United States Patent [19]

Gommel

[11] **3,756,206**

[45] **Sept. 4, 1973**

[54] **ENGINE**

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[22] Filed: **Jan. 17, 1972**

[21] Appl. No.: **218,373**

[52] **U.S. Cl.** ..... **123/75 CC,** 123/59 A, 123/73 R

[51] **Int. Cl.** **F02b 75/02,** F02d 39/02

[58] **Field of Search** ..... 123/75 CC, 59 A, 123/57, 75, 59, 73

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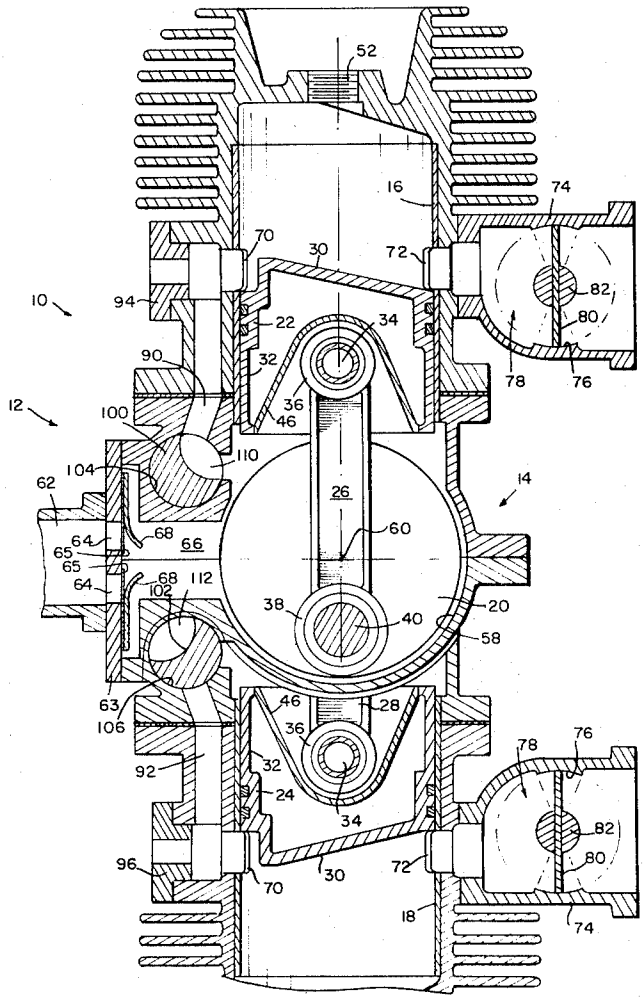
Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Cort R. Flint
Attorney—William R. Coffey et al.

[57] **ABSTRACT**

A 4-cycle, internal combustion engine comprising a crankcase and a pair of cylinders, each cylinder being open at one end into communication with the crankcase. Each cylinder is provided with an inlet port, and a crankshaft is disposed in the crankcase to be adjacent the open ends of the cylinders. A piston is reciprocably received in each cylinder to define therewithin a variable-volume combustion chamber, each piston being drivingly connected in a conventional manner to the crankshaft. A system is provided for admitting a gaseous mixture to the crankcase, and there is a passageway leading from the crankcase to each inlet port. valves are provided for respectively opening and closing the passageways, the valves being drivingly connected to and operated by the crankshaft. The valves are arranged and driven such that each passageway is opened only on alternate occasions when both pistons move toward the axis of the crankshaft. Thus, the pumping action of both pistons drives the gaseous mixture through the only open passageway into one of the two cylinders. The inlet port and an exhaust port is provided in the side wall of each cylinder at peripherally spaced apart points remote from the closed end of the cylinder. An auxiliary chamber in open communication with each exhaust port is provided, each said auxiliary chamber being provided with a port at a point remote from the point of communication of the chamber with the cylinder exhaust port. A butterfly valve is provided for dominating each auxiliary chamber port, the butterfly valve being drivingly connected to the crankshaft.

