J. TODD.

EXPLOSIVE ENGINE.

APPLICATION FILED MAR. 30, 1903.

1,076,172.

Patented Oct. 21, 1913.

3 SHEETS-SHEET 1.

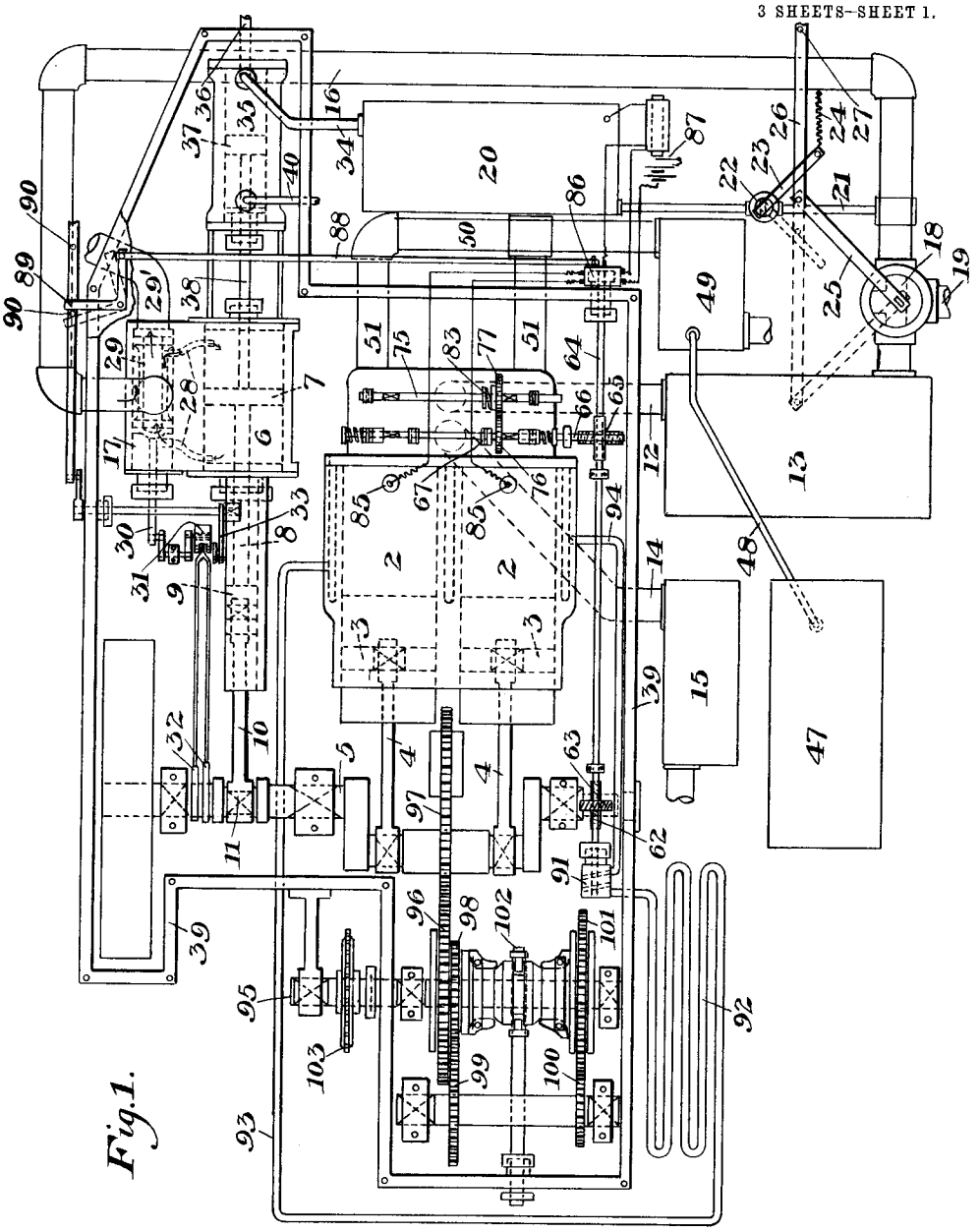


Fig. 1.

