No. 824,936. PATENTED JULY 3, 1906.

M. C. KESSLER.

EXPLOSIVE ENGINE.

APPLICATION FILED SEPT. 24, 1904.

6 SHEETS—SHEET 1.

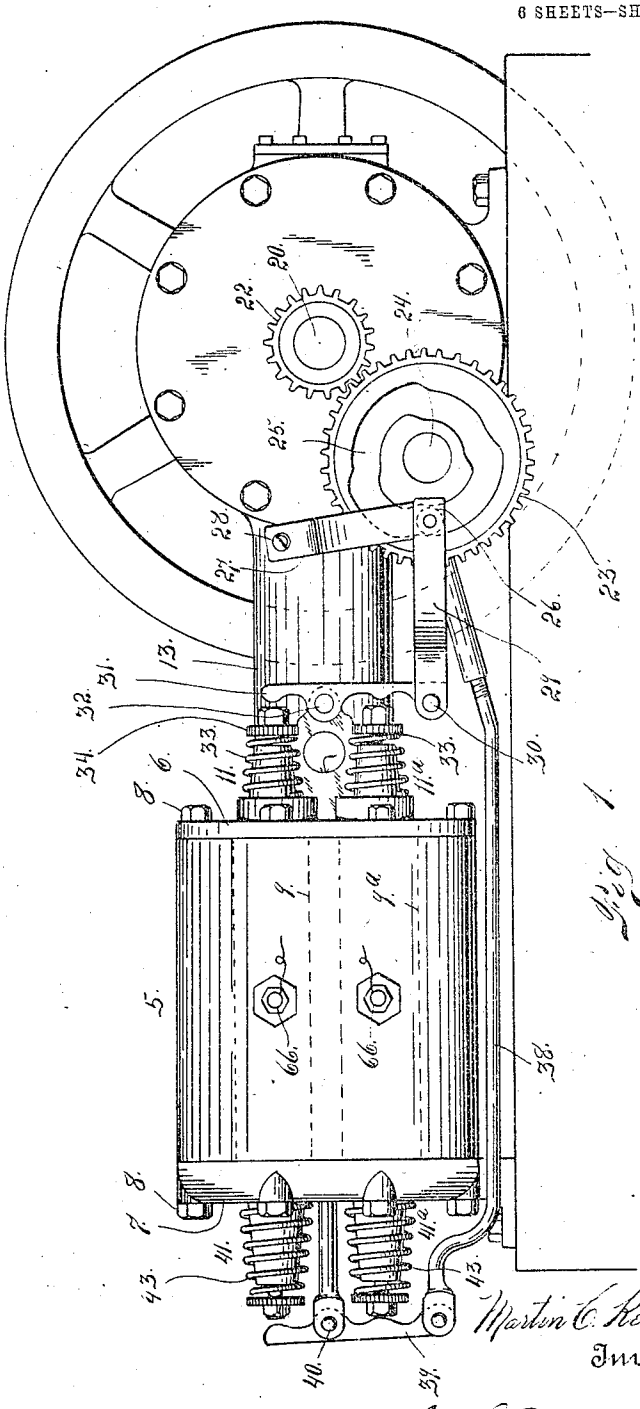

Fig. 1.