1 Claim, 14 Drawing Figures

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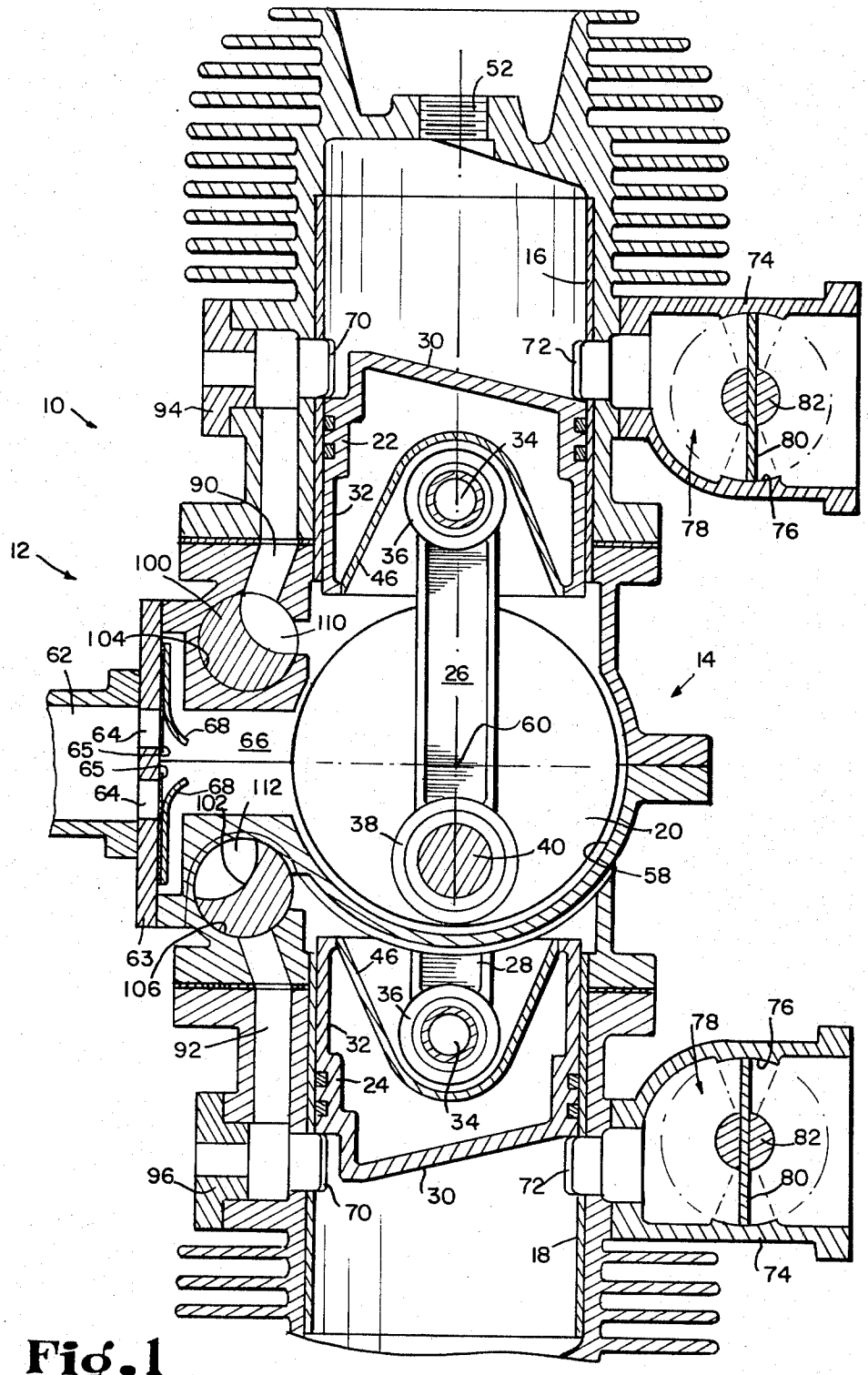