WITNESSES

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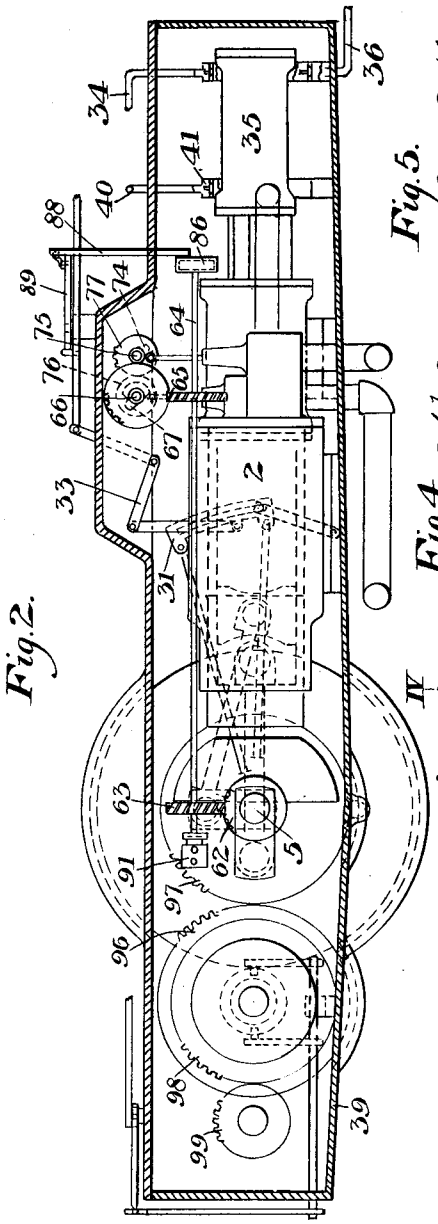


Fig. 2.

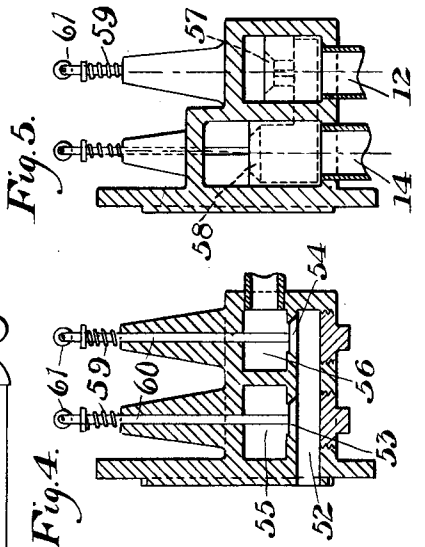


Fig. 5.

Fig. 4.

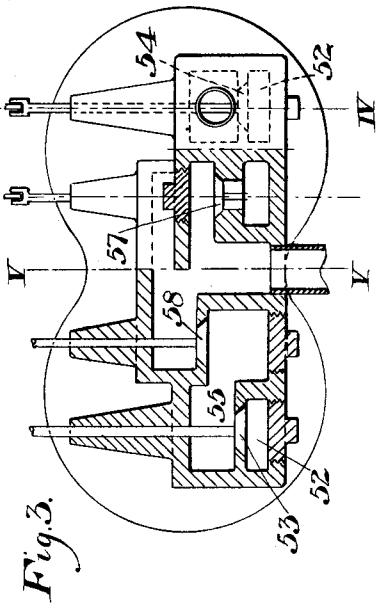


Fig. 3.

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3 SHEETS—SHEET 3.

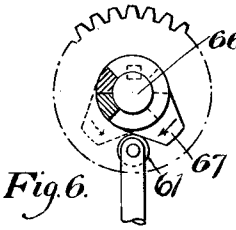


Fig.6.

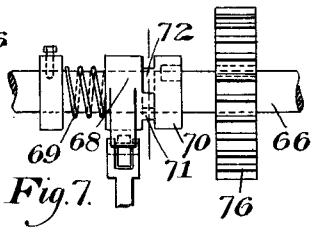


Fig.7.

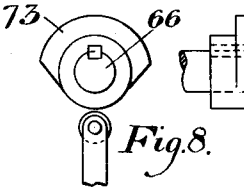


Fig.8.

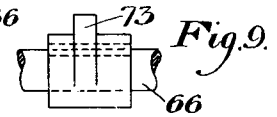


Fig.9.

Fig.10.