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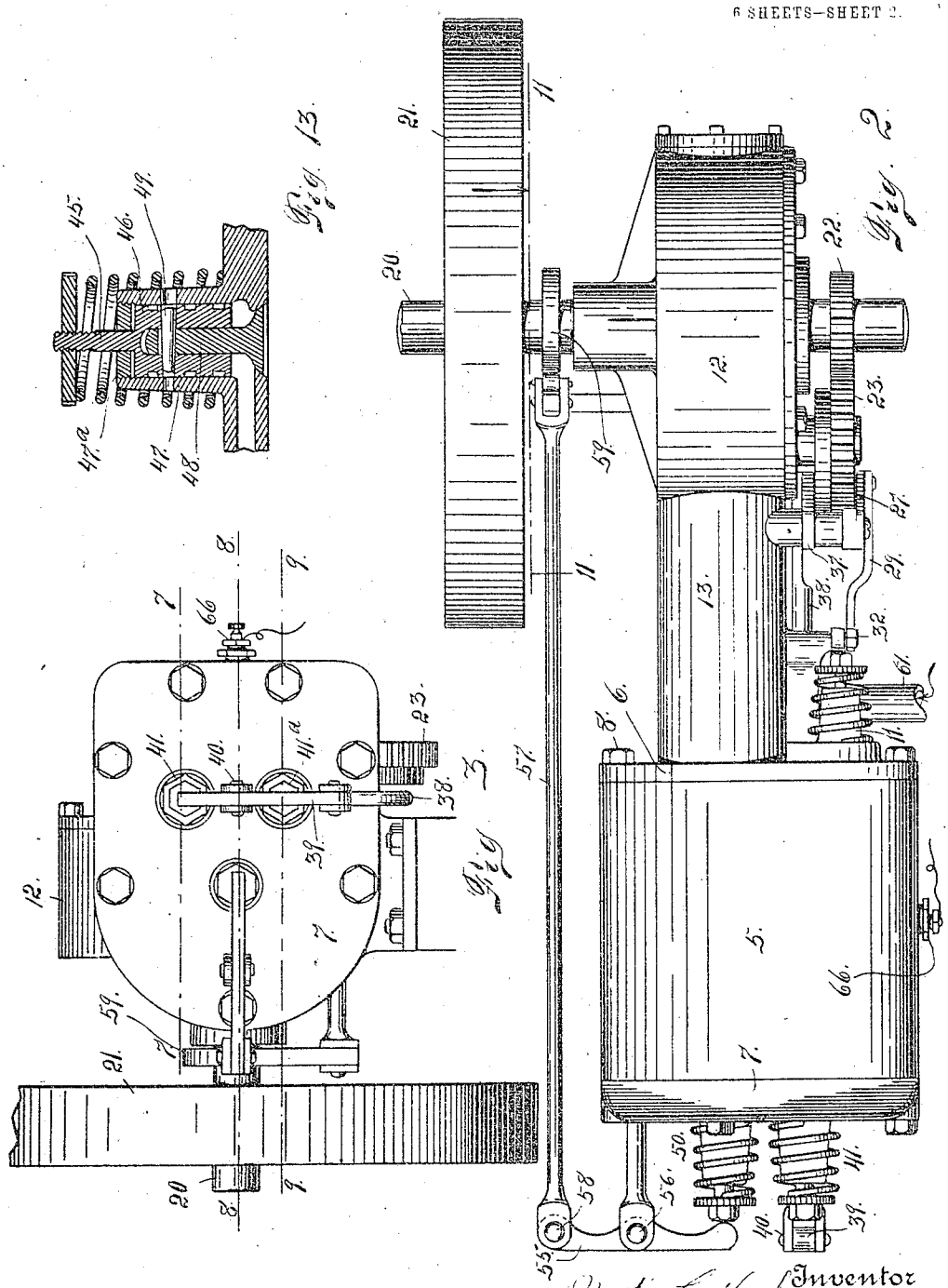

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6 SHEETS—SHEET 3.