52
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Fig.1

Fig.2

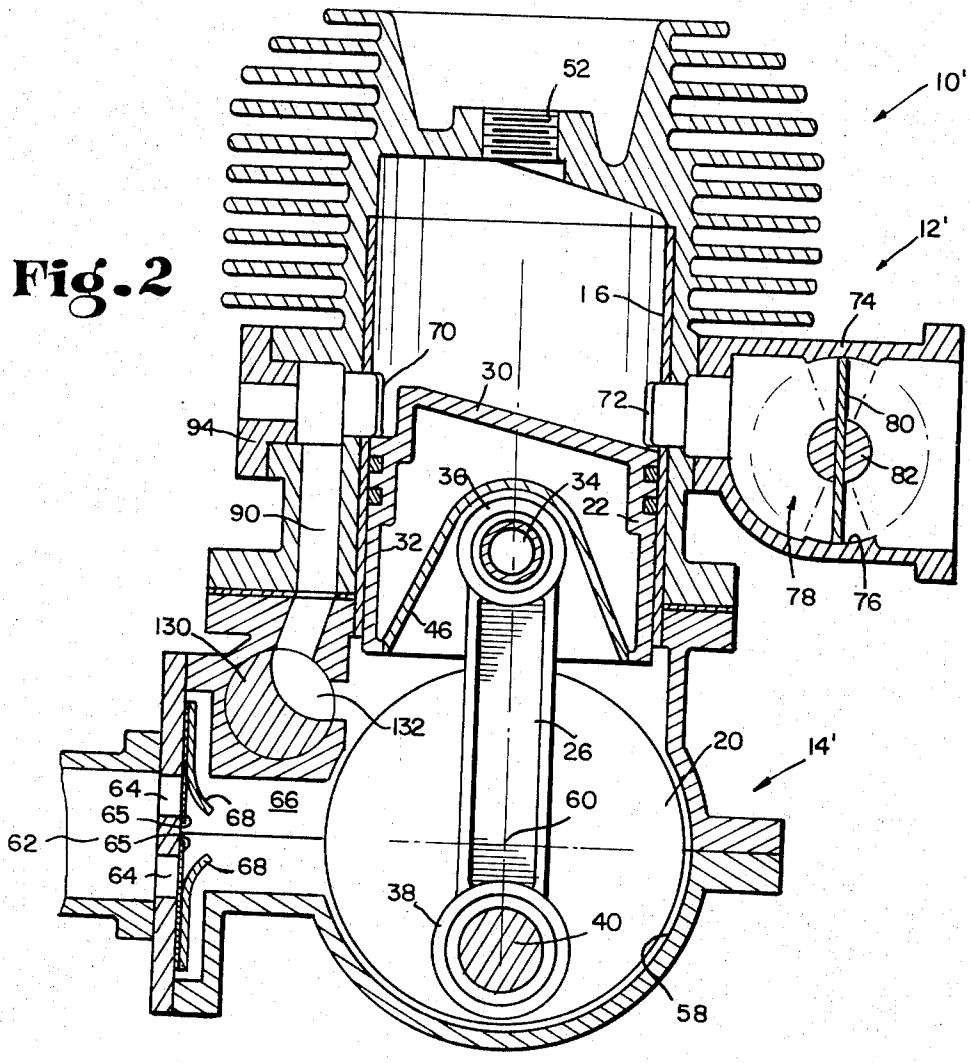


Fig.4a

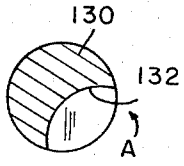


Fig.4b

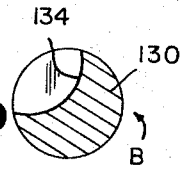


Fig.3

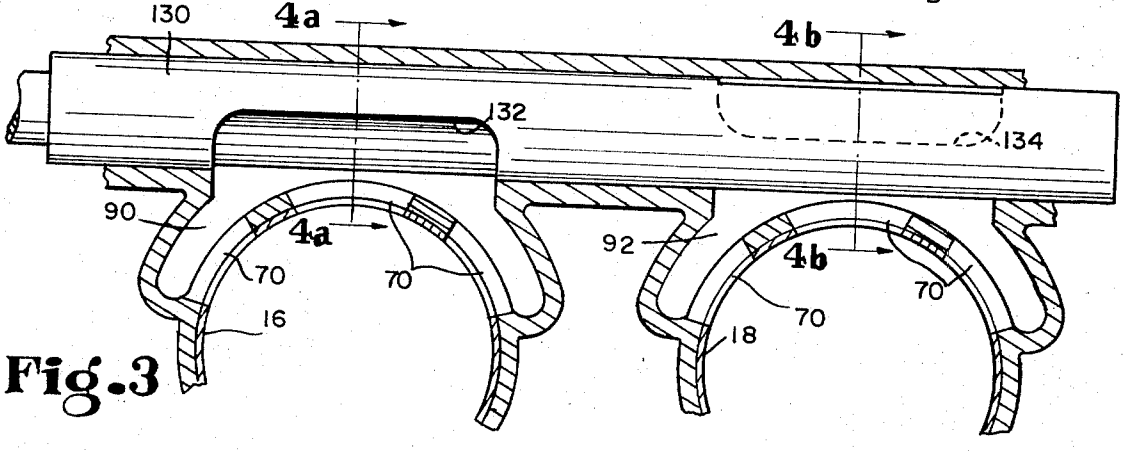
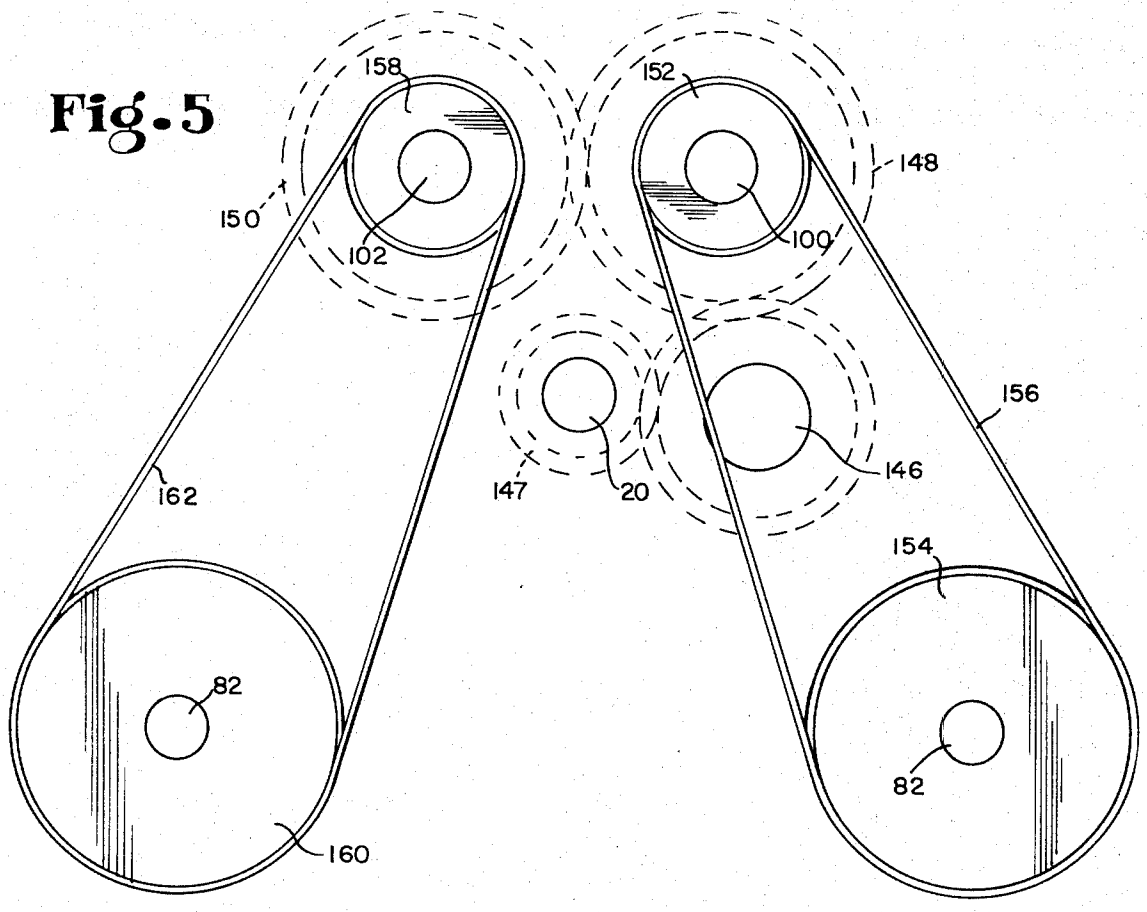
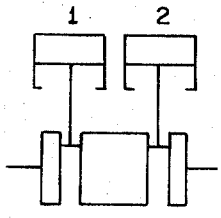