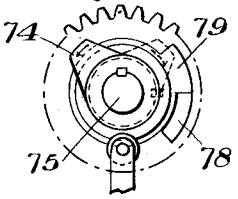


Fig.11.

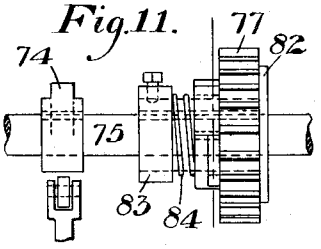


Fig.12.

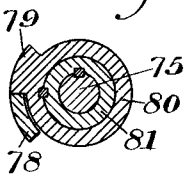


Fig.13.

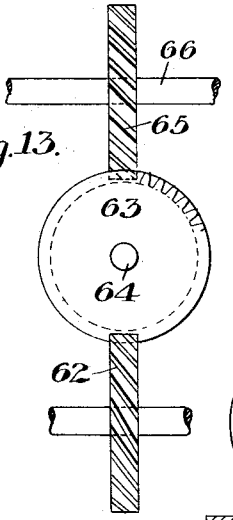


Fig.14.

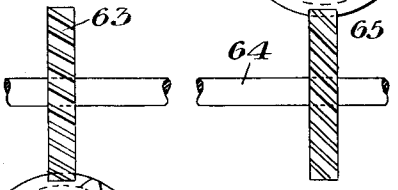


Fig.15.

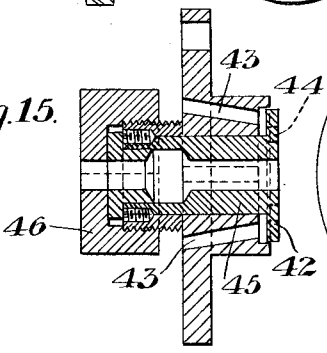
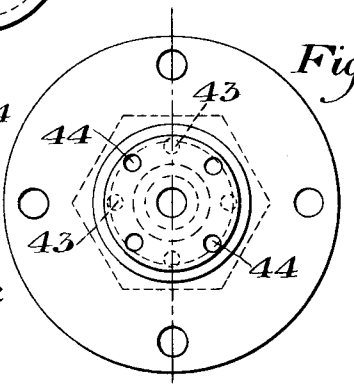


Fig.16.



WITNESSES

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EXPLOSIVE-ENGINE.

1,076,172. Specification of Letters Patent. Patented Oct. 21, 1913.

Application filed March 30, 1903. Serial No. 150,108.

To all whom it may concern:

Be it known that I, JAMES TODD, of Sewickley, Allegheny county, Pennsylvania, have invented a new and useful Explosive-Engine, 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 top plan view showing one form of my improved engine system, with the casing cover removed; Fig. 2 is a sectional side elevation of the same; Fig. 3 is an end elevation partly in section on two different planes of the gas engine valves; Fig. 4 is a section on the line IV—IV of Fig. 3; Fig. 5 is a section on the line V—V of Fig. 3; Figs. 6 and 7 are detail views of the exhaust cam; Figs. 8 and 9 are detail views of the supplemental exhaust cam; Figs. 10, 11 and 12 are detail views of the admission cam; Figs. 13 and 14 are detail views of the spiral gears for operating the valves, and Figs. 15 and 16 are detail views of the inlet port for the air pump.

My invention relates to the class of explosive engines, and is designed to provide an engine of this type which may be reversed and which shall be self-starting, balanced and noiseless in its action, and non-centering.

To this end the invention consists in combining the explosive motor or gas engine cylinder or cylinders with an auxiliary double-acting cylinder or cylinders also connected to the main shaft, this auxiliary cylinder operating in the manner of a steam engine cylinder.

It also consists in means for supplying the products from the gas engine cylinder or cylinders to the double acting cylinder preferably through an intermediate tank. Also in providing connections for supplying the auxiliary cylinder with the exhaust products from the gas engine to actuate the piston therein, or by changing the said connections and actuating the piston from another source it may be used as a pump to exhaust the gas engine under a partial vacuum.

The invention further consists in providing a casing for the engine in which a partial vacuum may be maintained, in an arrangement of the cranks for the main and auxiliary cylinders, in reversing mechanism, and in the construction and operation of the parts as more fully hereinafter described and claimed.

