

938,401.

Patented Oct. 26, 1909.

3 SHEETS—SHEET 1.

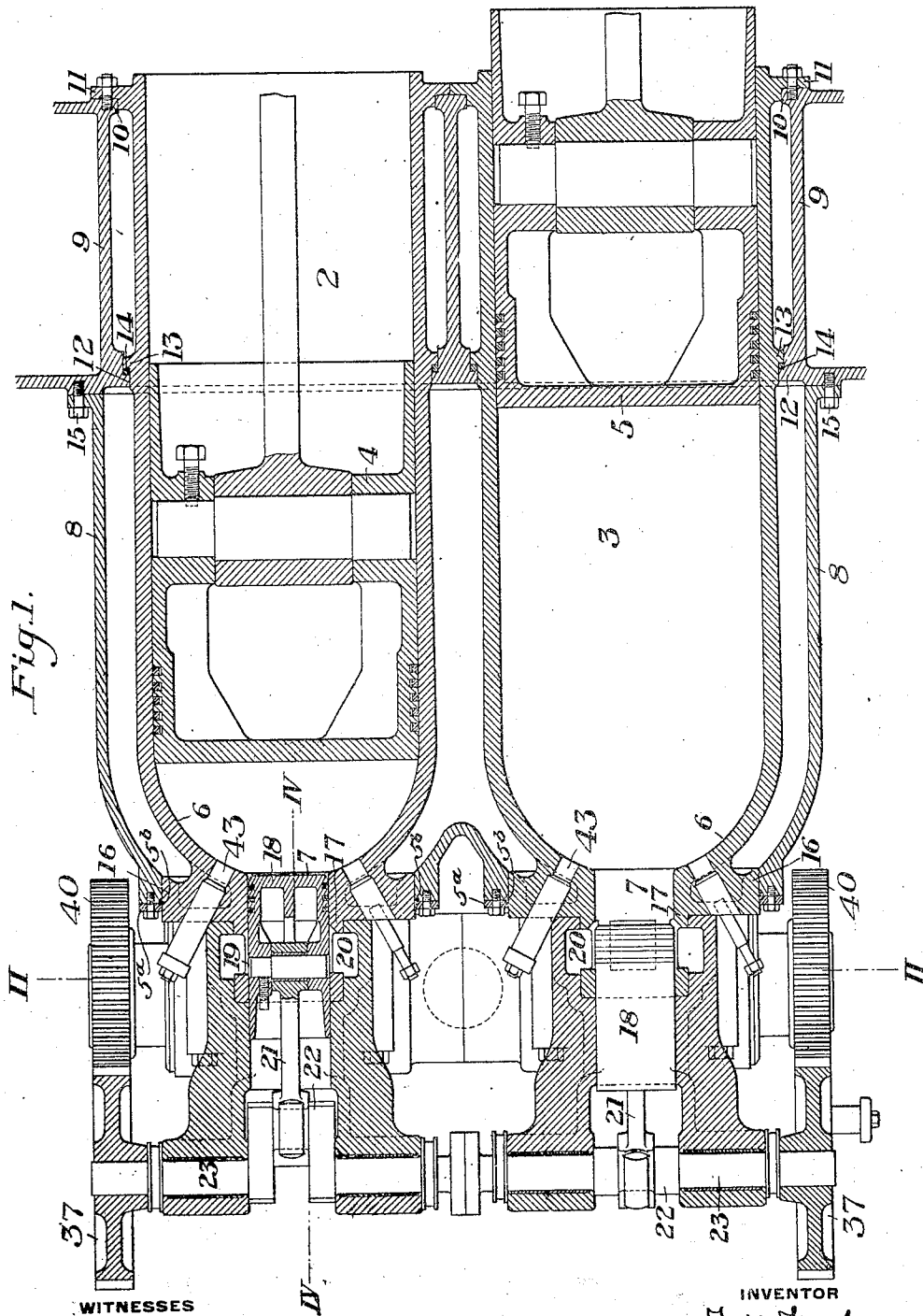


Fig. 1.

