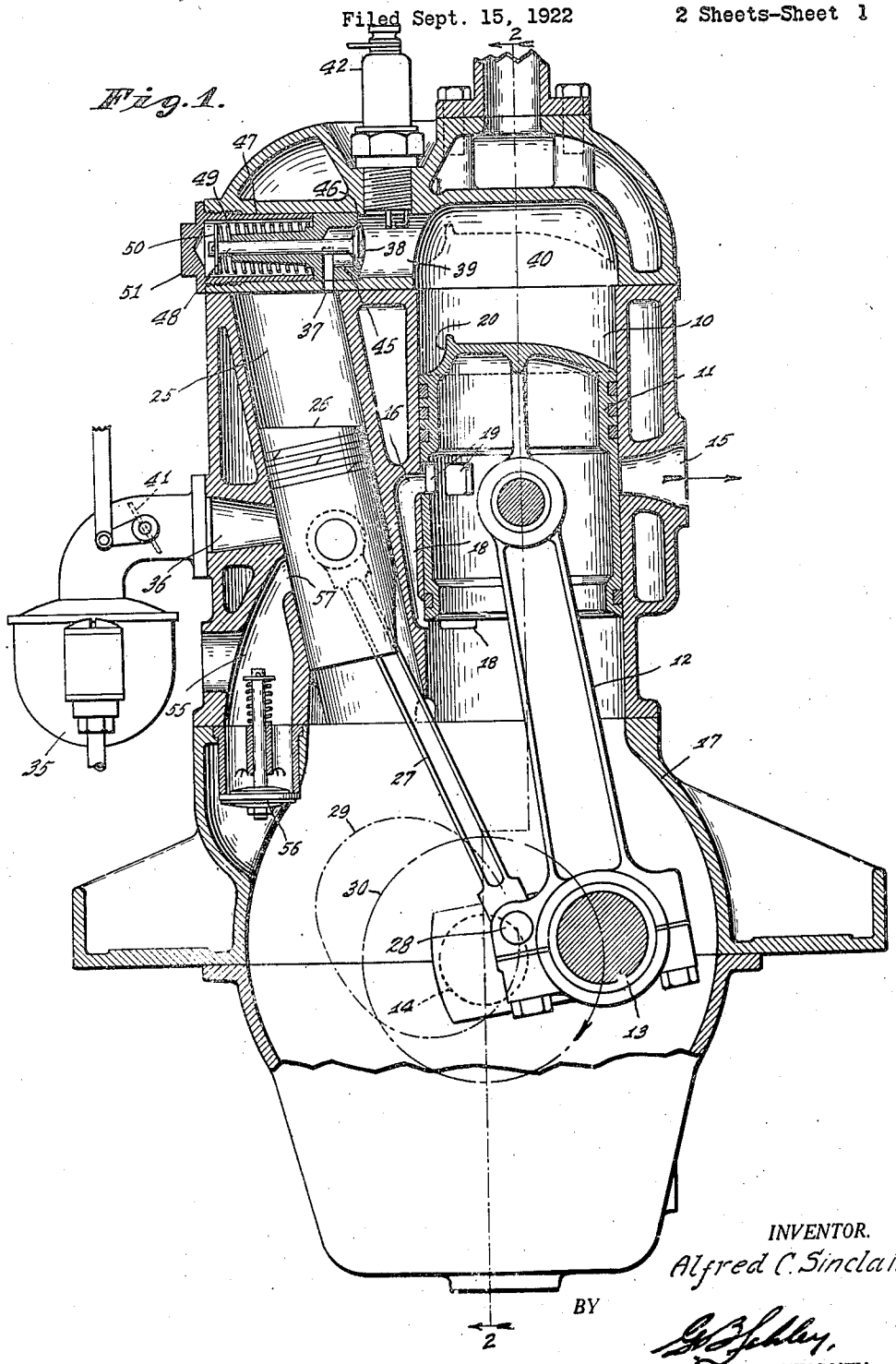
March 27, 1928. 1,664,091

A. C. SINCLAIR

INTERNAL COMBUSTION ENGINE

Filed Sept. 15, 1922 2 Sheets-Sheet 1

Fig. 1.



INVENTOR.
Alfred C. Sinclair

BY

ATTORNEY.