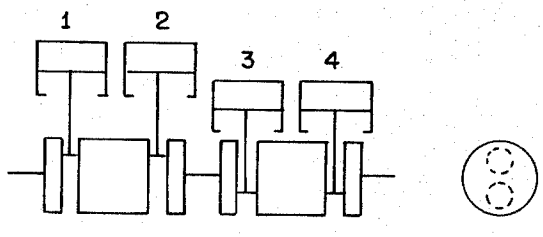
Fig.5





2-CYLINDER

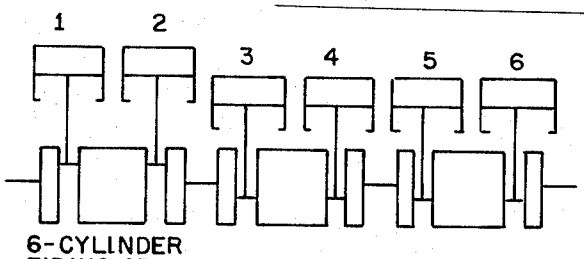
Fig.6



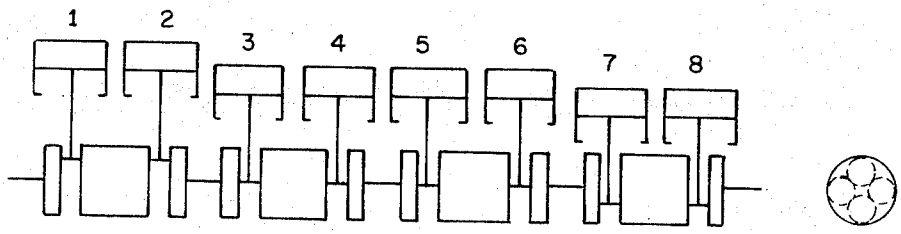
4-CYLINDER
FIRING ORDER- 1-3-2-4

Fig.7

Fig.8

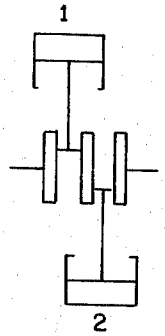


6-CYLINDER
FIRING ORDER- 1-3-5-2-4-6



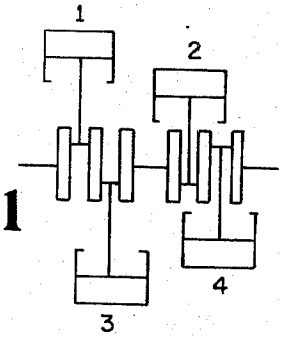
8-CYLINDER
FIRING ORDER- 1-3-7-5-2-4-8-6