WITNESSES  
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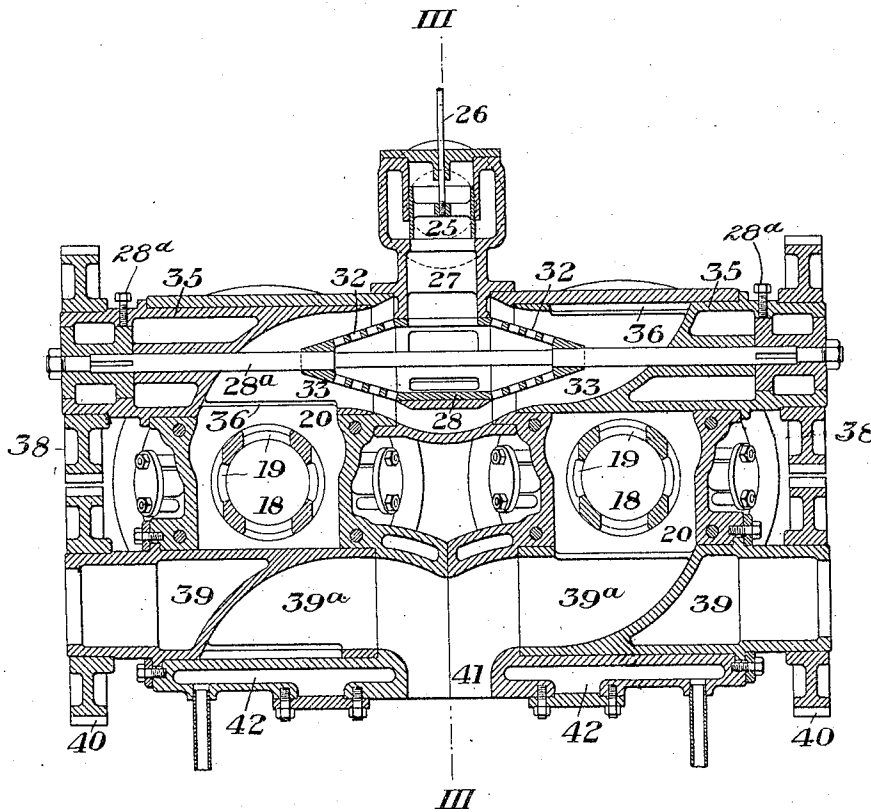
F. H. TREAT.  
EXPLOSIVE ENGINE.  
APPLICATION FILED APR. 15, 1907.

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3 SHEETS—SHEET 2.

*Fig. 2.*



WITNESSES

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3 SHEETS—SHEET 3.

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# UNITED STATES PATENT OFFICE.

FRANCIS H. TREAT, OF CLEVELAND, OHIO.

## EXPLOSIVE-ENGINE.

938,401.

Specification of Letters Patent.

Patented Oct. 26, 1909.

Application filed April 15, 1907. Serial No. 368,152

*To all whom it may concern:*

Be it known that I, FRANCIS H. TREAT, of Cleveland, Cuyahoga county, Ohio, have invented a new and useful Improvement in Explosive-Engines, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a horizontal section showing one embodiment of my invention; Fig. 2 is a section on the line II—II of Fig. 1 with the main valves removed and the auxiliary and exhaust valves slightly out of their true positions; Fig. 3 is a section on the line III—III of Fig. 2; and Fig. 4 is a section on the line IV—IV of Fig. 1.

My invention has relation to explosive engines of the four-cycle type, and more particularly to improvements in the valve apparatus of that character of engine for controlling the admission and the retention of the explosive mixture of gas and air; and the explosive gases in the cylinder; and also the escape of the exhaust gases therefrom.

It also relates to the means for forming said explosive mixture, and for regulating the supply of gas and air to govern the engine.