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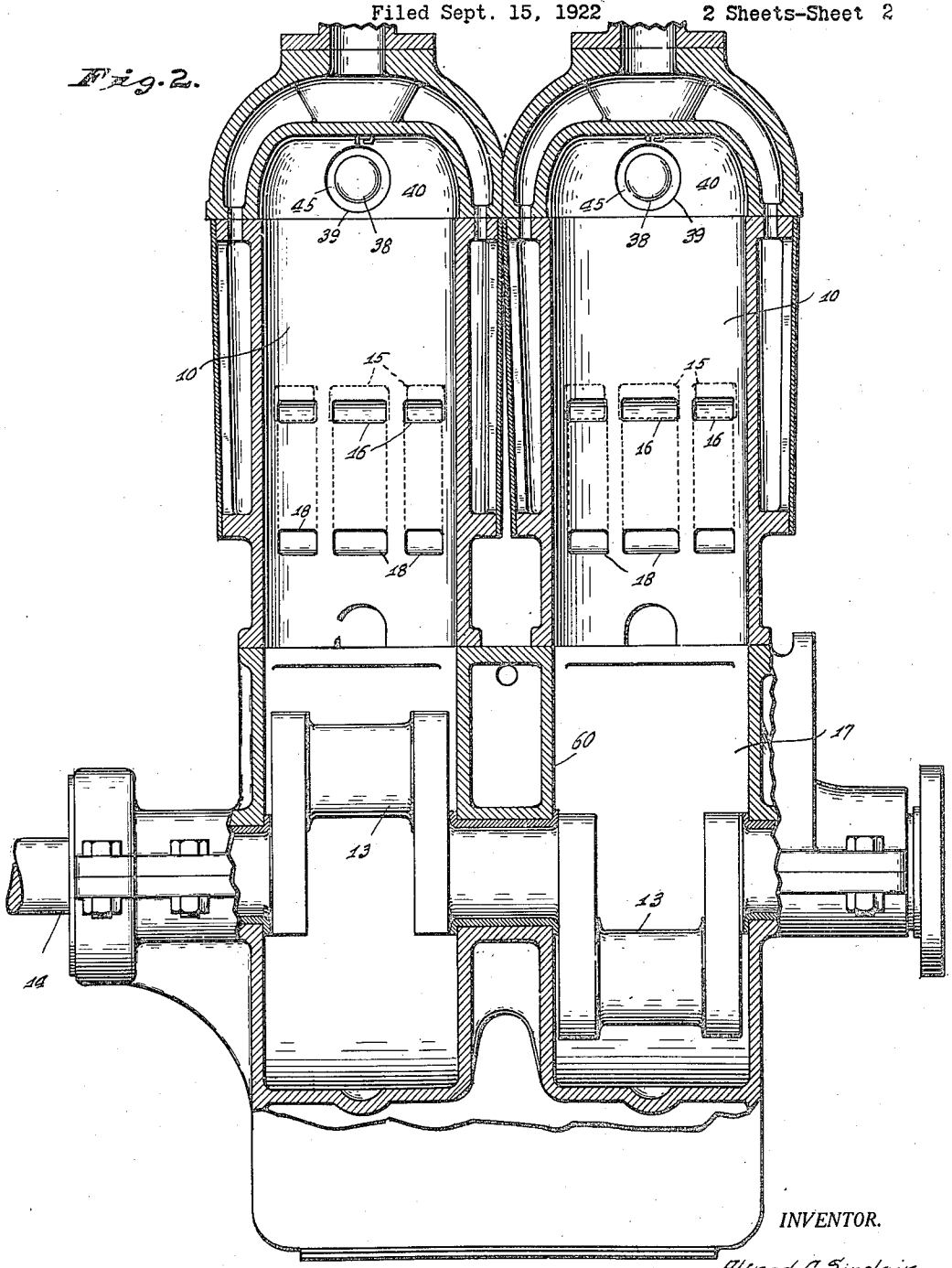
Fig. 2.



INVENTOR.

Alfred C. Sinclair,

BY

ATTORNEY.

Patented Mar. 27, 1928. 1,664,091

UNITED STATES PATENT OFFICE.

ALFRED C. SINCLAIR, OF NEW ORLEANS, LOUISIANA.

INTERNAL-COMBUSTION ENGINE.