In the drawings, I show a form of my invention wherein two parallel gas engine cylinders are employed, each working on the four cycle plan, and one exploding alternately with the other; in connection with an auxiliary cylinder of double-acting steam engine form. In these drawings 2, 2 are the parallel gas engine cylinders having pistons 3, 3 with connecting rods 4, 4 leading to a common crank on the main engine shaft 5. The auxiliary cylinder 6 is set at one side and is provided with a piston 7 whose piston rod 8 is connected to a cross-head 9 with connecting rod 10 extending to a crank 11 on the shaft 5, which crank is about 90 degrees back of the gas engine crank. The gas engine cylinders exhaust through valves hereinafter described into a main exhaust pipe 12 leading to a closed receiver 13, or through a secondary exhaust-pipe 14 into a muffler 15, and thence to the open air. Leading from the receiver 13 to the valve chest 17 of the auxiliary cylinder is a supply pipe 16 which is provided, preferably near the receiver, with a three-way valve 18 arranged to connect the receiver to the chest 17, or to close this connection and at the same time open the receiver to the air through the side outlet 19.

In starting the engine compressed air is used, this being supplied from a tank 20 from which pipe 21 leads into pipe 16 between the valve 18 and the auxiliary cylinder. The pipe 21 is provided with a controlling valve 22 having an operating lever 23 which is normally held in the position shown in full lines in Fig. 1 by a spring 24. The valve 18 is provided with an operating arm 25 to which leads a pivotal link 26 extending to a convenient point for the operator, and on the link 26 is a pin 27 which is arranged to contact with the arm 23.

In starting the engine the link 26 and arm 25 are moved into the position shown in dotted lines in Fig. 1. The first part of this movement closes the connection between the receiver 13 and the pipe 16, and opens the receiver to the atmosphere, and the further movement causes the pin 27 to act upon and open the valve 22, thus supplying compressed air to the valve chest 17. The compressed air passing through pipe 16 enters the valve chest 17, from which the supply-

ports 28 lead into the cylinder 6. The valve chest contains the balanced piston valve 29 of ordinary steam engine type and through which the exhaust passes into the outlet pipe 29'. The valve stem 30 is connected to an ordinary reversing link gear 31 actuated by eccentrics 32, the link being shifted through the lever and link system indicated at 33 in Fig. 2. This portion of the apparatus is of ordinary type, and will not need further description.

The compressed air tank is supplied through pipe 34 leading from the upper rear end of the air pump 35, and the air is taken in through the lower pipe 36 at the rear end of this cylinder. The pipes 34 and 36 are provided with check valves of ordinary form. The piston 37 of this air pump cylinder is arranged in tandem with the auxiliary cylinder 6 and its piston-rod 38 is formed as a continuation of the piston-rod 8.

In order to reduce the noise of the running parts of the engine I preferably inclose the cylinders in a casing 39, this casing having a removable top cover-plate or plates, and hand-holes or man-holes with closures; and within this casing I preferably maintain a partial vacuum by means of the air pump cylinder 35. The front end of this cylinder is provided with an exhaust-pipe 40 which leads outwardly through the casing to the open air and is provided with a downwardly seating check-valve 41. I have shown the inlet-valve at the front end of this cylinder in Figs. 15 and 16. This valve consists of a valve disk 42 covering inlet ports 43 opening through the cylinder-head, and itself containing non-registering ports 44. This disk is formed as part of a hollow sleeve 45 which extends through the head and is secured at its outer end to the stuffing box 46 for the piston-rod. The friction of the piston-rod will move this inlet valve inwardly and open it as the suction stroke begins and then close it on the beginning of the opposite stroke, the air being forced out through the pipe 40.

The gas engine cylinders are supplied from a gasolene tank 47, from which pipe 48 leads to the carbureter 49. The pipe 50 leading from this carbureter is connected to the branch supply-pipes 51 one for each of the cylinders 2.