My invention is especially applicable to that class of four-cycle engines in which the explosive mixture enters the cylinder and the exhaust gases leave the cylinder through a single valve-controlled passage, in which the valve is in its closed position during the compression and the explosion strokes, and acts to retain the gases in the cylinder during those strokes, and also to resist the heavy pressures developed in the cylinder. The valve remains in its open position during the suction and the exhaust strokes, and does not interfere with the flowing in of the explosive-mixture, or the out-flowing of the exhaust gases during that portion of the cycle. Auxiliary valves are employed at the termination of said common passage, outside the cylinder walls, and working under very light pressures, to open communication with the mixing passages, and with the exhaust discharge passage, and to close the same at the proper time.

My invention has for its objects, the furnishing of devices for the valves, valve apparatus, and operating mechanisms, of a simple and durable construction, in which only rotary and crank motions will be em-

ployed, and in which the use of the puppet valves and springs generally employed, will be avoided; also to furnish means for regulating the flow of gas and air into the mixing passages, (the same being induced by the suction of the engine piston) whereby the flow of the gas will be momentarily interrupted near the end of each suction stroke of the piston, the air being permitted to flow without interruption, so that at the time of the closing of the inlet valve, the passage between it and the cylinder closing valve will be filled only with air, thus effecting an economy in gas, and avoiding a disagreeable noise in the exhaust escape pipe, which might be caused by the ignition and burning of any explosive mixture that might be left remaining therein by the flowing through of the hot exhaust gases from the cylinder.

With these several objects in view, and to form the combined inlet and exhaust passage to the cylinder, and a chamber for the controlling valve, I provide an auxiliary cylinder with a piston, pitman and crank equipment, similar in their general features, to the main cylinder. This auxiliary cylinder, I provide with a port opening through its side walls, in position to be covered and uncovered by the piston at about mid-stroke when it is traveling at its maximum rate of speed. This auxiliary cylinder, at its working end, forms a connection with the main cylinder, so that the explosion chamber will be common to both cylinders. The piston valve actuating shaft is caused to revolve at half the speed of the main crank-shaft of the engine, whereby said auxiliary piston makes one forward and back movement, in each cycle of the engine's operation, resulting in said port being closed during two strokes of the main piston and open during two strokes thereof, in each of said four-stroke cycles.

I have shown my invention in connection with two cylinders which may constitute a complete engine, or to which other cylinders may be added, it being understood that the invention may be used in an engine having one cylinder, or more than two cylinders.

Referring to the accompanying drawings, the numerals 2 and 3, designate the two main cylinders, and 4 and 5 their respective pistons. The inner shell of these cylinders is contracted at the explosion end, in an approximately semi-globular shape to form the head or breech 6 inclosing the explosion chamber. To this is connected the auxiliary

cylinder 7 which I prefer to connect as shown, in opposed arrangement, and in line with the main cylinder, as facilitating their manufacture, their axes coinciding, though they may be connected at any desired angle or arranged in the same direction with their axes paralleled. In order to avoid packed joints difficult to maintain in these parts, which are subjected to very high pressures and high temperatures, I prefer to make the auxiliary cylinder in one piece, as shown, with the main cylinder.

The outer shell or jacket 8 is connected to the main frame of the engine by a flanged joint and bolts 15, a portion of said main frame being shown in section at 9. The main frame or bed plate has formed therein, for the reception of each cylinder, a circular opening or passage with raised portions 10 and 12 surrounding each end thereof, and which are machined to fit corresponding bearing surfaces 11 and 13 formed on the outside of the cylinder. These constitute a support and method of attachment which possess great rigidity. The flange portion of the bearing 11 surrounding the open end of the cylinder constitutes a shoulder to receive the reactive longitudinal thrust of said cylinder from the effect of the explosions against the cylinder head. The cylinders being entered in said openings of the bed plate through the crank end thereof, no additional means of attachment is required to resist the working stresses to which these parts are subjected. The stud bolts shown, connecting the part 11 to the bed plate, are only required to hold the cylinders securely in place and to compress the packing ring 14 of soft material which is interposed between the opposing shoulders shown as formed in the bearing surfaces 12 and 13 of the bed plate and cylinder. This forms a water-tight joint to resist the leakage of water from the cooling jacket into the openings in the bed plate surrounding the cylinder.

