United States Patent

Irgens

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[54] **TWO STROKE FUEL INJECT ENGINE WITH SCAVENGED PRE-COMBUSTION CHAMBER**

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[58] **Field of Search**....123/32 B, 32 C, 78 AA, 32 D, 123/32 E, 32 K, 32 L, 191 SP, 48 D, 48 B, 48 R, 73 CC

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[57] **ABSTRACT**

Disclosed herein is a two stroke fuel injection engine including a closed auxiliary cylinder extending from the head end of a main cylinder, together with an auxiliary piston which is movable in the auxiliary cylinder between an extended position adjacent to the main cylinder when the piston in the main cylinder is at bottom dead center and a retracted position remote from the head end of the main cylinder when the piston in the main cylinder is adjacent to top dead center position. Between the piston in the main cylinder and the auxiliary piston when in its retracted position, there is defined an initial or precombustion chamber which communicates with a fuel injection means and which is scavenged by movement therethrough of the auxiliary piston during travel from the retracted to the advanced position.

12 Claims, 2 Drawing Figures

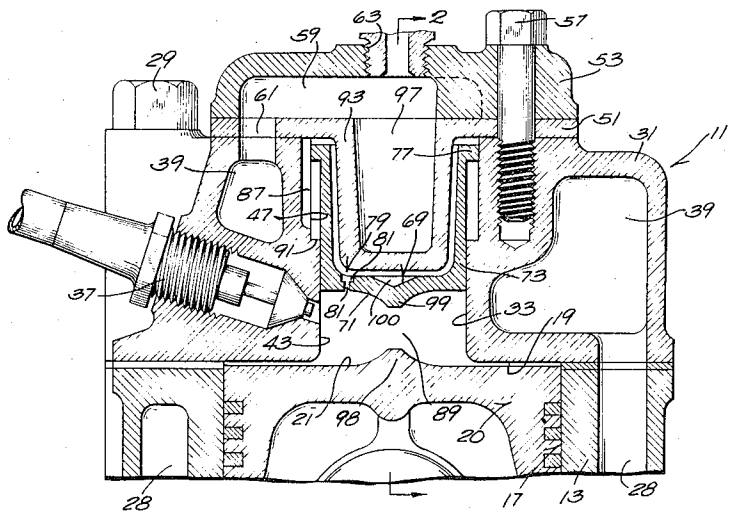


Fig. 1

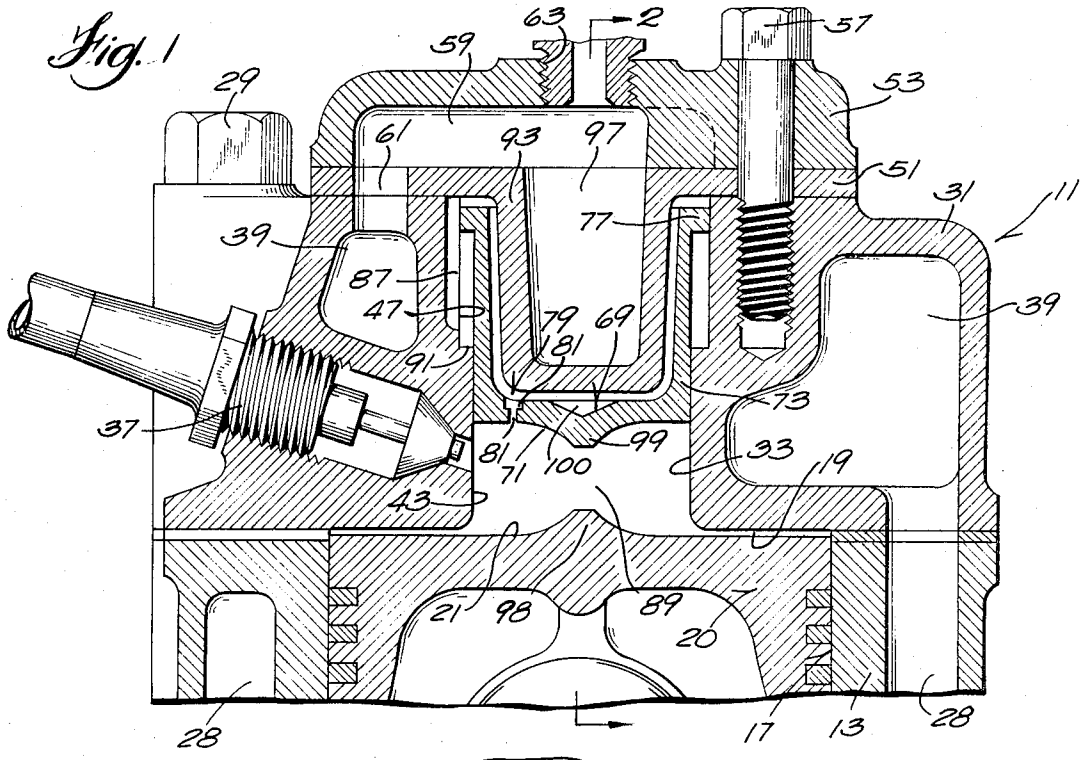
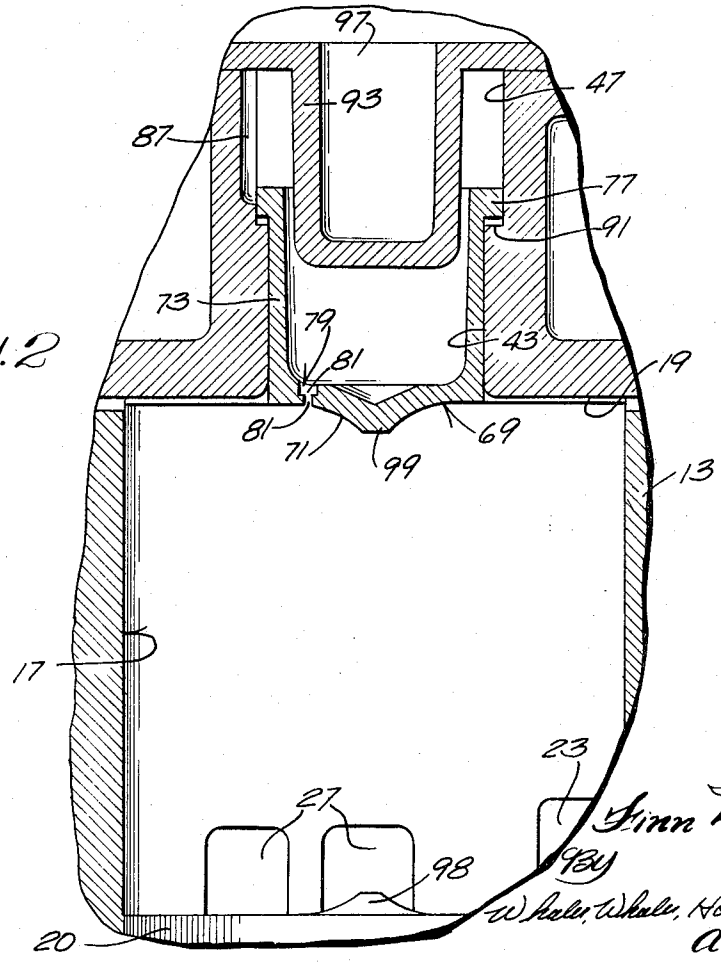


Fig. 2



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TWO STROKE FUEL INJECT ENGINE WITH SCAVENGED PRE-COMBUSTION CHAMBER

BACKGROUND OF THE INVENTION

The invention relates generally to fuel injection engines and more particularly to two stroke diesel engines. However, the invention is also applicable to two stroke fuel injection spark ignited engines. Still more particularly, the invention relates to engines including pre-combustion chambers which are not traversed by the piston operating in the cylinder and which are difficult to effectively scavenge.

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided a two stroke fuel injection engine with a so-called precombustion or initial combustion chamber which is periodically formed in an auxiliary cylinder or compression chamber, at least in part, by an auxiliary piston movable in the auxiliary cylinder between advanced and retracted positions in response to movement of a main piston in a main cylinder extending axially from the auxiliary cylinder.