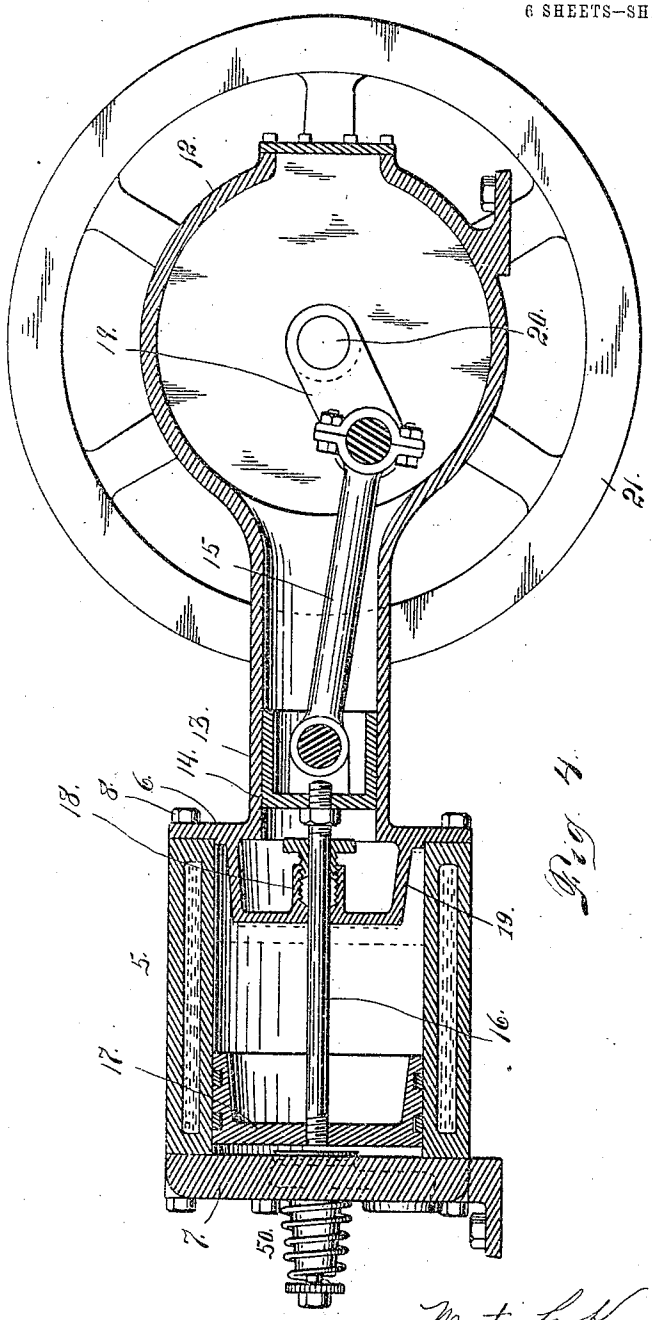

Fig. 4.

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6 SHEETS—SHEET 4.

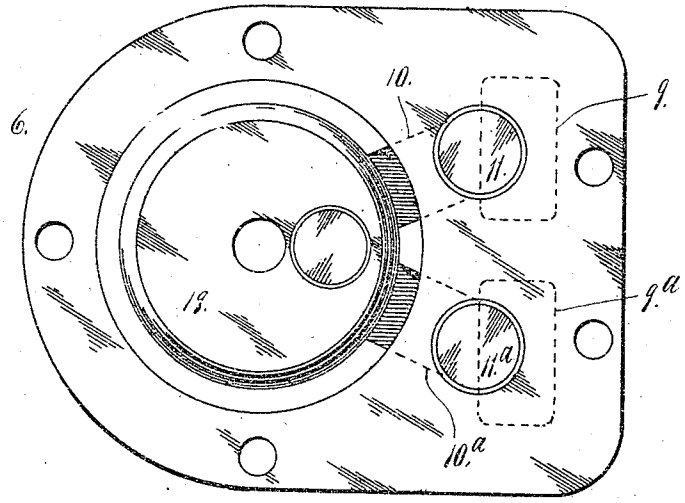

Fig. 5.

