Jan. 18, 1955 C. F. TAYLOR 2,699,765

SCAVENGING SYSTEM FOR TWO-STROKE INTERNAL-COMBUSTION ENGINES

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Fig. 2.

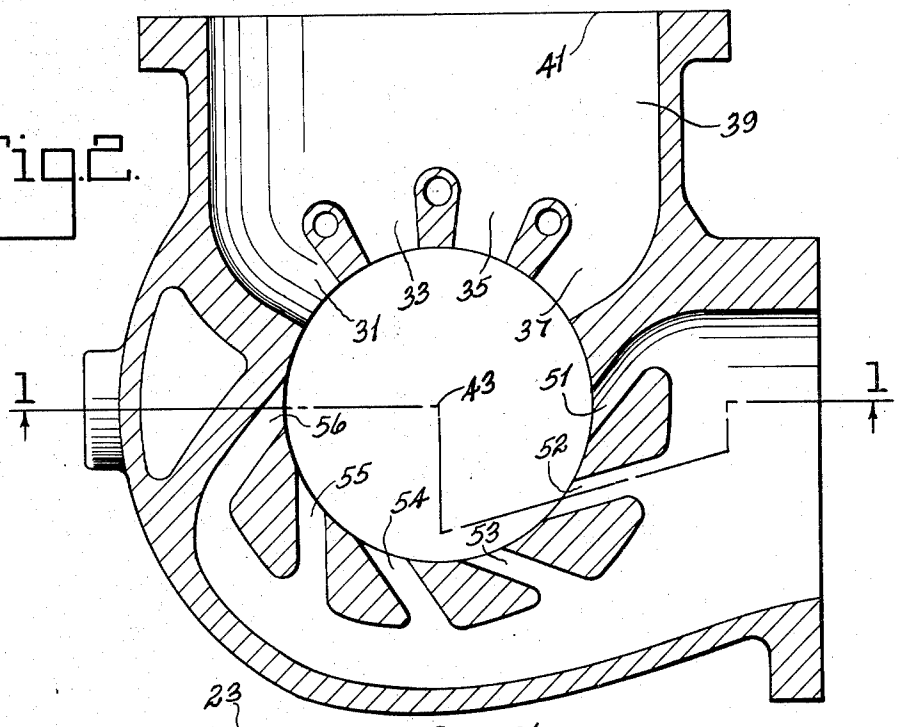
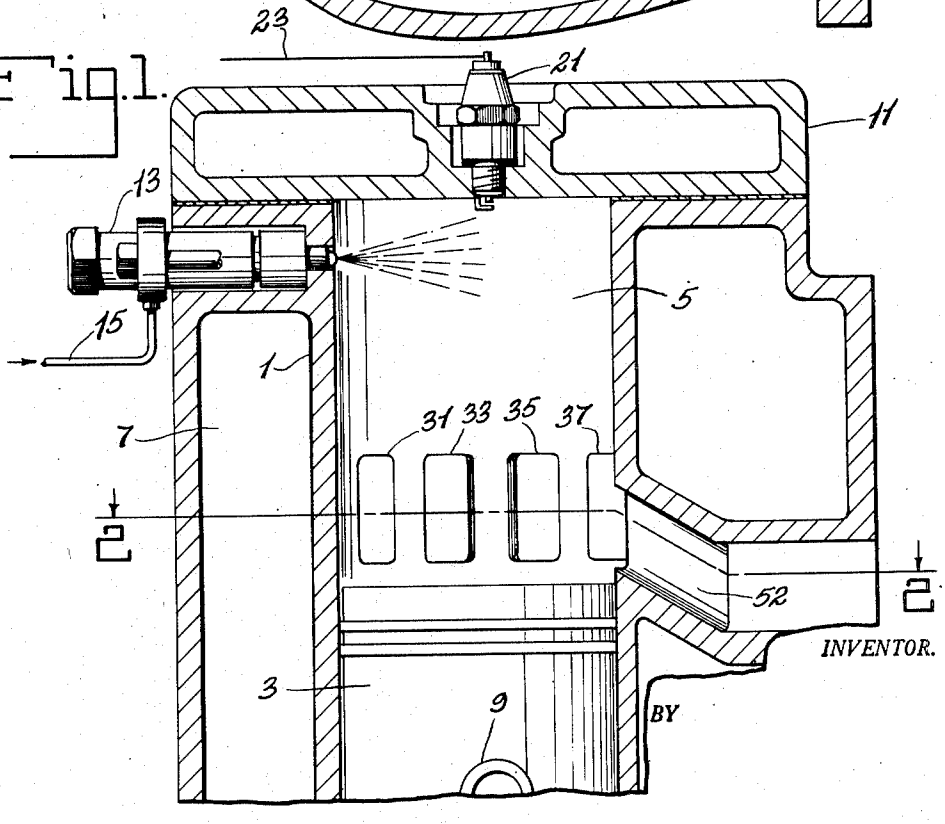


Fig. 1.