The auxiliary cylinders 7 are surrounded by a disk-like flange 16 inclosing a narrow space which forms a continuation of the water jacket for cooling the head and the auxiliary cylinder, and its opposite surface is made flat and forms the support for the valve apparatus and medium for its attachment to the end of the cylinder. The flange at the outer end of said collar is for the purpose of giving a broad outer face which has a bearing in a circular opening formed in the outer end of the outer shell 8 of the water jacket, and forms a telescopic connection therewith. This furnishes a support for the outer end of the cylinder, and at the same time permits a longitudinal movement to take place between these two members to accommodate whatever changes may be produced in their relative length through variations in their relative temperatures, a pack-

ing ring 5<sup>b</sup> of soft material being used in said telescopic joint, and being retained by the follower ring 5<sup>a</sup> and bolts shown, so that leakage of water is prevented.

The port 19 in the auxiliary cylinder surrounds the cylinder, and is crossed by four bridges to form a cross connection and to retain the packing rings of the piston. The rectangular chamber 20 with which these port openings communicate forms the connection with the auxiliary inlet and exhaust valves, and constitutes the outer terminus of the combined inlet and exhaust passage to the main cylinder, its dimensions being such as will give a proper area of passage.

Numerals 21 and 22 indicate respectively, the pitman, and crank of the auxiliary cylinder, 23 being the half speed shaft carrying said crank, a separate section being employed for each cylinder, and coupled together they operate as one shaft with the cranks set at an angle of ninety degrees to each other, said shaft being driven from the main shaft by any suitable connection (not shown), which will give the required relative speeds.

Of the two main cylinders shown, the pistons 4 and 5 are shown at opposite extremes of their movement, being coupled to cranks set opposite to each other, piston 4 standing as at the time of explosion, with the working face of the auxiliary piston in line with the inner face of the cylinder head, and its crank at dead center forward. The piston 5 stands as at the beginning of the compression stroke with the crank of its auxiliary piston at the lower quarter, the auxiliary piston standing a little short of mid-stroke, due to the angular position of the pitman. As will be seen, the port is slightly open, for this reason thereby furnishing sufficient lag to give the late closing of the valve desired. With one revolution of the main shaft the piston 5 will again stand in the same position, but it will be at the beginning of the exhaust stroke. The auxiliary piston will then be in the same position as shown, but will be moving in the opposite direction with its crank on the upper quarter, and the opening of the valve as shown, representing a lead which gives the early opening of the exhaust required.

The mixture of gas and air is effected and controlled in the following manner: The gas enters at port 24, (see Fig. 3), which is controlled by a regulating or throttle valve 25, the same being raised or lowered, as it is desired to increase or diminish the flow of gas through any desired agency, automatic or otherwise which may be connected to the upper end of the valve stem 26. From said port and valve, it flows through passage 27 to a rotary valve 28 having a series of ports through which its admission within the body of the valve is controlled, said valve turning

within the casing 30 which has entrance ports 31 arranged to register with the ports 29 of the valve 28. The valve 28 has end portions or nozzles 32 extending beyond the casing and projecting into the mixing passages 33, which are provided with perforations for the escape of the gas. The valve 28 is made adjustable on its shaft to bring its ports into different angular positions. This is indicated by the set-screw 28<sup>a</sup> in Fig. 2. Air is admitted through the port 34, its flow being regulated or controlled by the throttling valve 35, which is similar in its operation to its companion valve 25 for the gas described above. Thence the air flows into passages 33 where it meets and mingles with the gas flowing from the perforations of nozzles 32. The valve 28 is arranged on the central portion of a rotary shaft 28<sup>a</sup>, connecting at each end with a hollow cylindrical valve 35 which contains the passages 33 before referred to, said passages terminating in the ports 36 which are arranged to communicate with the chambers 20 which form the outer terminus of the combined inlet and exhaust passage before referred to. The valves 35 with the shaft 28<sup>a</sup> are driven at the same speed as the crank shaft 23 from said shaft through the gear wheels 37 and 38.