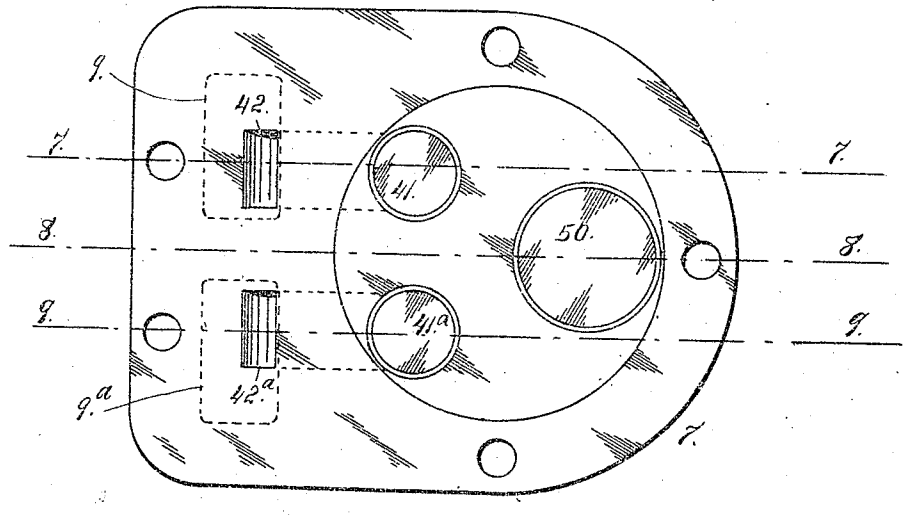

Fig. 6.

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6 SHEETS—SHEET 5

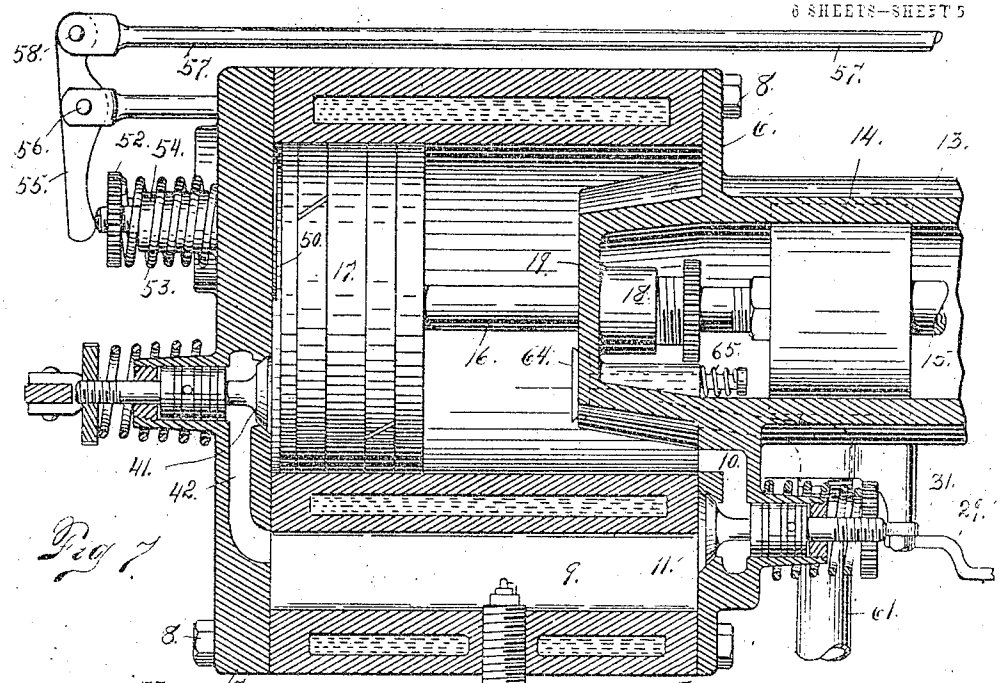

Fig 7.