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Fig. 3.

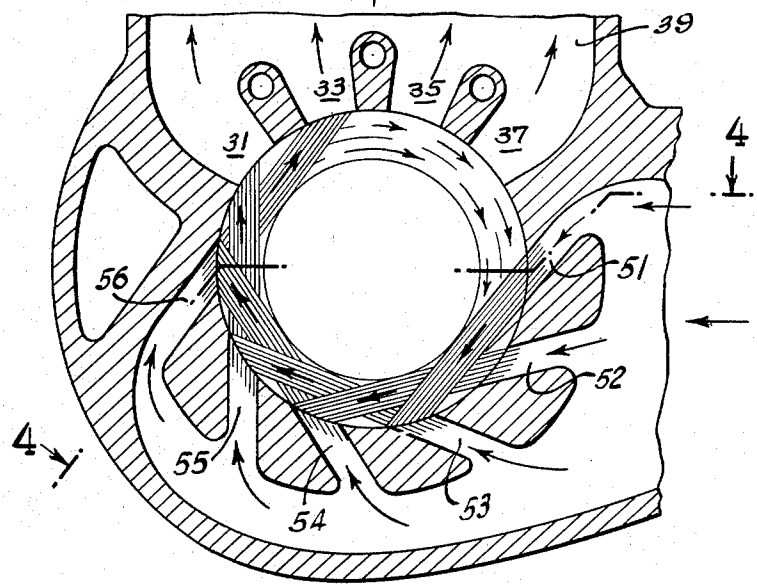
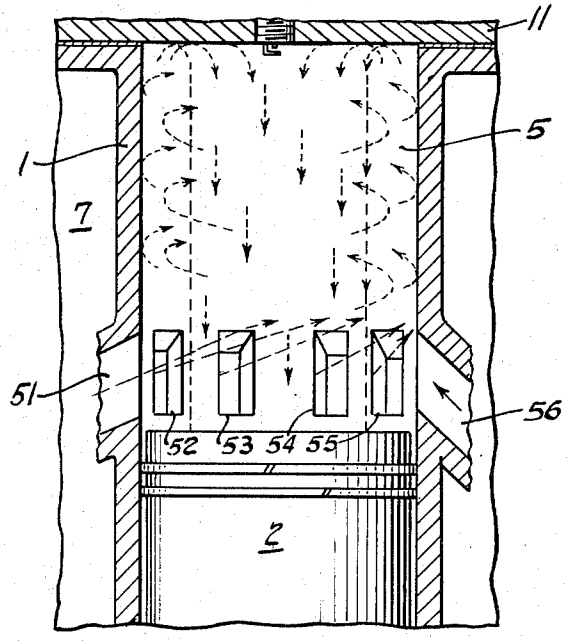


Fig. 4.



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2,699,765

SCAVENGING SYSTEM FOR TWO-STROKE INTERNAL-COMBUSTION ENGINES

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2 Claims. (Cl. 123—65)

This invention relates to a scavenging system for two-stroke cycle internal combustion engines. More particularly it relates to an improved scavenging system for two-stroke engines which require for their proper operation a high speed swirling or rotation of the charge within the engine cylinder during the combustion cycle.

It is known in the prior art to scavenge the cylinders of open chamber two-stroke engines by porting the cylinder wall near bottom dead center to permit exhaust gases to escape, and providing adjacent intake ports in the cylinder wall through which a fresh charge is admitted to displace or scavenge the waste combustion products from the cylinder. Generally the intake ports are closer to bottom dead center than the exhaust ports so that the exhaust ports are uncovered first during the descending piston stroke, to provide for the necessary "blow-down" of exhaust gases before the intake ports open. This scavenging arrangement is commonly known as loop scavenging since the fresh charge is generally considered to come into the cylinder and be deflected in a generally looped-shaped path upward to the top of the cylinder and then downward again, displacing the waste gases before it.