Each connecting chamber 20 opens at the opposite side to a rotary exhaust valve 39 which is rotated at the same speed as the valves 35 by means of the gears 40 which mesh with the gear wheel 37 on the half-speed shaft 23. The exhaust passages 39<sup>a</sup> of the valves 39 are arranged to communicate with a common exhaust passage 41. (See Fig. 2.) It will also be observed in connection with Fig. 2, that of the rotary valves 35 and 39, those on the right hand side stand 180 degrees apart from those on the left. They are shown in this relationship for the purpose of illustrating their open and closed positions in one view, although to be strictly correct, they should stand 90 degrees apart to agree with the relative positions of the two cranks 22 shown in Fig. 1.

An igniter 43 is shown in position in each cylinder, and on opening for a second one with igniter removed is also shown upon the opposite side of the auxiliary cylinder. Water jackets are provided for the exhaust valves, as indicated by 42.

During a suction stroke, the gas is drawn by the inspiration from the source of supply through port 24, passage 27, interrupting valve 28, and through the perforations of nozzles 32, into the mixing passages 33, where it meets and mixes with the air drawn in through port 34. These pass either to the left or to the right, depending upon whether the inspiration is from the cylinder 2 or the cylinder 3. A suction stroke of one cylinder is immediately followed by the other, and as the duration of each is equal to a quarter

of a revolution of the half speed shaft 23, gas and air will be flowing in through the ports 24 and 34 constantly during a half revolution of said shaft.

Two of the ports of valve 28 are arranged to be in register with the two ports 31 of the casing 30 during each suction stroke, and at full opening a little before the middle of the stroke and to close and interrupt the flow of the gas a little before the end of the stroke, so that the passages from the valves 35 into the cylinders will be filled with air only at the time of the closing of the ports 19 of the auxiliary cylinder 7 by the pistons 18, as before described.

As before explained, the pistons in the auxiliary cylinders effect the opening of the exhaust from the cylinders and close the inlet communication therethrough remaining open during the exhausting and the suction strokes. The precise function, therefore, of the rotary valves 39 and 35 is to effect the closing of the exhaust discharge, and the opening of the inlet supply passages, at the right moment during the time the valve of the common inlet and exhaust passage into the cylinder is open. The auxiliary valves thus act in concert with the main valves. As these auxiliary valves have only to deal with very light pressures, and for a part of the time with a slight vacuum, they may be fitted to run quite freely in their casings without fear of trouble from leakage, and they will be subject to but slight wear in use. In the employment of rotary and crank motions exclusively in the operation of the valves I am enabled to operate them with safety at very high speeds. By the use of a single acting piston to act as a valve for closing the cylinder and to resist the heavy pressures generated therein, a high degree of durability is assured, together with an ability to remain tight, as against the leakage of cylinder gases.

I am aware that it is common in four-cycle engines to arrange an exhaust port in a main cylinder to be opened and closed by the piston near the end of its stroke. I am also aware that it is common in two-cycle engines to use such an arrangement to control an inlet, as well as an exhaust port. But I am not aware that an auxiliary cylinder with a piston operated at half speed, to effect the opening and the closing of a port to a cylinder of a four-cycle engine has ever before been known or used.

The novel features of cylinder construction herein shown and described form the subject of a divisional application, Serial No. 381,674, filed July 1, 1907.