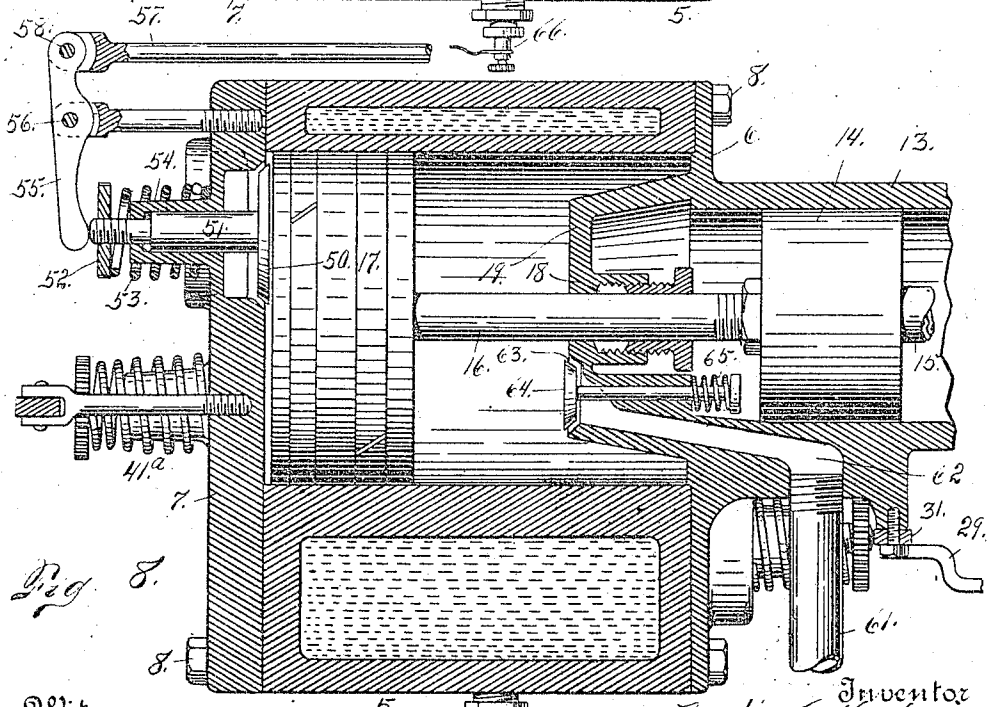

Fig 8.

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APPLICATION FILED SEPT. 24, 1904.

6 SHEETS—SHEET 6.

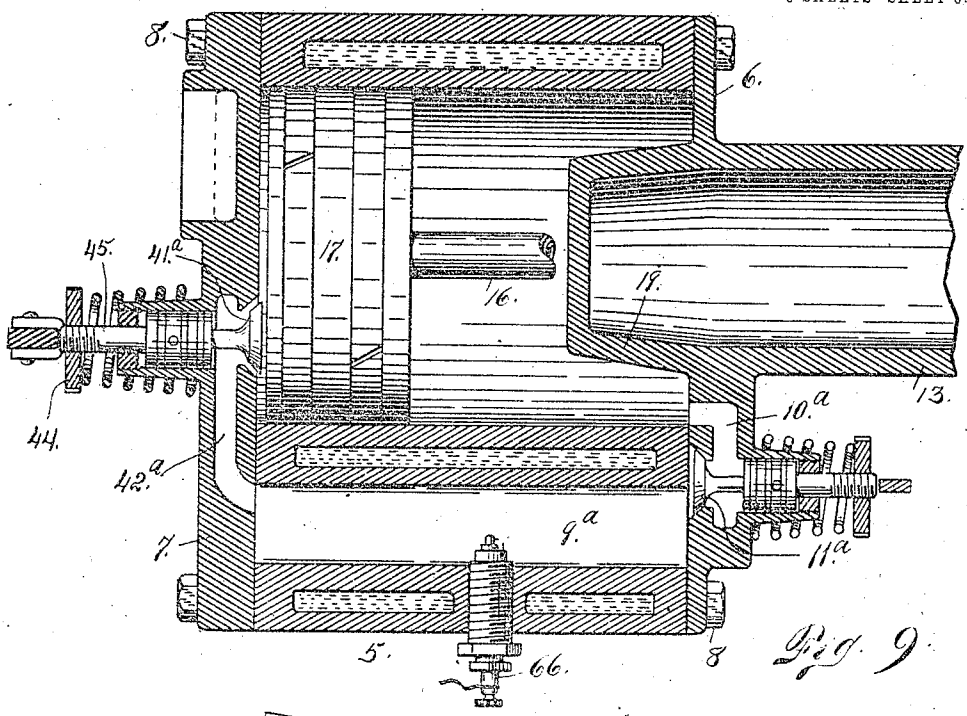

Fig. 9.