Two-stroke engines are also scavenged by what is known as the uniflow method. With this type of scavenging the exhaust port or ports are provided at one end of the cylinder, generally in the cylinder head, and the intake ports are provided in the cylinder wall at or near bottom dead center. With this arrangement when the intake ports are uncovered by the descending piston, the fresh charge rushes in and displaces the waste combustion products in a unitary direction upward and out the exhaust ports.

Uniflow scavenging is generally more efficient than loop scavenging because of the reduced tendency to mixing and dilution of fresh charge with combustion products. Also, when engine breathing capacity is important, uniflow scavenging offers advantages in that porting the cylinder at both ends permits the largest possible flow area for passage of fresh charge into the cylinder. For example all of the cylinder wall near bottom dead center can be used for intake ports, whereas with loop scavenging the exhaust ports must also share this space.

However the uniflow system involves a more complicated engine structure, including overhead valves, rocker arms, push rods, and the like. Hence, from the point of view of simplicity of structure and economy of construction it is preferable to use loop scavenging.

With engines requiring a substantial rate of rotation of the charge relative to engine speed, however, use of the simple loop scavenging system has heretofore been considered inadvisable, because the arrangement of the intake and exhaust ports and the path of inlet and outlet flow with such a system was such that an inadequate rate of rotation of the fresh charge in the cylinder could be obtained.

The present invention consists of an arrangement of intake and exhaust ports in a two-stroke engine such that loop scavenging, with its attendant advantages in simplicity of engine structure, can be employed, while at the same time both a substantial amount of air swirl and adequate scavenging efficiency can be obtained, and both air swirl rate and scavenging efficiency increase with engine speed.

It is an object of the present invention therefore to provide an improved scavenging system for two-stroke cycle internal combustion engines employing high speed swirl of the charge.

It is another object to provide a swirling charge two-stroke engine having improved simplicity.

Another object is to provide an improved valveless two-stroke swirling charge engine.

Another object is to provide a loop scavenged two-stroke swirling charge engine having intake ports arranged to provide a high velocity swirl of the intake charge about the cylinder axis with good scavenging efficiency.

These and other objects and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

Fig. 1 is a sectional view of a two-stroke engine cylinder having intake and exhaust ports constructed and arranged in accordance with the present invention, taken in the plane of line 1—1 of Fig. 2.

Fig. 2 is a sectional view of the engine shown in Fig. 1, taken in the plane of line 2—2 of Fig. 1.

Fig. 3 is a sectional view of a two- stroke engine cylinder, similar to the disclosure of Fig. 2, showing the overlaying manner in which scavenging air enters the cylinder; and

Fig. 4 is a sectional view of the engine cylinder shown in Fig. 3, taken in the plane of line 4—4 of Fig. 3, and disclosing the increasingly inclined flow axes of the scavenging air.

Briefly, the invention consists in providing cylinder wall intake ports, near bottom dead center, which are inclined tangentially so as to direct the fresh charge into the cylinder tangentially, thereby causing it to swirl or rotate around the axis of the cylinder. The intake ports are also slanted upward to give the entering fresh charge the proper upward directivity in the cylinder to produce the necessary loop-like flow path for proper loop scavenging. The upward directivity given the inducted charge also prevents it from being shunted directly out the exhaust ports, which are disposed in the cylinder wall opposite the intake ports, in the conventional loop scavenging position. This results in what might be called helical scavenging, wherein the fresh intake charge, being colder and more dense, swirls around the outermost portion of the cylinder, hugging the cylinder walls as it spirals upward toward the top of the cylinder. The waste combustion products, being hot and consequently less dense, are displaced to the center or core of the cylinder. Induction of additional fresh charge then causes this core or column of waste gases to be progressively displaced out of the exhaust ports. The exhaust ports are themselves arranged with their respective center lines focused at the center of the cylinder, so as to provide the easiest possible flow path for the egress of waste combustion products.

Referring now to Figs. 1 and 2 of the drawings, the engine includes a cylinder 1 with piston 3 forming a main cylinder combustion space 5, cooling jacket 7, and connecting rod 9 running to the usual crankshaft, not shown. A cylinder head 11 closes the top of cylinder 1.

A fuel injection nozzle 13 is mounted in the side of cylinder 1 in a position to inject fuel into the space 5. The nozzle depicted is of the fuel pressure actuated type, and is supplied with fuel at injection pressure from a suitable engine-driven fuel pump, not shown, through piping 15 in the conventional manner. Of course, if the fresh charge to be inducted to the combustion space is carbureted with fuel before induction, no fuel injection nozzle is necessary.