Fig.9



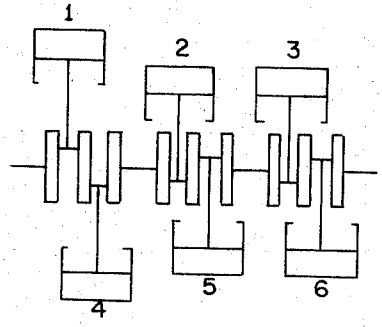
2-CYLINDER

Fig.10



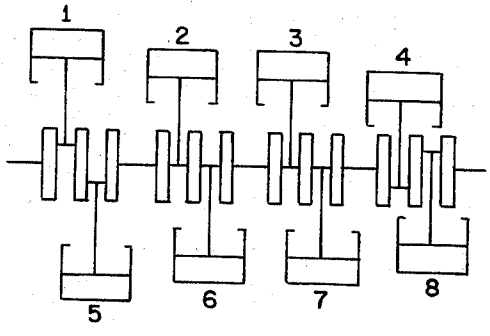
4-CYLINDER
FIRING ORDER 1-2-3-4

Fig.11



6-CYLINDER
FIRING ORDER-1-2-3-4-5-6

Fig.12



8-CYLINDER
FIRING ORDER-1-2-4-3-5-6-8-7

Fig.13

ENGINE

The primary object of the present invention is to provide an improved internal combustion engine of the reciprocating piston type, embodying many of the desirable characteristics of 2-cycle engines and of 4-cycle engines while eliminating undesirable characteristics of both types. Particularly, an object of the present invention is to provide a 4-cycle, internal combustion engine comprising a crankcase and a pair of cylinders opening away from the crankcase and being in communication therewith. A piston is reciprocably disposed in each cylinder to define therewithin a variable-volume combustion chamber. The two cylinders, which may be opposed or side-by-side, are provided with inlet ports, and there is a gaseous mixture carrying passageway leading from the crankcase to each inlet port. Means for admitting a gaseous mixture to the crankcase is provided. Valve means for opening and closing the passageways are provided, the valve means being arranged and driven such that each passageway is opened only on alternate occasions when both pistons move toward the axis of the crankshaft in the crankcase so that the gaseous mixture in the crankcase is pumped through the open passageway into its associated cylinder. In this manner, since the firing cycle of the two cylinders alternate, a two-piston volume charge of gaseous mixture is driven into each cylinder before its piston begins its compression stroke.

In the illustrative embodiment, the gaseous mixture is admitted into the crankcase by means including reed valves which open when the pressure in the crankcase is below the pressure of the source of gaseous mixture and which close when the pressure in the crankcase exceeds that of the gaseous mixture. The reeds open, therefore, when the pistons move away from the axis of the crankshaft and close when the pistons move toward the axis of the crankshaft. The crankshaft and the pistons and the connecting rods are proportioned and designed such that, at any time, the positions of the pistons respectively in the cylinders are substantially identical. That is, it is the simultaneous movement of the pistons away from the crankshaft which draws a gaseous mixture into the crankcase and toward the crankshaft which pumps two-piston volumes of gaseous mixture through the open passageway into one of the cylinders.

One important advantage of the engine of the present invention is that the inlet valve to each cylinder, i.e., the valve which opens and closes the passageway leading from the crankcase to the inlet port of each cylinder, is out of the high heat and high pressure area of the cylinder. Additionally, an exhaust chamber with a butterfly valve dominating its exhaust port is attached to each cylinder to be out of the high heat and high pressure area of the cylinder. This chamber between the exhaust port in the side wall of each cylinder and the butterfly valve permits the gases to burn completely at low heat and low pressure, thereby very significantly to reduce the temperature of the exhaust. This factor will, of course, reduce the pollution content of the exhaust and particularly the nitrous oxide content of the exhaust. It will be appreciated that a simple butterfly valve may not be air tight, and this is an advantage of my structure. Butterfly valves are inexpensive as compared to conventional poppet exhaust valve assemblies.

The engine of the present invention includes two cylinders or any multiple of two cylinders. The cylinders may be either opposed or side-by-side.

I refer to my U.S. Pat. No. 3,499,425 issued Mar. 10, 1970 and also disclosing an engine combining many of the desirable characteristics of 2-cycle and 4-cycle engines.

To the accomplishment of the above and related objects, my invention may be embodied in the forms illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that change may be made in the specific constructions illustrated and described, so long as the scope of the appended claims is not violated.

In the drawings:

FIG. **1** is a sectional view taken along two planes perpendicular to the axis of the crankshaft and showing the opposed cylinder version of the engine of the present invention, the two planes being respectively on the centers of the two cylinders;

FIG. **2** is a sectional view taken along a plane perpendicular to the axis of the crankshaft and showing the side-by-side version of the engine of the present invention;

FIG. **3** is a fragmentary sectional view showing the inlet valve means which controls the flow of gaseous mixture from the crankcase alternately to each side-by-side cylinder;

FIGS. **4***a* and **4***b* are sectional views of the rotary valve member of FIG. **3** taken along the respective indicated section lines;

FIG. **5** is a diagrammatical view showing the manner in which the rotary valves and butterfly valves are drivingly connected to the crankshaft of the opposed cylinder engine of FIG. **1**;

FIGS. **6–9** are diagrammatical views of a 2-cylinder, 4-cylinder, 6-cylinder and 8-cylinder engine with the cylinders side-by-side and showing the firing order of the cylinders; and

FIGS. **10–13** are diagrammatical views showing 2-cylinder, 4-cylinder, 6-cylinder and 8-cylinder engines of the opposed type and showing the firing orders of the cylinders.

Referring more particularly to FIG. **1**, it will be seen that I have illustrated an engine of the internal combustion, reciprocating-piston type, indicated generally by the reference numeral **10**, and comprising a cylinder block assembly **12** providing a generally cylindrically shaped crankcase **14** with opposed cylinders **16, 18** extending radially outwardly from the crankcase. A crankshaft **20** is disposed in the crankcase to extend axially therealong, and a piston **22, 24** is reciprocably received in each cylinder **16, 18** conventionally to define therewithin a variable-volume combustion chamber. Each piston **22, 24** is drivingly connected to the crankshaft in a conventional manner by a rod **26, 28.** Each piston **22, 24** conventionally includes a piston head **30** and a skirt **32** depending from the head and extending toward the crankshaft **20** and a trunnion **34** extending diametrically across the skirt. Each rod **26, 28** has one end **36** journal mounted to the trunnion **34** of its associated piston and its other end **38** journal mounted on an eccentric bearing portion **40** of the crankshaft **20.**

Importantly, it will be appreciated that each piston **22, 24** also includes shield means **46** closing the space bounded by its piston head **30** and skirt **32,** the shield means being formed to provide a cavity opening toward

the crankshaft **20** and proportioned to provide clearance for the oscillation of the said one end **38** of the associated piston rod **26, 28.** The purpose of this shield means **46** is to reduce the overall volume of the space within the crankcase **14** and pistons. This feature will be discussed in more detail as this description progresses.