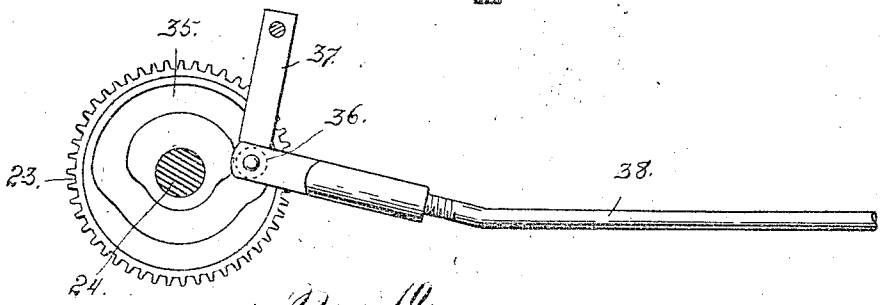

Fig. 10.

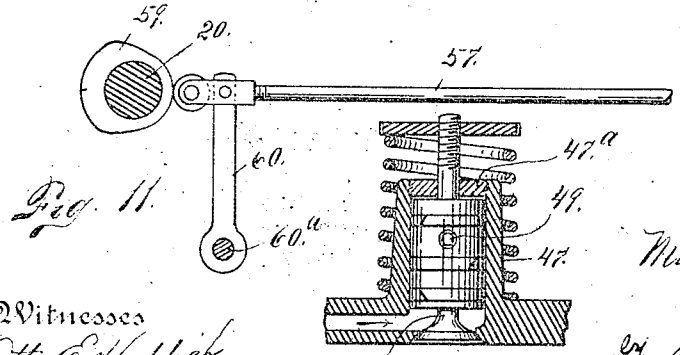

Fig. 11.

Fig. 12.

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UNITED STATES PATENT OFFICE.

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EXPLOSIVE-ENGINE.

No. 824,936. Specification of Letters Patent. Patented July 3, 1906.

Application filed September 24, 1904. Serial No. 225,774.

To all whom it may concern:

Be it known that I, MARTIN C. KESSLER, a citizen of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Explosive-Engines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the figures of reference marked thereon, which form a part of this specification.

My invention relates to improvements in explosive-engines, my object being to provide an apparatus of this class which shall be more efficient than those heretofore in use.

The distinguishing feature of my invention consists in the employment of chambers located outside of the piston-chamber, in which chambers the gas or explosive mixture is compressed during the movement of the cylinder-piston in one direction. In my improved construction a single cylinder is employed, and there are two auxiliary chambers located adjacent the cylinder-chamber, the auxiliary chambers being alternately in communication with the cylinder-chamber. In my construction there is an explosion for each complete reciprocation of the piston. During the movement of the piston in one direction the gas or explosive mixture is compressed in one of the auxiliary chambers, the piston being driven in this direction by the force of an explosion which has taken place in the other auxiliary chamber. During the movement of the piston in the opposite direction the exhaust takes place—that is to say, the products of combustion are forced out of the cylinder-chamber by the piston through a valve-controlled exhaust-port, the exhaust-valve being mechanically opened at the proper time to permit this result. At or about the time the exhaust is completed an explosion takes place in the auxiliary chamber, where the gas was compressed by the first forward movement of the piston, again driving the piston forward and compressing the gas in the auxiliary chamber, in which the first explosion took place. Then during the next rearward stroke of the piston the exhaust again takes place and this operation is continued. It will thus be seen that as the gas is compressed entirely outside of the cylinder-chamber the piston is allowed to travel practically the entire length of the cylinder-chamber, since it is not necessary to leave any space between the piston and the cylinder-head for compressed gas, as in ordinary constructions. Moreover, the explosion may be so timed as to take place in either auxiliary chamber before the valve controlling the inlet from the auxiliary chamber to the cylinder-chamber has been opened, and the opening of the valve may be so timed as to allow the force of the explosion to act on the piston at any desired point of its stroke regardless of the exact time when the explosion takes place.