A spark plug 21 is also mounted in the cylinder head 11, on the downstream side of nozzle 13. The spark plug 21 is connected through lead 23 to a conventional ignition circuit, not shown, which is actuated in synchronism with the engine in the usual manner.

Near piston bottom dead center the cylinder is provided with exhaust ports 31, 33, 35, 37 whose inner ends are spaced along a circumference of cylinder 1. The exhaust ports 31, 33, 35, 37 open into an annular exhaust passage 39 which connects at 41 to an exhaust manifold, not shown. Reciprocation of the piston 3 thus controls the opening and closing of the exhaust ports. The exhaust ports 31, 33, 35, 37 are preferably inclined so that their center lines or flow axes are focused at a point close to the center or axis 43 of the cylinder 1.

The cylinder 1 is also provided with intake ports 51,

52, 53, 54, 55, 56 formed through the wall thereof just above the bottom dead center position of the piston and on the opposite side of the cylinder 1 from the exhaust ports 31, 33, 35, 37. The exhaust ports extend upward in the cylinder wall farther than the intake ports in order to be uncovered earlier in the descending stroke of the piston and permit "blow down" or decompression of the waste combustion products before the intake ports are opened.

In accordance with the present invention the intake ports 51, 52, 53, 54, 55, 56 are inclined tangentially, all in the same clockwise direction, so as to direct the inducted charge into the cylinder 1 generally tangentially, and thereby cause it to swirl rapidly around the cylinder axis 43. The intake ports 51, 52, 53, 54, 55, 56 are also inclined upward, so as to impart to the inducted charge an additional velocity component axially of the cylinder 1, toward the cylinder head 11. This causes the inducted air to follow a generally helical or spiral path, in the manner of the pitch of a screw.

In operation of the engine above described with scavenging as contemplated by the present invention, the exhaust ports 31, 33, 35, 37, are uncovered by the piston 3 during the latter part of its power stroke. Waste combustion products thereby rush out through the exhaust ports 31, 33, 35, 37 and exhaust passage 39 to the exhaust manifold, thereby lowering the pressure within the cylinder 1 substantially to atmospheric. About 20 or 25 crankangle degrees after the exhaust ports 31, 33, 35, 37 are opened by the piston 3, the intake ports 51, 52, 53, 54, 55, 56 are uncovered and the fresh charge enters the cylinder 1.

The fresh charge has imparted to it by the orientation of the intake ports 51, 52, 53, 54, 55, 56 the proper velocity components to cause it to swirl rapidly around the cylinder axis 43 while at the same time rising helically toward the cylinder head 11. Since the fresh charge is cool, and therefore more dense than the hot waste combustion products it is intended to displace, the fresh charge will hug the walls of cylinder 1 as it swirls about the cylinder and climbs toward the cylinder head 11. The upward inclination of the intake ports 51, 52, 53, 54, 55, 56 is preferably sufficient, however, to direct the charge above the exhaust ports 31, 33, 35, 37 by the time it has swirled around to the exhaust port side of the cylinder. This prevents the fresh charge from being shunted immediately out the exhaust ports and short-circuiting the scavenging operation. To this end the intake ports which are closest to the exhaust ports, as measured along the swirl path of the fresh charge, may if preferred be inclined upward at the greatest angle, while the intake ports further removed may be inclined upwardly at a lesser angle.

As the fresh charge fills the peripheral portion of the cylinder 1 from bottom to top, it displaces the waste combustion products to the center or axial portion of the cylinder 1. This core of waste combustion products is then progressively displaced out of the cylinder 1 by flowing progressively downward to the focal point of the exhaust ports 31, 33, 35, 37 and thence out of the exhaust ports. As the piston 3 progresses on its compression stroke the intake and exhaust ports are covered, the swirling fresh charge is compressed within the cylinder 1 and combustion of the fresh charge then takes place in the manner desired.

As heretofore explained the intake ports 51, 52, 53, 54, 55, 56 must be inclined upward sufficiently to direct the fresh charge above the exhaust ports as it swirls around the cylinder wall, but the intake ports should not be directed upward at so great a pitch as to reduce excessively the tangential component of velocity of the inducted charge, since this would of course reduce the swirl rate excessively. In general, it may be said that those intake ports 51, 52, 53, 54, 55, 56 which are separated from the exhaust ports 31, 33, 35, 37 by the shortest path of swirling charge flow, and hence should be directed upward at the greatest angle, will have an upward angle of inclination, as measured from a plane normal to the cylinder axis 43, of 20 to 40 degrees. In accordance with the present invention it is also contemplated that the amount of tangential inclination of the intake ports 51, 52, 53, 54, 55, 56 will be equal for all intake ports and as large as necessary to provide the necessary air swirl rate. In general, this angle of inclination should preferably be about 40–60° as measured from a cylinder radius through the center of each respective intake port.