I will now describe the valves and passages controlling the inlets and outlets for the gas engine cylinders. These are more clearly shown in Figs. 3, 4 and 5, and are the same for each cylinder. In these figures 52 is a passage leading outwardly through the rear cylinder-head and provided with two upper ports controlled respectively by upwardly seating exhaust valve 53 and inlet valve 54. The valve 53 controls the main exhaust passage 55 which leads around the inlet passage 56 and extends under the check valve 57, see Fig. 5 and also under the supplemental exhaust-valve 58. The check valve 57 is a downwardly seating valve leading to the main exhaust-pipe 12, while the valve 58 controls the passage to the secondary exhaust 14. It is evident that the exhaust products from the cylinder cannot pass out through the secondary exhaust valve except when the main exhaust valve is opened. The connections to the valve 53 and the valve 58 are so arranged that the main exhaust-valve is opened at the end of the explosive stroke and remains open throughout the succeeding back stroke of the piston. When pressure is to be maintained in the receiver and the lead of the valve 29 is such (for example $\frac{1}{8}$ lead) that the auxiliary cylinder acts as an expansion cylinder, the exhaust passes out against the back pressure and during the back stroke the products will only flow through the check valve into the receiver. At the end of this back stroke there will be exhaust gases remaining in the clearance spaces under pressure, and these would cause trouble in admitting the next charge, and if under sufficient pressure would blow back through the carbureter. This difficulty I overcome by the supplemental exhaust which is timed so as to open slightly before the end of this back stroke, and allow it to pass out through the pipe 14, and muffle 15. The main exhaust valve closes at the usual time and cuts off the passage to the supplemental exhaust, whose valve may be closed at any time before the next opening of the main exhaust.

The inlet-valves 54 are moved downwardly at the proper intervals to admit the charge to the passage 52, as in the ordinary type. I have shown all of these valves, except the check valve 57, as being closed by springs 59 surrounding their stems 60, the stems being forced down against spring-pressure by cams acting upon the friction wheels 61.

I will now describe the connections by which the three mechanically moved valves for each cylinder are actuated. The main engine shaft 5 carries a spiral gear 62 intermeshing with a spiral gear 63 upon a longitudinal shaft 64. The gearing gives this shaft 64 a motion of two to one relative to the main shaft, and it in turn is connected by spiral gearing 65 with a cross-shaft 66 which extends directly over the valve stems of the main and supplemental exhaust valves.

In Figs 6 and 7, I show the cam for actuating the main exhaust. The fact that the engine is reversible necessitates a peculiar construction of the several cam mechanisms in order that they may operate the valves at the proper time for forward or reverse motion of the crank-shaft. In all of the views showing the cams I show them in full lines

in the position which they occupy near the end of the explosion stroke as the main exhaust is about to open. The cam 67 for operating the main exhaust is secured to the collar 68 which loosely surrounds the shaft and is forced by a spring 69 toward a collar 70 which is keyed to the shaft. The collar 68 has side lugs 71 which are adapted to engage lugs 72 projecting from the keyed collar 70, and in the position shown, with the engine running counter-clockwise the lugs 72 engage the cam and force it around in the direction indicated by the full lined arrow of Fig. 6, thus depressing the main exhaust against the action of this spring.

When the engine is reversed, the lugs on the cam and the feed collar are so arranged that the shaft will turn in the opposite direction through an angle of about 90 degrees before the lugs engage each other again; and this will open the main exhaust at the proper moment when the engine is running in a clockwise direction. I have shown in dotted lines in Fig. 6 the position of the cam in such case, the direction of rotation being indicated by the dotted arrow.

In Figs. 8 and 9, I show the cam 73 for the supplemental exhaust, which extends through a little more than 190 degrees of its circumference. This cam does not need to be shifted in reversing, since it is only necessary that the supplemental exhaust be closed at some time between the closing of the main exhaust and the next opening of the main exhaust.

In Figs. 10, 11 and 12, I show the arrangement of the admission cam. This cam 74 is connected with a shaft 75 which extends parallel with the shaft 66 and is geared to it by gear wheels 76 and 77, the wheel 77 being loose on the shaft 75. The cam 74 is keyed to the shaft 75 and the gear-wheel 77 has a side lug 78 which engages a lug 79 projecting from a collar 80 which is splined to an intermediate sleeve 81 on which the gear wheel loosely rotates, and which in turn is keyed to the shaft 75. The sleeve 81 has a ring or disk 82 at one end and a collar 83 at the other end, a spring 84 being placed between the collar 83 and the outer collar 80. These figures show in full lines the position of the cam and the lugs when the pistons are in the position shown in Fig. 1 and the engine shaft is rotating in a counter-clockwise direction. When reversed the gear wheel 77 will turn around the sleeve 81 through an arc of about 270 degrees, until it engages the other side of the lug 78.