What I claim is:—

1. In a gas engine of the four cycle type, a cylinder, a port leading into the explosion chamber of the cylinder, an auxiliary cylinder forming a continuation of said port, and

- itself having a lateral port, and a piston valve in said cylinder, said valve controlling said lateral port and also effecting the closure of the cylinder explosion chamber presenting its inner end to the explosion chamber to receive the force of the explosion, a half speed shaft, and actuating connections between said shaft and the piston, said valve and connections being arranged to effect the closing of the lateral port at about the mid stroke of the valve; substantially as described.
2. In a gas engine of the four-cycle type, a cylinder having an inlet port leading into the explosion chamber of the cylinder, an auxiliary cylinder forming a continuation of the port, and itself having a lateral port, a reciprocating single-acting piston valve working in the auxiliary cylinder and controlling said ports, said valve presenting its inner end to the explosion chamber to receive the force of the explosion, a half-speed shaft, a crank in said shaft, and a pitman connecting the crank with the valve, said crank and pitman being arranged to cause the valve to close said ports at about its mid-stroke and at the beginning of the compression stroke of the main cylinder piston; substantially as described.
3. In a gas engine of the four-cycle type, a cylinder having an inlet port leading into its explosion chamber, an auxiliary cylinder forming a continuation of the port, and itself having a lateral port, a piston valve in said cylinder arranged to close said ports at about its mid-stroke, said valve presenting its inner end to the explosion chamber to receive the force of the explosion, and actuating means for said valve whereby it makes half the number of strokes as the main engine piston; substantially as described.
4. In a gas engine of the four-cycle type, a cylinder having a combined inlet and outlet port, an auxiliary cylinder communicating with the said port, and having a lateral opening, and a piston arranged to cover and uncover the said opening at about the midpoint of its stroke, together with means for actuating said piston whereby it has a greater speed throughout the mid portion of its stroke than at other points of its movement; substantially as described.
5. In a gas engine of the four cycle type, a cylinder having a combined inlet and exhaust passage, an auxiliary cylinder forming a continuation of said passage, and having a lateral inlet and exhaust port, a piston valve in said cylinder arranged to close said port at its mid-stroke, said valve presenting its inner end to the explosion chamber to receive the force of the explosion, a half-speed shaft having an actuating connection with the valve, and a supplemental inlet valve; substantially as described.
6. In a gas engine of the four cycle type, a cylinder, having a combined inlet and exhaust passage, an auxiliary cylinder forming a continuation of said passage, and having a lateral inlet and exhaust port, a piston valve in said cylinder arranged to close said port at its mid-stroke, said valve presenting its inner end to the explosion chamber to receive the force of the explosion, a half-speed shaft having an actuating connection with the valve, and a supplemental exhaust valve; substantially as described.
7. In a gas engine of the four-cycle type, a cylinder having a combined inlet and exhaust passage, a piston valve controlling said passage, a half speed shaft for actuating said valve, and auxiliary rotary inlet and exhaust valves; substantially as described.
8. In a gas engine of the four-cycle type, a cylinder having a combined inlet and exhaust passage, a piston valve controlling said passage, means for actuating said valve whereby it makes half the number of strokes of the main engine piston, an auxiliary rotary inlet valve, and a gas interrupting valve for admitting gas to the auxiliary valve; substantially as described.
9. In an explosive engine of the four-cycle type, a mixing chamber, a port leading therefrom to the cylinder, a reciprocating main valve controlling said port, auxiliary rotary valves controlling the admission of the charge to said chamber, a rotary exhaust valve controlling the escape of exhaust from said chamber, and a shaft and connections for operating all said valves in proper time relations; substantially as described.
10. In a gas engine of the four cycle type, a cylinder having a combined inlet and exhaust passage, an auxiliary cylinder forming a continuation of said passage and having a lateral inlet and exhaust port, the piston valve in said cylinder presenting its end to the explosion chamber of the said cylinder to receive the force of the explosion, a half speed shaft having an actuating connection with the valve, and an auxiliary inlet valve, substantially as described.
11. In a gas engine of the four cycle type, a cylinder having a combined inlet and exhaust passage, an auxiliary cylinder forming a continuation of said passage and having a lateral inlet and exhaust port, the piston valve in said cylinder presenting its end to the explosion chamber of the said cylinder to receive the force of the explosion, a half speed shaft having an actuating connection with the valve, and auxiliary inlet and exhaust valves, substantially as described.
12. In a gas engine, a cylinder, an auxiliary cylinder connected thereto and having a chamber opening into and common to the explosion chamber of the cylinder, a combined inlet and exhaust opening leading into the auxiliary cylinder, and a piston