Application filed September 15, 1922. Serial No. 588,343.

It is the object of my invention to improve the operating characteristics, the efficiency, and the economy of a two-stroke cycle internal combustion engine. More specifically, it is my object to produce a practical two-stroke cycle engine which operates with a substantially uniform consumption of air per cycle and with a substantially constant compression, but the power is controlled by varying the quantity of a separately supplied mixture; and in which this separately supplied mixture is forcibly injected into the combustion chamber during the compression stroke, at a point in such stroke which depends on the throttling, and to produce thereby a stratification of the fluid in the combustion chamber whereby there is always an isolated portion of mixture at the spark plug in condition for ignition.

The invention in this application is directed specifically to two-stroke cycle engines; but it involves a generic invention which is not limited to two-stroke cycle engines and is claimed more broadly in my copending application, Serial No. 631,598, filed April 12, 1923.

In carrying out my present invention, I provide in addition to the main cylinder and piston, to the combustion chamber of which air is supplied by crank-case compression at the end of the explosion stroke, a smaller supplemental cylinder and piston which draws in by suction explosive mixture from a carbureter and forces such mixture thus drawn in into the combustion chamber of the main cylinder, through a valve which prevents return flow, the supplemental piston being substantially without clearance in its cylinder at one end of the stroke and having an angular lead over the main piston in the cycle. The supplemental piston assists in the compression of the air in the crank-case, to provide an additional volume for scavenging the main cylinder.

The accompanying drawings illustrate my invention: Fig. 1 is a vertical section through an engine embodying my invention, being taken in a plane perpendicular to the crank-shaft to show one main cylinder with its supplemental charging cylinder; and Fig. 2 is a vertical section taken longitudinally of the crank-shaft substantially on the line 2—2 of Fig. 1 to show my invention embodied in a two-cylinder engine.

The engine illustrated is a two-cylinder engine, having two main cylinders 10, the piston 11 in each of which is suitably connected by a connecting rod 12 to a crank 13 on the crank-shaft 14. The number of cylinders 10, of course, is not limited to two, but may be anything desired. The pistons 11 and connecting rods 12 are omitted from Fig. 2, in order better to show the ports in the cylinder wall. These ports include exhaust ports 15 on one side of the longitudinal central plane of the cylinder and air-supply ports on the other side of said central longitudinal plane. The exhaust ports 15, which in Fig. 2 are shown only in dotted lines, have their upper edges higher than the upper edges of the air-supply ports 16, so that as the piston 11 descends it will uncover first the exhaust ports 15 as it approaches the end of its down-stroke, but will not uncover the air-supply ports 16 until it gets slightly further down on such down-stroke. The exhaust ports 15 may lead to any exhaust system. The air-supply ports 16 are supplied by the compression of air in the crank-case 17, the supply from the crank-case to such air-supply ports 16 being by passages 18 in the wall of the cylinder, which passages 18 as shown communicate with the crank-case when the piston 11 is at the lower end of its stroke by way of openings 19 in the piston skirt. This arrangement of openings 19 in the piston skirt is merely an incident, however, to my invention, and is provided merely for economy of space because of the necessities of the supplemental or charging cylinder and piston which will be described later. The head of the piston 15 is provided on the side toward the ports 16 with a deflecting face 20, for directing upward the air which enters by the air-supply ports 16 and thereby preventing such supplied air from passing directly across the piston head to the exhaust ports 15.

For each main cylinder 10 there is a smaller supplemental or charging cylinder 25, in which there is a reciprocable piston 26. Conveniently, though not necessarily, each supplemental cylinder and piston 25—26 is in the same plane transverse to the crank-shaft 14 as is its associated main cylinder and piston 10—11, as that permits a compactness and simplicity of design which is desirable. This particular arrangement is shown in Fig. 1. Each supplemental piston 26 is drivingly connected by a connecting rod 27 to the crank-shaft 14, so that it will be reciprocated by the rotation of the crank-