It will be noted that a separate cam mechanism is provided on the shaft 66 for each of the separate gas engine cylinders, while the single cam-mechanism of Figs. 10, 11 and 12 operates the admission valves for both cylinders, see Fig. 1. This is the reason for using a different mechanism for the inlet valve cam from that for the exhaust-cam, and if two cams were used for the inlet valve they could be similar in arrangement to that for the exhaust valve, except for the difference on the arc through which the slip occurs.

The sparking plugs 85 are shown as wired to brushes acting on the circuit breaker 86 secured to the extension of the shaft 64 with the usual connections to the battery and induction coils shown at 87. In order to shift the brushes on reversing to give the same point of ignition while the main shaft is turning in the opposite direction, I preferably pivot the link connection 88 to a bell crank 89 which is mounted on the top of the casing cover and is arranged to be engaged by pins 90 upon the reversing connections for shifting the links. In this way I automatically shift the brushes when the engine is reversed thus keeping the point of ignition the same.

I have shown the circulating pump 91 as driven by the shaft 64 and connecting with the cooling coils 92 and the pipe 93 leading to one cylinder, the pipe 94 conducting the cooling fluid back from the other cylinder to the pump. I have also illustrated a driving shaft 95 having a gear wheel 96 intermeshing with an eccentric gear wheel 97 mounted on the common crank for both cylinders, thus avoiding a second crank. The eccentricity of the gear-wheel 97 gives the same action as though an ordinary gear wheel were mounted on the same axis as the engine shaft. The wheel 96, together with a wheel 98 are mounted on a collar surrounding shaft 95, the wheel 98 intermeshing with wheel 99 on a counter shaft having a pinion 100 intermeshing with a toothed wheel 101 loosely surrounding the shaft 95. The clutch 102 is arranged to throw in either set of gears, and thus give different speeds. The shaft 95 projects to the exterior of the closing casing and carries the chain or other wheel 103 for driving the automobile axle or other shaft to be driven.

In the operation of starting the engine the rod 26 is actuated to close the receiver connection with the pipe 16 and connect this pipe with the compressed air reservoir. During this movement of the rod the receiver is first connected to the open air through pipe 19 and then at a later part of the movement the valve 22 is opened, thus supplying compressed air to the valve chest of the double-acting cylinder. The piston of this double-acting cylinder will thus be actuated in the same manner as an ordinary steam engine, and will rotate the main engine shaft, its own valve being properly actuated through the eccentric. An explosive charge will thus be compressed in one of the gas engine cylinders, and as soon as the explosion takes place the oper-

ator will shift the link 26 to close the valve 22 and actuate the valve 18 to connect the receiver with the pipe 16. The main exhaust from the gas engine cylinder will pass into the receiver and thence be taken to the double-acting cylinder. At the same time air will be pumped into the compressed air reservoir, and the same pump cylinder will act to exhaust the air from the interior of the casing to produce a partial vacuum which will deaden the noise of the moving parts within this casing.

In using the apparatus with a pressure in the receiver above atmospheric pressure, the burnt products from the explosive engine cylinders expand within the double-acting cylinder, and the pressure of these products is thus converted into work, utilizing the power, instead of exhausting these products directly into the atmosphere. These gases are preferably expanded to at or near atmospheric pressure, thus obviating the noise of the exhaust. In this connection it is desirable to take the exhausted gases from the gas engine cylinder into pipes of sufficient size to act as a reservoir, or preferably as shown, into a small tank, though the connection may be direct. In starting, the compressed air acts through the auxiliary cylinder to drive the plungers of the gas engine cylinders until they discharge their contents and take in fresh fuel when the electric contact is closed, the compressed air is shut off from the auxiliary cylinder, the compounding tank is closed, and the valve opened from it to the auxiliary cylinder.