The auxiliary piston is in the retracted position when the piston in the main cylinder is at top dead center adjacent to the auxiliary cylinder. In the retracted position, the auxiliary piston is located remotely from the main cylinder to form in the auxiliary cylinder between the main and auxiliary pistons a pre-combustion or initial combustion chamber with which a fuel injection nozzle communicates. Injection of fuel into the heated and compressed combustion air displaced into the precombustion or initial combustion chamber by the compression stroke of the main piston can be used to ignite the fuel in the well known diesel manner to effect engine operation. Alternately, spark ignition can be employed.

The auxiliary piston is in the advanced or extended position when the piston in the main cylinder is at bottom dead center. In the extended position, the auxiliary piston is located at or closely adjacent to the head end of the main cylinder. When moving from the retracted position to the advanced position, the auxiliary piston sweeps the precombustion chamber in the auxiliary cylinder or compression chamber to thereby improve over-all engine scavenging by displacing from the precombustion chamber and into the main cylinder any burnt gases which can then be effectively scavenged from the main cylinder in the usual fashion.

Expressed somewhat differently, the invention provides an auxiliary cylinder or compression chamber in which there is located a floating piston which moves between extended and retracted positions in response to movement of the piston in the main cylinder. Such auxiliary piston reciprocation periodically creates and then sweeps through a pre or initial combustion chamber so as to improve over-all scavenging of the engine.

The invention also provides for shaping or forming of the opposed faces of the main and auxiliary pistons with means in the form of projections or protuberances for effecting turbulence in the pre or initial combustion chamber formed in the auxiliary cylinder, thereby to insure superior fuel air mixture and full combustion.

The invention also provides for restricted passing of gases from one side of the floating auxiliary piston to the other so as to facilitate initial orientation of the auxiliary piston. In this regard, the auxiliary piston is provided with a port through the face thereof to admit gases into the volume of the compression chamber behind the auxiliary piston.

In addition, the auxiliary piston is provided with a flange which is guided by an enlarged bore portion of the auxiliary cylinder and there is provided an arrangement for passing gases around the flange so as to avoid restricting free travel of the auxiliary piston, except when the auxiliary piston approaches the extended position. In this regard, the by-pass arrangement is terminated in advance of full approach of the auxiliary piston to the advanced position so as to trap gases and to provide a dash pot effect as the auxiliary piston completes its approach to the extended or advanced position.

Still further, the invention provides an arrangement for effectively cooling both the auxiliary cylinder and the auxiliary piston.

A principal object of the invention is the provision of a fuel injection type internal combustion engine with a pre or initial combustion chamber and means for effectively scavenging the pre or initial combustion chamber.

Another of the principal objects of the invention is the provision of a two stroke fuel injection type internal combustion engine including an auxiliary cylinder or compression chamber extending from the main cylinder and an auxiliary piston movable in the compression chamber between retracted and advanced positions thereby, during each cycle, to establish a pre or initial combustion chamber within the compression chamber and then to cause collapse or disappearance of the pre-combustion chamber by movement of the auxiliary piston through the compression chamber to expel the gases therefrom and into the main cylinder for scavenging in the usual manner.

Still another principal object of the invention is the provision of a pre or initial combustion chamber defined, in part, by co-axially reciprocating pistons each having therein cooperating means for effecting turbulence within the pre or initial combustion chamber.

Another of the principal objects of the invention is the provision of a two stroke fuel injection type internal combustion engine which is generally economical to construct and which will provide superior performance over a long and useful life.

Other objects and advantages of the invention will become known by reference to the following description and accompanying drawings.

DRAWINGS

FIG. 1 is a fragmentary sectional view taken along line 1—1 of FIG. 2 illustrating an engine embodying various of the features of the invention.

FIG. 2 is a fragmentary sectional view taken generally along line 2—2 of FIG. 1.