Each cylinder **16, 18** is conventionally provided with a threaded spark plug opening **52** in its closed end. It will be appreciated that the illustrative engine **10** is an air-cooled engine; but it will be understood that the basic engine may be either water cooled or air cooled, depending upon the particular application requirements.

The engine **10** is constructed such that a gaseous mixture is admitted to the crankcase **14** and then distributed to the cylinders **16, 18.** For this reason, the volume of the space within the crankcase **14** is reduced by defining that space, where possible, by a wall such as indicated at **58** cylindrically formed about the rotational axis **60** of the crankshaft **20.** Further, the crankshaft **20** is formed to provide eccentric bearing portions **40** on which the ends **38** of the rods **26, 28** are journal mounted and cylindrical counter balance portions concentric with the axis of the crankshaft **20** and of a diameter just slightly smaller than the internal diameter of the crankcase **14.** The combined axial length of the concentric cylindrical portions of the crankshaft **20** are generally equal to the axial length of the crankcase **14** less the combined axial length of the bearing portions **40,** thereby to reduce the volume of the gaseous mixture receiving space in the crankcase **14.** In other words, the crankcase **14** is made generally cylindrical and the crankshaft is made concentrically cylindrical at all portions other than the eccentric bearing portions **40** and of a diameter such that it will occupy as much of the space of a crankcase as possible. This structural feature accompanied by the shield means **46** on each piston **22, 24** creates a very effective pump for driving the gaseous mixture admitted to the crankcase **14** alternately into the cylinders **16, 18** when the pistons **22, 24** simultaneously move toward the axis of the crankshaft **20.** The crankshaft **20,** connecting rods **26, 28** and cylinders **16, 18** are proportioned and designed such that, at any time, the positions of the pistons **22, 24,** respectively, in the cylinders are substantially identical.

In this description and in the appended claims, the words "gaseous mixture" are intended to include air by itself or air mixed with the vapor of a fuel such as gasoline or even a fuel vapor by itself. When fuel injection techniques are used, air by itself is admitted to the crankcase **14.** In non-fuel injection engines, a mixture of air and gasoline vapors is admitted to the crankcase **14.**

Means are provided for admitting a gaseous mixture to the crankcase **14,** the illustrative means including an inlet conduit **62,** a plate **63** providing a pair of ports **64** leading from the conduit **62** to a space **66** in the crankcase **14,** and a pair of reed valves **65** for closing the ports **64.** The reed valves **65** normally close the ports **64.** The valves **65,** which may conventionally be 0.008 to 0.012 inches thick, are arranged such that when the pressure in the crankcase **14** drops below the pressure of the gaseous mixture source, the valves open to admit the gaseous mixture into the crankcase and, when the pressure in the crankcase exceeds that of the gaseous mixture source, the valves close the ports **64.** Particularly, the valves **65** open when the pistons **22, 24** move away from the crankshaft **20** and close when the pistons move toward the crankshaft. The pistons **22, 24** and the reed valves **65,** therefore, act as a pump. Conventionally, curved stops **68** are provided for limiting the flexing of the reed valves.

Each cyinder **16, 18** is provided at peripherally spaced points remote from its closed end, with an inlet port or ports **70** and an exhaust port or ports **72.** The arrangement of these ports **70, 72** is such that they are opened and closed by movement of the pistons **22, 24** in the cylinders **16, 18.** The advantages of such a port arrangement are discussed in my said prior U.S. Pat. No. 3,499,425.

The cylinder block assembly **12** includes, with each cylinder **16, 18,** a housing **74** including a port **76** therein providing an auxiliary chamber **78** in open communication with the cylinder exhaust port **72.** It will be appreciated that the port **76** is at a point remote from the point of communication of the auxiliary chamber **78** with the exhaust port **72,** and that the port **76** is dominated by a butterfly valve **80** carried on a shaft **82.** The butterfly valve **80** may be rotatably or oscillably driven.

The cylinder block assembly **12** includes means providing a passageway **90, 92** leading from the crankcase **14** to each inlet port **70.** In the illustrative engine **10,** adjacent each inlet port **70** is a fuel injector fitting or nozzle **94, 96** which may be conventionally connected to a source of fuel vapor. In such a case, when air is pumped from the crankcase **14** through the passageway **90, 92,** the fuel vapor is mixed with the air and admitted to the cylinder **16, 18** through the port **70.**