The engine is self-starting whether it is run forward or backward. Inasmuch as the pressure supplied to the auxiliary cylinder is practically uniform, the speed of the gas engine pistons will be made more uniform, this preventing to a large extent the variation of speed between explosions. The noise of the exhaust is prevented by the auxiliary cylinder which expands the gases to substantially atmospheric pressure, except as to the small amount in the clearance spaces, which is discharged into the muffler. The noise of the moving parts of the engine is absorbed in the partial vacuum within the casing, which casing also protects the engine from dust. The crank of the auxiliary cylinder cannot become centered on account of the different angle of said crank from that of the gas engine, the cylinders and the partial vacuum in the engine case. The gas engine pistons being subject to the pull or suction of the vacuum and operating together, a vacuum pull on the gas engine pistons is exerted, so that when the power is cut off these pistons will be drawn to their extreme forward position, so that by placing the crank of the auxiliary cylinder so that it is not in the same position, nor opposite to the position of the main crank, the auxiliary crank cannot become centered. If the engine is intended to reverse, the auxiliary crank should be nearly ninety degrees to one side of the main crank; but if the engine is to run in one direction only, then the auxiliary crank should be somewhat less than 180 degrees back of the main crank, thus giving the auxiliary piston the greatest possible stroke before its valves close, and the fly wheel carries it over the center.

The cylinder 6 may be used as a pump to remove the exhaust gases from the main cylinder, thus creating a partial vacuum in the exhaust receiver or tank. There would also be a more powerful explosion, due to a greater portion of the burnt gases being removed, giving less interference with the full power of the explosion, and admitting a larger charge, as a portion of the inert or burnt gases are removed; and further the partial vacuum would exert a pull on this side of the piston during its exhaust stroke thus pulling it on this stroke and increasing the working pressure of the gas engine piston. In this case the lead of the valve 29 would be increased (for example $\frac{1}{4}$ lead) so that the volume taken into the cylinder 6 would be greater than the exhaust from the gas engine cylinders 2, and create a partial vacuum in the receiver 13 and pipe 16. In either case, whether the auxiliary cylinder is used as a motive cylinder or as a pump, it may be connected direct to the main explosive cylinder or cylinders, without the intermediate reservoir or pipe system.

The advantages of my invention result from the use of a double-acting auxiliary cylinder which makes the engine reversible, and which may be used either as a pump to mechanically exhaust the burnt gases or as a motive cylinder, and allow further expansion of the gases, by adjusting the lead of the valve therefor. The auxiliary cylinder will not center owing to the partial vacuum in the case, which vacuum also prevents the noise of the working parts. It will also be readily understood by those familiar with the art, that the main cylinder may be double acting, and the auxiliary cylinder may be single acting.

Many other changes may be made in the form and arrangement of the cylinders and connections, the relative arrangement of the parts, etc., without departing from the spirit and scope of my invention, as defined in the appended claims.

I claim—

1. In an explosive engine, an explosive cylinder having a valve-controlled exhaust, an auxiliary cylinder connected to the exhaust for receiving the burnt gases therefrom, a piston in said cylinder, connections between said piston and a moving part of the explosive engine, a secondary exhaust

for said explosive engine through which some of the spent gases may be forced by the movement of the piston, and means for controlling said exhaust, substantially as described.

2. In an explosive engine, a single-acting primary explosive cylinder having a valve-controlled exhaust, connections for supplying a mixture of air and fuel to the cylinder, means for exploding the mixture in the cylinder, a double-acting auxiliary cylinder connected to the valve-controlled exhaust, a piston in said cylinder, connections between said piston and a moving part of the explosive engine, the burnt gases from the explosive cylinder passing from the exhaust to the auxiliary cylinder, a secondary exhaust for said explosive engine through which some of the spent gases may be forced by the movement of the piston, and means for controlling said exhaust, substantially as described.

3. In an explosive engine, a single-acting primary explosive cylinder provided with a valve-controlled exhaust, connections for supplying an explosive mixture to the cylinder, means for exploding said mixture in the cylinder, a reservoir connected with the valve-controlled exhaust to receive burnt gases therefrom, an auxiliary cylinder connected to the reservoir, a piston in said cylinder, and connections between said piston and a moving part of the explosive engine, the burnt gases from the explosive cylinder passing from the reservoir to the auxiliary cylinder, a secondary exhaust for said explosive engine through which some of the spent gases may be forced by the movement of the piston, and means for controlling said exhaust, substantially as described.

4. A gas engine having a plurality of cylinders, a case inclosing the cylinders, a pump arranged to maintain a partial vacuum within said case; substantially as described.