shaft. As shown, the connection of the lower end of the connecting rod 27 is to a pin 28 carried by the head at the lower end of the connecting rod 12 at one side of said head, which causes the pin 28 to travel in an approximately elliptical path 29 while the main crank 13 travels in its circular path 30. The precise shape of the path 29, however, is immaterial, and there is no great advantage in the elliptical shape, although it does give the piston 26 a slightly longer stroke than that of the piston 11. The piston 26 has an angular lead in the cycle over the piston 11, by between 20° and 25° in the engine illustrated; which lead is obtained in such illustrated engine by having the cylinder 25 oblique to the cylinder 10 and converging downward therewith, and by having the connecting rod 27 attached to the pin 28 in the manner shown. This lead of the piston 26, however, is not necessarily obtainable in this particular manner, though the construction illustrated produces the lead very satisfactorily. The piston 26 when moved to the upper end of its stroke is arranged to leave substantially no space above it in the cylinder 25, to get substantially the complete expulsion of the fluid from such cylinder.

The cylinder 25 is supplied with a rich explosive mixture from a carbureter 35, the outlet of which leads to a mixture-inlet port 36 arranged in the side wall of the cylinder 25. This mixture-inlet port 36 is preferably arranged to be uncovered only during the lower portion of the stroke of the supplemental piston 26, to admit the supply at that time of a rich explosive mixture from the carbureter 35 into the cylinder 25, drawn in by the high vacuum then existing in such cylinder 25. This arrangement of the port 36 makes it unnecessary to have any other valve than that provided by the movement of the piston 26 with relation to the port 36; but it is not essential that the port be thus located in the cylinder 25, or that it be without any additional valve. The mixture which is drawn into the cylinder 25 at the end of the down-stroke of the piston 26 is compressed within the cylinder 25 during the up-stroke of such piston, and when sufficiently compressed is forced outward through an opening 37 in the head of the cylinder 25 and past a spring-seated check-valve 38 into and through an ignition passage 39 and into the combustion space 40 at the top of the cylinder 10. This forcing in of the mixture from the cylinder 25 into the combustion space 40 occurs during the up-stroke of the piston 11, beginning at a point in such up-stroke which is dependent upon the setting of the throttle 41 of the carbureter 35. A spark plug 42 is provided with its electrodes in the ignition passage 39, for producing ignition at the proper point in the cycle, which point may be advanced or retarded in the usual manner.

The check-valve 38 is shown as being formed by a valve-seat member 45 which is seated against a shoulder 46 at the inner end of a hole 47 provided in the cylinder-head casting in line with the ignition passage 39; and in this valve-seat member 45 the stem 48 of the valve 38 is slidingly mounted, and is held to its seat by a suitable compression spring 49 acting between the outer side of the valve-seat member 45 and a disk 50 on the end of the valve stem 48. This spring 49 and its associated parts are enclosed, and the valve-seat member 45 is clamped against the shoulder 46, by a hollow screw-plug 51 which is screwed in the outer end of the hole 47. This construction of the check-valve 38, however, is merely an incidental feature of construction.

The air for compression in the crank-case 17 is supplied from the atmosphere by way of an air-inlet passage 55, at the inner end of which is an inwardly opening check-valve 56 for preventing the outflow of air which has been admitted. Preferably the air-inlet passage 55 has a supplemental opening 57 through the lower part of the cylinder 25, in position to be uncovered by the skirt of the piston 26 during the upper part of the movement of such piston; this supplemental opening 57 assists in getting the crank-case 17 filled with air.

The operation is on the two-stroke cycle. The piston 26 in its reciprocation has a lead on the piston 11, as already explained, of between 20° and 25° in the engine shown. As the pistons 11 and 26 move upward, they draw air into the crank-case 17 through the air inlet passage 55, past the check valve 56, and (while the piston 26 is at the top of the stroke) through the supplemental opening 57. The quantity of air thus drawn in is substantially the sum of the displacements of the two pistons. When now the pistons 11 and 26 move downward, the supplemental piston 11 still maintaining its lead, the air which has been drawn into the crank-case 17 is compressed therein by the movement of such pistons. When the piston 11 nears the bottom of its stroke, it uncovers the ports 15 and 16 in succession. The uncovering of the ports 15 permits the outflow of the burned gases from the preceding explosion within the cylinder 10. The uncovering of the ports 16 occurs after the pressure within the cylinder 10 has been relieved by the outflow of the burned gases, and when it occurs the air which has been compressed in the crank-case by the downward movement of the pistons is admitted from such crank-case by the way of the openings 19 and passages 18 through such ports 16 into the cylinder 10. The air thus admitted is deflected upward by the deflecting face 20, and pushes