in said cylinder arranged to control the said opening; substantially as described.

13. In a gas engine, a cylinder having a neck portion formed with a port leading thereir, and an auxiliary cylinder forming a continuation of said port and having lateral openings, said auxiliary cylinder forming a chamber for the main valve and a main piston valve in said cylinder arranged to effect the closing of the explosion chamber during the compression stroke of the main piston and to present its end to the said chamber; substantially as described.

14. In an explosive engine, a rotary gas controlling valve consisting of a hollow body having admission ports, means for periodically closing said ports as the valve is rotated, said valve having escape openings through its wall, a mixing chamber or passage into which the gas is discharged through said escape openings, means for admitting the air to the mixing chamber or passage, and means for constantly rotating said valve to alternately open and close its admission ports; substantially as described.

15. In an explosive engine, a rotary shaft, a gas controlling valve carried thereby, means for periodically admitting gas to the interior of said valve, an auxiliary valve mounted on the same shaft with the first named valve, and having a port communicating with the interior of the gas valve, means for supplying air to the said port exteriorly of the gas valve, and a main valve for controlling the supply of mixed air and gas to the engine cylinder; substantially as described.

16. In an explosive engine, a gas interrupting valve comprising a hollow rotating body, means for admitting gas thereto, said valve having escape openings or passages leading outwardly from the same, and an air supply passage surrounding said valve and into which the valve discharges, together with means for admitting air to said passage, and means for constantly rotating said valve; substantially as described.

17. In an explosive engine, a cylinder having a neck extension at its explosion end forming an auxiliary cylinder, a combined inlet and outlet passage leading through the walls of said cylinder, and a piston valve in said cylinder arranged to control said port,

said valve presenting its end to the explosion chamber of the cylinder to receive the force of the explosion and to effect the closing of the explosion chamber; substantially as described.

18. In an explosion engine of the four-cycle type, an auxiliary cylinder communicating with the explosion chamber of the main cylinder by a single opening and having a lateral inlet and outlet port, a piston valve arranged to reciprocate the auxiliary cylinder, a half-speed shaft having a crank and a pitman connecting the crank and valve, said valve and its actuating crank and piston being set to cause the valve to close said port at its mid-stroke and at the beginning of the compression stroke of the main piston, and to thereafter advance to assist in the compression and to receive the force of the explosion against its inner end and transmit it to the crank; substantially as described.

19. In an explosion engine, a gas interrupting valve, comprising a hollow rotating body having a plurality of admission ports, means whereby said ports are alternately opened and closed as the valve is rotated, said valve having escape openings or passages leading outwardly from the same, an air chamber surrounding said valve and into which the said escape openings or passages discharge, means for supplying air to the air chamber, means for effecting an angular adjustment of the valve to vary the time of its interrupting action, and means for constantly rotating said valve; substantially as described.

20. In a gas engine of the four-cycle type, a cylinder having an exhaust port leading into its explosion chamber, an auxiliary cylinder forming a continuation of the port, and itself having a lateral port, a piston valve in said cylinder arranged to close said ports at about its mid-stroke, and actuating means for said valve whereby it makes half the number of strokes as the main engine piston; substantially as described.

In testimony whereof, I have hereunto set my hand.

FRANCIS H. TREAT.

Witnesses:

R. J. WARDNER,  
LIRRIE MAWELL.