Then, a rotary valve **100, 102** extends across each passageway **90, 92** to open and close that passageway, each rotary valve being received in a bore **104, 106** which is parallel with the axis **60** of the crankshaft **20.** Each rotary valve **100, 102** is provided with a cutout **110, 112** on its periphery such that each passageway **90, 92** is opened during a portion of each revolution of each valve. The valves **100, 102** are both drivingly connected to the crankshaft **20** and are arranged so that their respective passageways **90, 92** are opened only on alternate occasions when both pistons **22, 24** move toward the axis **60** of the crankshaft **20.** That is, each time the pistons **22, 24** move toward the axis **60,** the fuel mixture in the crankcase **14** is pumped through the opened passageway **90** or **92** into the cylinder **16** or **18** to be compressed. In preferred embodiments, each passageway **90, 92** remains open throughout the period when its associated inlet port **70** is opened by the piston **22, 24.** The manner in which the rotary valves **100, 102** may be driven to open each passageway **90, 92** only on alternate occasions when both pistons **22, 24** are moving toward the axis **60** will be discussed in conjunction with FIG. **5.**

Turning now to FIGS. **2, 3, 4***a* and **4***b*, a discussion of my side-by-side version of the engine of the present invention will be discussed, like reference numerals indicating like parts. This engine **10'** is arranged such that its cylinders **16, 18** are disposed side-by-side with their axes lying in a plane which is radial to the axis **60** of the crankshaft **20.** The two cylinders **16, 18** open into the common crankcase **14'** which is generally cylindrically formed for the reasons discussed above.

The two passageways **90, 92** leading to the inlet ports **70** from the crankcase **14'** are alternately opened and

closed by means of a single rotary valve member **130** which extends parallel to the axis of the crankshaft and across both passageways. This illustrative valve member **130** is provided with a cutout **132** associated with the passageway **90** and a diametrically opposite cutout **134** associated with the passageway **92.** The valve member **130** is driven from the crankshaft **20** and the cutouts **132, 134** are positioned such that each passageway **90, 92** is opened only on alternate occasions when the two pistons **22, 24** move toward the axis **60** of the crankshaft **20.** The eccentric bearing portions **40** associated with the pistons **22, 24** are identically disposed so that the two pistons move simultaneously together toward and away from the axis of the crankshaft **20.**

Turning now to FIG. **5,** it will be seen that I have shown diagrammatically the rotary valves **100, 102,** the crankshaft **20** and the shafts **82** on which the butterfly valves **80** are carried. Illustratively, an idler gear **146** is used drivingly to connect a gear **147** on the crankshaft **20** to a gear **148** on the rotary valve **100.** The gear **148** is engaged with a gear **150** on the rotary valve **102.** A cogwheel **152** is mounted on the rotary valve **100,** a cogwheel **154** is mounted on the shaft **82** and a cogbelt **156** drivingly connects the shaft **82** associated with the cylinder **16** to the rotary valve **100.** Similarly, a cogwheel **158** is mounted on the valve **102,** a cogwheel **160** is mounted on the other shaft **82** associated with the cylinder **18,** and a cogbelt **162** is trained about these cogwheels. It will be appreciated that this drive system is merely illustrative and that other forms of drive systems may be used.

In some embodiments of the present engine, the valves **100, 102** may be rotated at one-half the speed of the crankshaft **20** while the two shafts **82** are rotated at one-fourth the speed of the crankshaft.

With the above description in mind, the 4-cycle operation of the engine of the present invention will be discussed. The firing sequence for the cylinder **16** with its piston **22** is as follows:

On the power stroke the piston **22** moves toward the axis **60** and the exhaust goes out the exhaust port **72** and the port **76** which is opened by the butterfly valve **80.** The exhaust continues to go out the port **72** until the piston **22** moves back up to close port **72.** The inlet valve **100** is closed to block the passage **90** during the power stroke of the piston **22** so that the fuel mixture cannot be pumped from the crankcase **14** into the cylinder **16** during the power stroke. The piston **22** then goes up again. The piston **22** then goes down again or toward the axis **60.** During this stroke, the valve **100** is in a position such that the passageway **90** is open and the butterfly valve **80** is closing the port **76.** The two-piston volumes of air resulting from movement of both pistons **22, 24** toward the axis **60** pumps the gaseous mixture through the passageway **90** into the cylinder **16.** The piston **22** then goes up or away from the axis **60** on its compression stroke to compress the gaseous mixture for firing.

Recapitulating, the engine of the present invention is a 4-cycle engine with each piston **22, 24** having four strokes including stroke No. 1 which is a power stroke at the bottom of which the exhaust leaves the cylinder through the exhaust port and the open butterfly valve; stroke No. 2 is the piston moving up again in the cylinder; stroke No. 3 is the piston moving downwardly again in the cylinder to pump (together with its associated piston) the gaseous mixture from the crankcase **14** into the cylinder; and stroke No. 4 is a compression stroke.

The cylinder **18** has the same firing sequence as the cylinder **16** except that the cylinder **18** is on opposite cycles. That is, when the piston **22** is on its power stroke, the piston **22** and the piston **24** pump the gaseous mixture from the crankcase **14** through the passageway **92** into the cylinder **18** for compression and firing. When the piston **24** is on its power stroke, the piston **24** and the piston **22** pump the gaseous mixture from the crankcase **14** through the passageway **90** into the cylinder **16** for compression and firing. Thus, when one piston **22, 24** is on its power stroke, the other piston is on its intake stroke, and when one piston is on its compression stroke, the other piston is on its stroke which is conventionally referred to as the exhaust stroke in the Otto cycle engine.