GENERAL DESCRIPTION

Illustrated in the drawings is an internal combustion engine 11 of the two stroke fuel injection type including an engine block 13 including wall means defining a main cylinder 17 having a head end 19 and suitable

water jacket passages for coolant. Reciprocably mounted in the main cylinder is a main piston **20** which includes a transverse wall having a face **21** and which, except as described hereinafter, is conventionally constructed. Also formed in the engine block **13** are one or more suitable exhaust ports **23** for discharging the burnt products of combustion and one or more suitable inlet ports **27** for admitting combustion air, which exhaust and inlet ports **23** and **27** are opened and closed in response to piston movement as is the usual case for two stroke engines. Incoming combustion air can be supplied through the inlet ports **27** to the main cylinder **17** by crankcase pressure as is usually the case in two stroke engines or by any other suitable arrangement. Suitable coolant passages **28** are also provided in the engine block **13**.

Attached to the head end **17** of the cylinder block **13** by bolts **29** or other suitable means is a cylinder head **31** including wall means defining an auxiliary cylinder or compression chamber **33** which communicates with and preferably extends co-axially with the main cylinder **17**. The cylinder head **31** also includes a fitting receiving a schematically shown fuel injection nozzle **37** and suitable coolant passages **39** which communicate with the coolant passages **28** in the cylinder block **13**. The auxiliary cylinder or compression chamber **33** is defined by a first portion or bore **43** communicating with and located adjacent to the head end **19** of the main cylinder **17** and by a second portion or bore **47** communicating with the other end of the first portion **43** and having a larger diameter than the first bore or portion **43** of the auxiliary cylinder **33**.

The auxiliary cylinder or compression chamber **33** is closed at the end remote from the main cylinder **17** by a head plate **51** held in place by a head cap **53** which is connected to bolts **57**, or otherwise secured, through the head plate **51** to the cylinder head **31**. The head cap **53** includes a coolant passage **59** communicating through a coolant passage **61** in the head plate **51** with the coolant passages **39** in the cylinder head **31**. If desired, the head cap **53** can be provided with a fitting **63** providing for out-flow of coolant water from the coolant passages **59** and **61**.

Located in the auxiliary cylinder or compression chamber **33** is an auxiliary or free floating piston **69** which includes a transverse wall having a face **71** and a skirt **73** which guides movement of the auxiliary piston **69** and which extends from the circular periphery of the transverse face **71** and has an outer diameter approximating the diameter of the first auxiliary cylinder bore **43**. Extending from the end of the skirt **73** remote from the piston face **71** is a flange **77** having an outer cylindrical surface with a diameter approximating that of the second auxiliary cylinder bore **47**.

The auxiliary piston **69** is essentially free floating within the auxiliary cylinder or compression chamber **33** in response to pressures occurring during reciprocating movement of the main piston **20**. Fluid flow around the auxiliary piston is negligible although some leakage can be expected between the piston and the cylinder walls. In addition, in order to accommodate initial orientation of the auxiliary piston in the compression chamber, and particularly if the piston is provided with piston rings to prevent leakage, there is provided a relatively small bleed opening or port **79** communicating through the transverse wall of the piston from the face **71** to the other wall surface remote from the face **71**. The bleed opening or port **79** comprises a bore having a restricted area **81** adjacent to the face of the auxiliary piston and an enlarged counterbore **83** at the other wall surface remote from the main cylinder **17**.

Means are also provided for by-passing fluid around the flange **77** so as to insure free floating action, notwithstanding the dash-pot action which is also provided and which will later be explained. While various arrangements can be employed for passing gas around the opposite surfaces of the auxiliary piston flange **77**, in the disclosed construction, there is provided one or more by-pass slots or grooves **87** which extend radially from and axially of the second portion or bore **47** of the auxiliary cylinder **33**.

In this last regard, in operation, the floating piston **69** reciprocates, in response to the pressures created by reciprocation of the main piston **20**, between extended and retracted positions and so as to afford equal or nearly as equal pressure on both sides of the auxiliary piston. The extended position (See FIG. **2**) occurs when the main piston **20** is adjacent bottom dead center, i.e., at the most remote location from the head end **19** of the main cylinder **17** and when the pressure in the main cylinder is at its lowest. Because the pressure on the face **71** of the auxiliary piston **69** is low, the fluid behind or above the auxiliary piston will force the auxiliary piston downwardly, i.e., toward the main piston **20**, until equal or nearly equal pressures exist on both sides of the auxiliary piston **69**. In the extended position, the auxiliary piston face **71** is generally in flush relation to the head end **19** of the main cylinder **17**.

