end surfaces on said ridges co-operating at the end of the compression stroke of the pistons to form a narrow slit or gap for inducing fluid jets in said compression spaces, means for supplying scavenging fluid to said passages, and an outlet at the opposite end of the cylinder.

10. A two stroke cycle internal combustion engine according to claim 14 in which the ridges on the opposed pistons are of equal height.

15. A two stroke cycle internal combustion engine according to claim 14 in which the ridges on the piston controlling the scavenging openings is higher than the cam or ridge on the other piston.

16. A two stroke cycle internal combustion engine according to claim 14 in which the ridge on the piston controlling the scavenging openings is higher than the cam or ridge on the other piston.

17. In a two stroke cycle internal combustion engine with uniflow scavenging, a combustion cylinder, a plurality of substantially parallel passages leading to scavenging openings in said cylinder at one end of the cylinder and directed substantially perpendicularly towards an axial centre plane of the cylinder and distributed over the whole length of the cylinder diameter included in the axial centre plane, opposed working pistons in the cylinder, a ridge extending substantially diametrically over the top of one of said pistons and having an end surface which at the end of the compression stroke of the engine forms a narrow slit or gap with adjacent portions of the engine dividing the combustion chamber in separate spaces, a fuel injection device having nozzles directing fuel jets in fan shape towards said piston, means for supplying scavenging fluid to the passages, and an outlet at the opposite end of the cylinder.

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