When the engine of the present invention is running at high speeds, e.g., over 4,000 rpm, the butterfly exhaust valves may be eliminated or held steadily open.

Modern automobile engines often include means for recycling the exhaust through the intake to reduce pollution. Some other modern automobile engines supply compressed air to the exhaust to burn the exhaust gases at low pressure to reduce pollution. The engine of the present invention obtains this feature of burning the exhaust gases at low pressure to reduce pollution. Particularly, the fresh gases pumped into the cylinders **16, 18** will mix with and burn the exhaust gases trapped in the chambers **78,** and this burning will take place at low pressure. The effect of this is to reduce the pollution content of the exhaust and particularly the unburned hydrocarbon content of the exhaust.

The exhaust of the engine of the present invention is extremely cool. An engine constructed in accordance with the present invention can be operated and a person can place his hand in the output side of the butterfly exhaust valve and not be burned by the exhaust itself. This, of course, reduces the nitrous oxide content of the exhaust which is a pollution factor producing smog and eye irritation.

Butterfly valves **80** of the engine of the present invention may rotate at one-fourth, three-fourths or 1¼ the speed of the crankshaft **20.** The butterfly valves may be oxcillated by a crank running at one-half the speed of the crankshaft **20.**

An important advantage of the engine of the present invention is that the fuel injection fittings or nozzles **94, 96,** if they are used, may be out of the high heat and high pressure zones of the cylinders **16, 18.**

The 4-cycle engine of the present invention has approximately the same weight as comparable 2-cycle engines, approximately the same manufacturing costs as comparable 2-cycle engines and approximately the same height as comparable 2-cycle or "L" head engines.

Turning now to FIGS. **6–9,** it will be seen that I have shown, by diagrammatical views, how a 2-cylinder, 4-cylinder, 6-cylinder or 8-cylinder engine may be constructed using the side-by-side arrangement discussed in conjunction with FIG. **2** as well as a proposed firing order for such 4-cyclinder, 8-cylinder and 8-cylinder engines. Then, in FIGS. **10–13,** I have provided diagrammatical views showing how a 2-cylinder, 4-cylinder, 6-cylinder or 8-cylinder engine may be constructed using the opposed cylinder concept discussed in conjunction with FIG. **1** as well as a proposed firing

order for the 4-cylinder, 6-cylinder and 8-cylinder engine.

It will be appreciated that an extremely compact and relatively short engine may be provided by constructing the engines of FIGS. 10–13 as horizontally opposed engines.

Lubrication may be provided by making oil with the fuel mixture going into the crankcase or by positive pressure pumping of oil to the bearings and pistons.

What is claimed is:

1. A 4-cycle, internal combustion engine comprising a pair of cylinders, each cylinder being open at one end and provided, at peripherally spaced points remote from the other end of said cylinder, with an inlet port and an exhaust port in its side walls, a crankshaft arranged adjacent the open ends of said cylinders, a piston reciprocably received in each said cylinder and defining therewithin a variable-volume combustion chamber, means extending through the open end of each said cylinder and drivingly connecting the piston therein to said crankshaft, the last said means and said crankshaft being arranged so taht said pistons move simultaneously toward and away from the axis of said crankshaft, each said piston being movable in its associated cylinder past its said ports to close and open same during each revolution of said crankshaft, a crankcase for said crankshaft, means for admitting a gaseous mixture to said crankcase, means providing a passageway from said crankcase to the inlet port of each said cylinder, and valve means for opening and closing said passageways, said valve meeans being drivingly connected to and operated by said crankshaft, and said valve means being arranged alternately to open said passageways only on occasions when said pistons move toward the axis of said crankshaft, said crankcase being generally cylindrically shaped about the axis of said crankshaft, said crankshaft being formed to provide eccentric bearing portions on which said means for drivingly connecting said pistons to said crankshaft are journalled and, on opposite ends of said bearing portions, counter balance portions which are fully cylindrical and concentric with the axis of said crankshaft and of a diameter slightly smaller than the internal diameter of said crankcase, the combined axial length of said counter balance portions being generally equal to the axial length of said crankcase less the combined axial lengths of said bearing portions, thereby to reduce the volume of the gaseous mixture receiving space in the crankcase to increase the efficiency with which the piston movement pumps said gaseous mixture to said cylinders, said means for admitting a gaseous mixture to said crankcase including reed valve means arranged to open when the pressure in said crankcase drops below the pressure of the gaseous mixture source and to close when the pressure in said crankcase exceeds the pressure of said source, said first mentioned valve means including rotary valve means, said rotary valve means including one or more valve members extending parallel to the axis of said crankshaft and across each said passageway, each of said valve members being formed to close its associated passageway during a portion of each revolution and to open it during the rest of each revolution throughout the period when its associated inlet port is opened by its associated piston, means defining an auxiliary chamber in open communication with the exhaust port of each said cylinder, each said auxiliary chamber being provided with a port at a point remote from the point of communication of said auxiliary chamber with said exhaust port, butterfly valve means dominating said auxiliary chamber port, and means driven from said crankshaft for opening said butterfly valve means only on the occasions when its associated cylinder exhaust port is opened by the piston therein moving downwardly on its power stroke.

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