The retracted position (See FIG. **1**) occurs when the main piston **20** is adjacent top dead center, i.e., adjacent to the head end **19** of the main cylinder **17** and, in this regard, as the main piston **20** moves toward top dead center, the pressure in the main cylinder **17** substantially increases, and thereby forces the auxiliary piston **69** to move away from the main piston **20** and toward its retracted position, and at the same time, compresses the fluid above the auxiliary piston **69**. In the fully retracted position, the face **71** of the auxiliary piston **69** is spaced from the face **21** of the main piston **20** to define a pre-combustion or initial combustion chamber **89** which is located within the auxiliary cylinder or compression chamber **33**, which communicates with the fuel injection nozzle **37**, and which, due to the heat resulting from compression of the incoming combustion air during the compression stroke, can provide for initial combustion upon fuel injection when the components are approximately as shown in FIG. **1** and if diesel operation is employed.

As shown in FIG. **1**, when the auxiliary piston **69** is in its fully retracted position, the auxiliary piston flange **77** is slightly spaced from the head plate **51**. Such spacing can be accomplished by projections on the upper surface of the flange or by projections on the head plate or otherwise. As a consequence of such spacing, communication exists, even when the auxiliary piston **69** is in the retracted position, around the flange **77** and between the volume behind the auxiliary piston **69**, i.e., above the auxiliary piston **69** in the drawings, and the

space between the auxiliary piston skirt 73 and the second auxiliary cylinder bore 47. Consequently, fluid can readily pass from the top to the bottom of the flange 77, and vice versa, during auxiliary piston reciprocation, i.e., in and out of the area defined by the second bore 47 of the auxiliary cylinder 33 and the portion of the auxiliary piston skirt 73 adjacent to the flange 77.

Means are provided to provide metal-to-metal contact between the flange 77 and the shoulder 91 (See FIG. 2) between the first and second bores 43 and 47 of the auxiliary cylinder 33 when the auxiliary piston 69 approaches the extended position. While other arrangements can be employed, in the disclosed construction, the second auxiliary cylinder bore 47 extends toward the main cylinder 17 slightly beyond the adjacent surface of the flange 77 when the auxiliary piston 69 is in the extended position. Additionally, the slots or grooves 87 for by-passing fluid around the flange 77 are terminated in spaced relation to the shoulder 91 so as to cause entrapment of fluid by the flange 77 as the auxiliary piston 69 approaches the extended position, thereby to provide a dash-pot effect as the auxiliary piston 69 approaches the extended position.

In order to obtain proper displacement of the piston through the compression chamber during movement to the retracted position, the volume above the auxiliary piston is controlled and in order to effectively cool the auxiliary piston 69, the head plate 51 is provided with a projecting portion 93 which substantially occupies the area inside the auxiliary piston skirt 73 when the auxiliary piston 69 is in the retracted position and which defines a recess or water jacket 97 communicating with the coolant passage 61 in the head cap 53.

In order to obtain better combustion, means are provided on each of the main piston face 21 and the auxiliary piston face 71 for causing turbulence in the pressurized air as the main piston 20 approaches the head end 19 of the main cylinder 17. While various arrangements can be employed, in the disclosed construction, such means includes the provision on each of the main piston face 21 and the auxiliary piston face 71 of respective projections 98 and 99 which are centered co-axially with the main and auxiliary cylinders. While various other configurations for the protuberances can be provided, it is preferred that the projections 98 and 99 be generally in the form of truncated cones having outer surfaces which are concave in radial cross section.

The undersurface of the head is desirably recessed at 100 under the projection 99 in order to minimize the weight of the auxiliary piston 69.