Having briefly outlined my improved construction, as well as the function it is intended to perform, I will proceed to describe the same in detail, reference being made to the accompanying drawings, in which is illustrated an embodiment thereof.

In the drawings, Figure 1 is a side elevation of an explosive-engine equipped with my improvements. Fig. 2 is a top plan view of the same. Fig. 3 is a rear end view of the machine. Fig. 4 is a central vertical section taken through the engine. Fig. 5 is an inside view of the front head of the cylinder. Fig. 6 is a similar view of the rear head. Figs. 7, 8, and 9 are sections taken on the lines 7 7, 8 8, and 9 9, respectively, of Figs. 3 and 6. Fig. 10 is an inside view of the cam-gear and the connections employed in operating the exit-valves of the auxiliary chambers. Fig. 11 is a section taken on the line 11 11, Fig. 2, looking in the direction of the arrow and illustrating the cam mechanism for operating the exhaust-valve of the cylinder. Figs. 12 and 13 are sectional views in detail, illustrating the valves for controlling the inlet and exit passages of the auxiliary chambers.

The same reference characters indicate the same parts in all the views.

Let the numeral 5 designate the cylinder provided with front and rear heads 6 and 7, the said heads being secured in place by suitable bolts 8. The material of the cylinder is reinforced on one side and in this reinforced portion are located two auxiliary chambers, (designated 9 and 9^a, respectively.) These chambers communicate with the cylinder-chamber by way of inlet-passages 10

and 10ª, and these passages are controlled by valves 11 and 11ª, which are alternately opened through the instrumentality of suitable mechanism to allow the compressed gas to pass first to one chamber and then to the other. The cylinder is provided with suitable water-jackets and is connected with a crank-chamber 12 by means of a tubular part 13, in which is located a cross-head 14, connected with a pitman 15 at one extremity and with a stem 16 of the cylinder-piston 17 at the opposite extremity. The piston-stem passes through a stuffing-box construction 18, which projects into the cylinder, and is supported by a part 19, which enters the hollow piston when the latter is at its forward limit of movement. The part 13 is connected with the forward head of the cylinder.

Within the crank-chamber 12 is located a crank 19, connected with a shaft 20, passing centrally through the said chamber. One extremity of this shaft is provided with a fly-wheel 21, while to the other extremity is attached a gear 22, meshing with a larger gear 23, fast on a spindle 24, mounted exteriorly on the crank-chamber. This gear 24 is provided on one side with a cam-groove 25, which is engaged by a projection 26, supported by a link 27, pivotally connected with the frame part 13, as shown at 28. Connected with the lower extremity of the link 27 is a rod 29, whose extremity remote from the link is pivotally connected with a lever 31, as shown at 30. This lever 31 is fulcrumed on the casing part 13, as shown at 32, and projects both above and below the fulcrum. When the rod 29 is moved in one direction, the lever 31 acts on the stem of the valve 11 to open the latter, while when the said rod moves in the opposite direction the lever acts on the stem of the valve 11ª to open the same. These valves are held normally closed by springs 33, which engage collars 34, fast on the valve-stems at one extremity, while the opposite extremities of the springs bear against the head of the cylinder. The springs therefore normally hold the valves in the closed position. When the valve 11 is open, the explosive mixture is forced by way of the passage 10 into the auxiliary chamber 9, while when the valve 11ª is open the explosive mixture is forced from the cylinder-chamber by way of the passage 10ª into the auxiliary chamber 9ª.