ahead of it the greater part of the remaining burned gases in the cylinder 10, which burned gases escape through the still open ports 16. More than a cylinder-full of air is supplied through the air-supply ports 16, because of the compression of air in the crank-case by both pistons 11 and 26, which materially helps in scavenging the cylinder 10. When the piston 11 starts upward, the cylinder 10 has within it substantially a cylinder-full of air, at substantially atmospheric pressure, with very little contamination from burnt gases from the preceding explosion, but with no fuel mixed with this air. It is this air which is fundamentally compressed in the cylinder 10 by the up-stroke of the piston 11, and it is compressed to a substantially constant volume and constant pressure.

The supplemental piston 26 at the bottom of its down-stroke has drawn in a rich mixture of air and fuel from the carbureter 35, by way of the mixture-inlet port 36. The amount of this mixture drawn in varies with the opening of the throttle 41. On the up-stroke of the supplemental piston 26, which up-stroke is slightly in advance of that of the main piston 11, the mixture thus drawn into the cylinder 35 is compressed until its pressure is sufficient to open the valve 38; whereupon this compressed mixture from the cylinder 25 is forced by the piston 26 through the opening 37 and past the check valve 38 into and through the ignition passage 39 and into the combustion chamber 40 of the cylinder 10. During this forcing-in of the mixture into the cylinder 25, the air already in the cylinder 10 is being compressed by the upward movement of the piston 11. The point at which the valve 38 opens to allow the passage of the explosive mixture from the cylinder 25 to the combustion chamber 40 varies with the amount of explosive mixture in such cylinder 25 at the beginning of the up-stroke of the piston 26, and therefore is controlled by the setting of the throttle 41; the valve 38 opening earlier in the cycle when the throttle 41 is wide open than when it is partly closed. Substantially the entire charge of the mixture in the supplemental cylinder 25 is forced out of such cylinder because of the absence of any substantial clearance between the piston 26 and the head of the cylinder 25. Because this explosive mixture is actually forced into the combustion space 40, instead of being merely drawn in by suction, it is heated and not cooled as it enters such combustion space, which makes it much more ready for ignition. This mixture thus forced into the combustion space apparently stratifies to a greater or less extent with relation to the air already in the cylinder 10, instead of mixing thoroughly therewith, although there is of course some mixing; and I believe the mixing is greater the earlier the valve 38 is opened. In any case, I have found that for any throttle opening, and for any speed of the engine within wide limits, I obtain an ignitable charge in the ignition passage 39; which charge is ignited when the spark occurs at the spark plug 42. The combustion extends to the explosive mixture in the combustion chamber 40, which is at a compression which varies comparatively slightly, and produces the explosion which forces the piston 11 downward on its explosion stroke.

I have described the operation of my engine in connection with a single main cylinder 10. The operation is substantially the same for each main cylinder 10, regardless of the number of cylinders; the pistons of the several cylinders being properly connected to the crank shaft to get balanced operation. When there are two or more main cylinders, the crank-case is divided into sections corresponding to the number of cylinders, vertical dividing walls 60 such as shown in Fig. 2.

I claim as my invention:

1. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has an acute-angle lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered successively at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

2. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston smaller in displacement than the main cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has an acute-angle lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main pistons in its movement, and a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

3. A two-stroke cycle engine, comprising a

main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

4. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered successively at the end of the explosion stroke of the main piston, said air inlet ports communicating with said chamber.

5. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston smaller in displacement than the main cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement and a chamber in which air is compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

6. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

7. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, a valve permitting flow through said passage only toward the main cylinder, and a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

8. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, a valve permitting flow through said passage only toward the main cylinder, and a chamber in which air is compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

9. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber, and a spark plug having its electrodes located in said passage.

10. A two-stroke cycle engine, comprising

a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the supplemental piston has a lead over the main piston in their cycle of movement, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, a valve permitting flow through said passage only toward the main cylinder, a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber, and a spark plug having its electrodes located in said passage on the main-cylinder side of said valve.

11. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, a crank-shaft connected to said main piston, a supplemental cylinder and piston, said supplemental piston also being driven from said crank-shaft and being arranged to have a lead over the main piston in their cycle of movement, a crank-case in which air is compressed by the movement of the main piston and which is connected to said main cylinder by passages which are opened when the main piston is at the lower part of its stroke, said main cylinder also having exhaust ports which are controlled by the piston movement, a carbureter from which explosive mixture is supplied to said supplemental cylinder by the suction action of said supplemental piston on its down stroke, and a valved passage between the upper ends of said two cylinders.

12. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, a crank-shaft connected to said main piston, a supplemental cylinder and piston, said supplemental piston also being driven from said crank-shaft and being arranged to have a lead over the main piston in their cycle of movement, a crank-case in which air is compressed by the movement of both pistons and which is connected to said main cylinder by passages which are opened when the main piston is at the lower part of its stroke, said main cylinder also having exhaust ports which are controlled by the piston movement, a carbureter from which explosive mixture is supplied to said supplemental cylinder by the suction action of said supplemental piston on its down stroke, and a valved passage between the upper ends of said two cylinders.

13. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, a crank-shaft connected to said main piston, a supplemental cylinder and piston, said supplemental piston also being driven from said crank-shaft and being arranged to have a lead over the main piston in their cycle of movement, a crank-case in which air is compressed by the movement of the main piston and which is connected to said main cylinder by passages which are opened when the main piston is at the lower part of its stroke, said main cylinder also having exhaust ports which are controlled by the piston movement, a carbureter from which explosive mixture is supplied to said supplemental cylinder by the suction action of said supplemental piston on its down stroke, a valved passage between the upper ends of said two cylinders, and a spark plug having electrodes in said passage which interconnects said two cylinders.

14. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, a crank-shaft connected to said main piston, a supplemental cylinder and piston, said supplemental piston also being driven from said crank-shaft and being arranged to have a lead over the main piston in their cycle of movement, a crank-case in which air is compressed by the movement of both pistons and which is connected to said main cylinder by passages which are opened when the main piston is at the lower part of its stroke, said main cylinder also having exhaust ports which are controlled by the piston movement, a carbureter from which explosive mixture is supplied to said supplemental cylinder by the suction action of said supplemental piston on its down stroke, a valved passage between the upper ends of said two cylinders, and a spark plug having electrodes in said passage which interconnects said two cylinders.

15. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, a crank-shaft to which the main piston is connected, a crank-case, said cylinder being provided with exhaust ports and with air-supply ports which are covered and uncovered by the piston movement, said air-supply ports being supplied with air by crank-case compression, and a supplemental piston and cylinder arranged to obtain explosive mixture by a sucking stroke of the supplemental piston, said supplemental cylinder being connected to the main cylinder by a valved supply passage of which the main cylinder end is always open so far as movement of the main piston is concerned, and means for driving said supplemental piston so that it has a lead over the main piston in the cycle of operation.

16. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying air to said main cylinder when the main piston is at one end of its stroke, and means for forming outside of said main

cylinder a mixture of fuel and air and for forcing said mixture into said main cylinder during the compression stroke of the main piston by a passage which remains open to the main cylinder to the end of said compression stroke.

17. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying air to said main cylinder when the main piston is at one end of its stroke, means for forming outside of said main cylinder a mixture of fuel and air and for forcing said mixture into said main cylinder during the compression stroke of the main piston of which the main-cylinder end is always open so far as movement of the main piston is concerned, and means for igniting said forced-in charge near its point of entrance into the main cylinder.

18. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying air to said main cylinder when the main piston is at one end of its stroke, means for forming outside of said main cylinder a mixture of fuel and air and for forcing said mixture into said main cylinder during the compression stroke of the main piston, a conduit through which said previously formed mixture is thus forced into the main cylinder and which is continuously open to said main cylinder, and ignition means in said conduit.

19. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying air to said main cylinder when the main piston is at one end of its stroke, a supplemental cylinder and piston, said supplemental cylinder having an inlet for receiving air and fuel and an outlet connected to the main cylinder, said outlet being located near the end of said supplemental cylinder, a conduit by which said outlet from the supplemental cylinder is connected to the main cylinder, said conduit being permanently open to the combustion space of the main cylinder, and means for operating said supplemental piston with a lead over the main piston.

20. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying air to said main cylinder when the main piston is at one end of its stroke, a supplemental cylinder and piston, said supplemental cylinder having an inlet for receiving air and fuel and an outlet connected to the main cylinder, means for operating said supplemental piston with a lead over the main piston, a conduit by which said outlet from the supplemental cylinder is connected to the main cylinder, said conduit being permanently open to the combustion space of said main cylinder, and ignition means in said conduit.

21. A two-stroke cycle internal combustion engine, comprising a main cylinder and piston, means associated therewith for supplying to said main cylinder when the main piston is at one end of its stroke a quantity of air greater than the displacement of said main piston, and means for forming outside of said main cylinder a mixture of fuel and air and for forcing said mixture into said main cylinder during the compression stroke of the main piston, a conduit by which said outlet from the supplemental cylinder is connected to the main cylinder, said conduit being permanently open to the combustion space of the main cylinder.

22. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the rates at which the supplemental piston and the main piston make strokes are equal, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

23. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the rates at which the supplemental piston and the main piston make strokes are equal, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage, and a chamber in which air is compresed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber, said exhaust ports being closed early in the return-stroke of the main piston to trap in the main cylinder the air supplied through the air-inlet ports.

24. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the rates at which the supplemental piston and the main piston make strokes are equal, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, and a chamber in which air is

compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber.

25. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the rates at which the supplemental piston and the main piston make strokes are equal, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage, and a chamber in which air is compressed by strokes of both pistons, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber, said exhaust ports being closed early in the return-stroke of the main piston to trap in the main cylinder the air supplied through the air-inlet ports.

26. A two-stroke cycle engine, comprising a main cylinder and piston, a supplemental cylinder and piston, means interconnecting said two pistons whereby the rates at which the supplemental piston and the main piston make strokes are equal, means for supplying explosive mixture to said supplemental cylinder, the ends of said two cylinders being interconnected by a passage of which the end is never covered by the main piston in its movement, a chamber in which air is compressed by the main piston on its explosion stroke, said main cylinder being provided with exhaust ports and with air-inlet ports which are uncovered at the end of the explosion stroke of the main piston, said air-inlet ports communicating with said chamber, and a spark plug having its electrodes located in said passage.

27. A two-stroke cycle internal-combustion engine, comprising a main cylinder and piston, a supplemental cylinder and piston, said two pistons being arranged to operate with equal rates of strokes, said main cylinder being provided with exhaust and air-inlet ports which are intermittently opened and closed during the engine operation; said air-intake ports being arranged to receive air compressed by at least one of the pistons during the explosion stroke of the main piston, a carbureting device through which explosive mixture is drawn into the supplemental cylinder, a passage leading from the end of said supplemental cylinder and continuously opening into the compression space of the main cylinder, and a valve in the passage from the supplemental cylinder to the compression space of the main cylinder for preventing back-flow from the main cylinder to the supplemental cylinder.

28. A two-stroke cycle internal-combustion engine, comprising a main cylinder and piston, a supplemental cylinder and piston, said two pistons being arranged to operate with equal rates of strokes, said main cylinder being provided with exhaust and air-intake ports which are intermittently opened and closed during the engine operation; a carbureting device through which explosive mixture is drawn into the supplemental cylinder, a passage leading from the end of said supplemental cylinder and continuously opening into the compression space of the main cylinder, and a valve in the passage from the supplemental cylinder to the compression space of the main cylinder for preventing back-flow from the main cylinder to the supplemental cylinder.

29. A two-stroke cycle internal-combustion engine, comprising a main cylinder and piston, a supplemental cylinder and piston, said two pistons being arranged to operate with equal rates of strokes, said main cylinder being provided with exhaust and air-intake ports which are intermittently opened and closed during the engine operation, a carbureting device through which explosive mixture is drawn into the supplemental cylinder, a passage leading from said supplemental cylinder and continuously opening into the compression space of the main cylinder, a valve in the passage from the supplemental cylinder to the compression space of the main cylinder for preventing back-flow from the main cylinder to the supplemental cylinder, said valve being located in said passage with a space between it and said combustion space of the main cylinder, and igniting means associated with said space between said valve and combustion space.

In witness whereof, I have hereunto set my hand at Indianapolis, Indiana, this 8th day of September, A. D. one thousand nine hundred and twenty-two.

ALFRED C. SINCLAIR.