In operation, as the main piston 20 advances toward top dead center, the combustion air already introduced through the inlet port 27 into the main cylinder 17 is compressed. The compression stroke continues until the face 21 of the main piston 20 is essentially flush with the cylinder head 19, thereby causing the combustion air charge to be displaced into the auxiliary cylinder 33 and substantially compressed, thereby generating a substantial amount of heat. Consequent to the displacement of the combustion air into the initial combustion chamber 89, the auxiliary piston 69 is displaced outwardly from the main piston 20 to the retracted position, thereby exposing the fuel injection nozzle 37 to the initial combustion chamber 89, including the headed compressed combustion air. Displacement of the auxiliary piston 69 to the retracted position also serves to pressurize and compress the fluid above the auxiliary piston, which pressurized fluid later serves to displace the auxiliary piston to the advanced position when the pressure in the main cylinder is reduced. Upon injection of fuel into the initial combustion chamber 89, combustion can take place in the usual manner well known with respect to diesel engines. Alternately, spark ignition can be employed. Such combustion forces the main piston 20 away toward the bottom dead center position. When the exhaust valve opens, the pressure in the main cylinder 17 falls, causing the compressed fluid above the auxiliary piston to displace the auxiliary piston 69 to the extended position with the auxiliary piston face 71 flush with the head end 19 of the main cylinder 17. As a consequence, when the exhaust ports 23 are opened by the main piston 20, improved scavenging can take place. In summary, the free floating action of the auxiliary piston occurs in response to the pressure condition in the main cylinder and the piston floats in such manner as to achieve, as nearly as possible, at all times, equal pressures on both sides of the auxiliary piston.

Various of the features of the invention are set forth in the following claims.

What is claimed is:

1. An engine comprising a main cylinder having a head end, a main piston reciprocable in said main cylinder relative to a position adjacent to said head end, an auxiliary cylinder extending from and communicating with said head end of said main cylinder, an auxiliary piston free of connection with said main piston and including a face in opposing relation to said main piston and a rear side remote from said main cylinder head end, said auxiliary piston being movable in said auxiliary cylinder between an extended position with said face adjacent to said head end of said main cylinder and a retracted position with said face spaced from said head end of said main cylinder, said auxiliary piston defining, when in said retracted position, an initial combustion chamber in said auxiliary cylinder extending between said main cylinder head end and said auxiliary piston and said auxiliary piston effecting full scavenging of said initial combustion chamber in response to travel from said retracted position to said extended position, said auxiliary cylinder including a portion extending from said rear side of said auxiliary piston and being closed to prevent fluid flow therethrough relative to said auxiliary cylinder portion, and a valveless means permitting restricted fluid flow between said auxiliary cylinder portion and the space adjacent to said auxiliary piston face.

2. An engine in accordance with claim 1 wherein said engine is a two stroke engine and further including an air inlet port and an exhaust port in said cylinder remote from said head end, said air inlet and exhaust ports being opened and closed in response to main piston movement.

3. An engine in accordance with claim 1 wherein said auxiliary cylinder extends co-axially from said main cylinder and each of said main piston and said auxiliary piston includes a piston face with a centered protube-

rance extending toward the other piston face to cause turbulence in the gases in said initial combustion chamber upon movement of said main piston to adjacent to said head end of said main cylinder.

4. An engine comprising a main cylinder having a head end, a main piston reciprocable in said main cylinder relative to a position adjacent to said head end, a closed auxiliary cylinder extending from said head end of said main cylinder, and including a first bore adjacent to said main cylinder and a concentric axially adjacent second bore remote from said main cylinder and having a diameter larger than the diameter of said first bore, an auxiliary piston, having a face, a skirt extending from the circular periphery of said face and having a diameter closely approximating the diameter of said first bore, and a radially outwardly extending flange projecting from said skirt remote from said face and having an outer cylindrical surface with a diameter approximating the diameter of said second bore, said auxiliary piston being movable in said auxiliary cylinder between an extended position adjacent to said main cylinder when said main piston is remote from said head end of said main cylinder and a retracted position remote from said head end of said main cylinder when said main piston is adjacent to said head end of said main cylinder, whereby to define, when said auxiliary piston is in said retracted position, an initial combustion chamber between said auxiliary piston and said main piston, a by-pass slot extending radially outwardly from and axially of said second bore and terminating, at one end, in axially spaced relation from the end of said second bore adjacent to said first bore and, at the other end, beyond said flange in the direction away from said head end of said main cylinder when said auxiliary piston is in said retracted position, and fuel injection means communicating with said initial combustion chamber.