The quantity of fresh charge introduced into the cylinder in each cycle should preferably be sufficient to provide a scavenge ratio of at least 1:1; the expression "scavenge ratio" meaning the ratio of the weight of charge actually supplied to the weight of charge required to fill the cylinder, at exhaust pressure and charge inlet temperature. The charge is generally supplied at a small controlled superatmospheric pressure to give the scavenge ratio desired.

To illustrate the advantages of the present invention, in a test of one exemplary embodiment it has been found that by providing a scavenging system as herein described, the rate of swirl of the charge during the combustion cycle can be increased from 4.7 revolutions per engine revolution to 8.3 revolutions per engine revolution, at 1800 R. P. M., with only a slight sacrifice in scavenging efficiency, as represented by a decrease in brake mean effective pressure from 58.8 p. s. i. to 52.0 p. s. i.

The present invention is particularly useful with two-stroke engines operating with combustion in the manner described in the patent to E. M. Barber, 2,484,009. In engine operation as there described, the oxidizing gas is caused to swirl rapidly around the cylinder combustion chamber. Fluid fuel to be burned in the engine is injected during each cycle of operation of the engine. The first increment of injected fuel is ignited as soon as combustible mixture is formed from it. This forms a patch of combustible mixture which is confined in one direction by the stream of swirling oxidizing gas traveling toward the patch and containing little or no vaporized fuel so that it is incombustible. The patch is confined on the other side by gaseous products of combustion traveling away from a flame front at the edge of the patch where the mixture is burned substantially as fast as it is formed. Combustion is thus confined to and completed at the leading edge of the patch. Thus, during each cycle of operation of the engine a patch of combustible mixture is progressively formed and consumed in a localized area of the cylinder. As a result, little or no "end gases" are permitted to exist, and even when existent are not exposed to the pressure and the temperature at which spontaneous ignition occurs for the time required to bring about spontaneous ignition. Consequently, "ping" or "knock" is inhibited even with fuels of low anti-knock value at high compression ratios.

Thus it may be seen that in two-stroke engines of the type wherein a high rate of swirl of the charge during the combustion cycle is of importance, the present invention provides an effective solution to the problem of achieving a very large increase in swirl rate at a relatively small sacrifice in scavenging efficiency or power output, and a scavenging efficiency and swirl rate which increase with engine speed, with a structural configuration which retains all the advantages of the extreme simplicity of the conventional loop scavenging system.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In a two-stroke cycle reciprocating piston internal combustion engine having a cylinder closed at one end by a cylinder head, a plurality of exhaust ports in the wall of said cylinder adjacent piston bottom dead center position, and a plurality of intake ports in the cylinder wall adjacent said piston bottom dead center position and opposite the exhaust ports, each of the intake ports having a flow axis inclined tangentially to said cylinder to impart a tangential velocity component to the intake charge, each of said intake ports being inclined upwardly toward said cylinder head to impart a velocity component axially of said cylinder to said intake charge, each of said intake ports having a degree of upward varying inversely to its charge flow-path distance from the exhaust ports.

2. In a two-stroke cycle reciprocating piston internal combustion engine, a cylinder closed at one end by a cylinder head, a plurality of exhaust ports in the wall of said cylinder adjacent piston bottom dead center position, a plurality of intake ports in the cylinder wall adjacent said piston bottom dead center position and opposite said plurality of exhaust ports, each of the intake

ports having a flow axis inclined tangentially to said cylinder to impart a tangential velocity component to the flow of the intake charge, each of said intake ports being progressively inclined upwardly toward said cylinder head to impart a velocity component axially of said cylinder to said flow of said intake charge, the intake port which is the shortest counter-flow distance from said plurality of exhaust ports having the largest upward angle of inclination.

References Cited in the file of this patent

UNITED STATES PATENTS

2,034,093	Gehrandt	Mar. 17, 1936
2,111,282	Edwards	Mar. 15, 1938

FOREIGN PATENTS

284,735	Great Britain	Feb. 6, 1928
288,466	Great Britain	Apr. 12, 1928