5. In an explosive engine, an explosive cylinder having an exhaust, an auxiliary cylinder arranged to receive the burnt gases from the exhaust, a piston in said auxiliary cylinder, a valve arranged to cut off the exhaust connection to the auxiliary cylinder and open said exhaust to the atmosphere, an air compressor arranged to be actuated from a moving part of the explosive engine, a compressed air tank communicating with the air compressor, an air supply connection from the tank to the auxiliary cylinder for moving the piston in the latter, means to open and close said connections, and mechanical connections between the auxiliary cylinder piston and the explosive engine piston for starting the explosive engine; substantially as described.

6. In an explosive engine, an explosive cylinder, a reservoir arranged to receive the burnt gases from the cylinder, an auxiliary cylinder arranged to receive the burnt gases from the reservoir, an air compressor, a compressed air tank communicating with the compressor, and mechanism for connecting and disconnecting the air tank and the burnt gas reservoir with the auxiliary cylinder, a piston in the auxiliary cylinder connected with the main engine piston for starting the same, and said connection serving to connect the auxiliary cylinder piston to the piston of the main engine to operate them in time with each other; substantially as described.

7. In an explosive engine, an explosive cylinder having an exhaust, an auxiliary engine having a cylinder, a piston in said cylinder connected with the main engine and in communication with the exhaust for the main engine arranged to receive the burnt gases therefrom, link gear for reversing the auxiliary engine, mechanism for shifting the valve mechanism of the explosive cylinder, and a connection between the link gear and the valve-shifting mechanism of the explosive engine to reverse the link gear when the auxiliary engine is reversed, substantially as described.

8. In an explosive engine, an explosive cylinder having an exhaust, a sparking device for the explosive cylinder, an auxiliary engine having a cylinder, a piston in said cylinder connected to the main engine and having a valve chest in communication with the exhaust for the main engine arranged to receive the burnt gases therefrom, link gear for reversing the auxiliary engine, and means for automatically reversing the sparking device when the engine is reversed; substantially as described.

9. An explosive engine cylinder, a casing arranged to inclose the cylinder and its working parts, a pump arranged to create a partial vacuum within the casing, and a compressed air reservoir, said pump being arranged to discharge into the air reservoir; substantially as described.

10. An explosive engine cylinder, an auxiliary cylinder arranged to receive the burnt gases therefrom, a casing inclosing the cylinders and their working parts, a pump arranged to create a partial vacuum within the casing, and a compressed air reservoir connected to the auxiliary cylinder, said pump being connected to the driving gear and arranged to supply air to the reservoir; substantially as described.

11. An explosive engine cylinder having a piston connected to the main driving shaft, an auxiliary cylinder, a piston within said cylinder connected to a crank on the main shaft at an angle to the main crank, a case surrounding the cylinders, and a pump for maintaining a partial vacuum within said case, said pump being actuated

by the piston within the auxiliary cylinder; substantially as described.

12. An explosive engine, a case surrounding the engine, and means for maintaining a partial vacuum within said case; substantially as described.

13. The combination with an explosive engine, of an exhaust reservoir for the explosive engine, an auxiliary cranking engine for the main engine, a supply pipe leading from the exhaust reservoir to the cranking engine, an air pump actuated by one of the engines, a storage tank connected to the air pump, a supply pipe leading from the air tank to the supply pipe for the auxiliary cranking engine, and a hand actuated controller for cutting off the connection between the air tank and the cranking engine and for opening the connection between the air tank and the cranking engine; substantially as described.

14. In an explosive engine, an explosive cylinder having a valve-controlled exhaust, a piston in the explosive cylinder, an exhaust reservoir, an auxiliary cylinder having a valve chamber in connection with the exhaust reservoir, valves in said valve chamber, a double acting piston in the auxiliary cylinder, a crank shaft connected to the pistons in both cylinders, and means connected to the crank shaft for operating the valves for both cylinders; substantially as described.

15. In an explosive engine, an explosive cylinder having a valve-controlled exhaust, a piston in the explosive cylinder, an auxiliary cylinder having a valve chamber in connection with the explosive cylinder exhaust, valves in said valve chamber, a double acting piston in the auxiliary cylinder, a crank shaft connected to the pistons in both cylinders, and link gear to shift said valve connections to reverse the movement of the crank shaft; substantially as described.

In testimony whereof, I have hereunto set my hand.

JAMES TODD.

Witnesses:
C. P. BYRNES,
H. M. CORWIN.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."