5. An engine in accordance with claim 1 including a water jacket in close proximity to said auxiliary cylinder.

6. An engine in accordance with claim 5 including a head cap including a portion projecting into said auxiliary cylinder from the end thereof remote from said main cylinder.

7. An engine in accordance with claim 6 wherein said projecting part includes water jacket means communicating with said first mentioned water jacket.

8. An engine comprising a main cylinder having a head end, a main piston reciprocable in said main cylinder relative to a position adjacent to said head end, a closed auxiliary cylinder extending from said head end of said main cylinder, and an auxiliary piston movable in said auxiliary cylinder between an extended position adjacent to said main cylinder and a retracted position remote from said head end of said main cylinder, whereby to define, when said auxiliary piston is in said retracted position, an initial combustion chamber between said auxiliary piston and said main piston, fuel injection means communicating with said initial combustion chamber, and means for affording gas flow from one side to the other of said auxiliary piston including a bleed hole in said piston face from one side to the other thereof.

9. A two stroke fuel injection engine comprising an engine block including means defining a main cylinder having a head end, an exhaust gas port remote from said head end, and an air inlet port remote from said head end, a main piston reciprocable in said main cylinder relative to said ports to effect opening and closure thereof and relative to a position adjacent to said head end, a cylinder head fixed to said engine block and including means defining an auxiliary cylinder extending from said head end of said main cylinder, said auxiliary cylinder including a first bore adjacent to said main cylinder and a concentric axially adjacent second bore remote from said main cylinder and having a diameter larger than the diameter of said first bore, said cylinder head also including coolant jacket passages in close proximity to said auxiliary cylinder, an auxiliary piston movable in said auxiliary cylinder between an extended position adjacent to said main cylinder when said main piston is remote from said head end of said main cylinder and a retracted position remote from said head end of said main cylinder when said main piston is adjacent to said head end of said main cylinder, whereby to define in said auxiliary cylinder and when said auxiliary piston is in said retracted position, an initial combustion chamber in said auxiliary cylinder between said auxiliary piston and said main piston, said auxiliary piston having a face, a skirt extending from the circular periphery of said face and having a diameter closely approximating the diameter of said first auxiliary cylinder bore, and a radially outwardly extending flange projecting from said skirt remote from said face and having an outer cylindrical surface with a diameter approximating the diameter of said second auxiliary cylinder bore, fuel injection means in said cylinder head communicating with said initial combustion chamber, a by-pass slot in said cylinder head extending radially outwardly from and axially of said second auxiliary cylinder bore and terminating, at one end, in axially spaced relation from the end of said second auxiliary cylinder bore adjacent to said first auxiliary cylinder bore and, at the other end, beyond said flange in the direction away from said head end of said main cylinder when said auxiliary piston is in said retracted position, and a head cap connected to said cylinder head for closing the end of said auxiliary cylinder remote from said main cylinder and including a member projecting into said auxiliary cylinder from the end thereof remote from said main cylinder and within said auxiliary piston skirt when said auxiliary piston is in said retracted position, said projecting part including coolant water jacket means communicating with said coolant jacket passages in said cylinder head.

10. An engine in accordance with claim 9 wherein said auxiliary cylinder extends co-axially from said main cylinder, wherein said main piston also includes a transverse face and wherein said piston faces each include a centered protuberance extending toward the other piston face to cause turbulence in the gases in said initial combustion chamber upon movement of said main piston to adjacent to said head end of said main cylinder.

11. An engine in accordance with claim 1 wherein said valveless means comprises a bleed hole in said auxiliary piston.

12. An engine in accordance with claim 1 wherein said auxiliary cylinder extends substantially co-axially with said main cylinder and has a diameter less then one-half of the diameter of said main cylinder.

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