On the opposite side of the gear 23 is formed a cam-groove 35, in which is located a projection 36, supported by a link 37. With this projection is also connected a rod 38, which leads to a lever 39, fulcrumed at 40 and adapted to alternately act on valves 41 and 41ª, whereby passages 42 and 42ª may be opened and closed at will for the purpose of admitting gas from the chambers 9 and 9ª alternately to the piston-chamber. These valves are normally closed by coil-springs 43, whose outer extremities bear against stops 44 of the stems 45, while their inner extremities bear against the rear head of the cylinder. As shown in the drawings, (see Figs. 12 and 13,) each stem 45 is connected with a bushing 46, located within a chamber 47 and provided with packing to form a fluid-tight joint. The valve-stem proper, 48, enters an opening formed in the bushing and is connected with the bushing by a key 49, which passes through registering openings formed in the casing 47 and the bushing 46 and through a slot formed in the valve-stem proper, whereby the valve is allowed sufficient movement for purposes of automatic adjustment or to allow it to properly seat itself. As shown in the drawings, each casing 47 is provided at its outer extremity with a screw-plug 47ª, through which the stem 45 passes. Attention is called to the fact that this screw-plug is not necessary and may be dispensed with. It may be stated that the mechanism of the valves 11, 11ª, 41, and 41ª are all of the same construction.

The rear extremity of the cylinder is provided with an exhaust-port normally closed by a valve 50, provided with a stem 51, having a disk 52 at its outer extremity, the said disk being acted on by a coil-spring 53, surrounding the casing 54, through which the valve-stem passes. This exhaust-valve is opened through the instrumentality of a lever 55, fulcrumed at 56 and having one arm connected with a rod 57, as shown at 58. The extremity of this rod remote from the lever is engaged by a cam 59, fast on the shaft 20. The extremity of the rod adjacent the cam 59 is supported by a link 60, whose lower extremity is pivotally connected with the engine-frame, as shown at 60ª. Every time the shaft 20 makes a complete revolution or every time the cylinder-piston makes a complete reciprocation the exhaust-valve is opened to permit the products of combustion and gases to escape from the cylinder.

The explosive mixture is conducted to the cylinder-chamber by way of an inlet-pipe 61, a passage 62, and a port 63, controlled by a valve 64, whose stem is acted on by a coil-spring 65, which normally has a tendency to close the valve.

Each chamber 9 9ª is penetrated by an electrode 66, suitably located in an electrical circuit so arranged that whenever the circuit is closed a spark will be produced and the explosive mixture in the chamber ignited.

From the foregoing description the use and operation of my improved explosive-engine will be readily understood. Assuming that the piston 17 is at its rearward limit of movement and the cylinder-chamber has been filled with the explosive fluid mixture by the opening of the valve 64, which opens in re-

sponse to the suction produced by the rearward movement of the piston, during this movement of the piston the exhaust-valve has been opened through the instrumentality of the mechanism heretofore described, thus allowing the exhaust or the products of combustion and gases to pass through and out to the atmosphere. At or approximately at the time that the piston reaches its rearward limit of movement the valve 41 is opened through the instrumentality of the lever 39 and its connections, the cam-groove 35 being so regulated as to produce this result. Previously or approximately at the time the valve 41 opens a spark is produced in the chamber 9 through the instrumentality of its electrode 66, and the force of the explosion communicates with the cylinder-chamber by way of the passage 42 and the valve-controlled port. This explosion acts on the piston 17 to drive the latter forwardly or toward the right, referring to Figs. 1, 2, 4, 7, 8, and 9 of the drawings. As soon as the piston begins its forward movement the induction-valve 64 closes both through the action of its spring and the piston-pressure. At the same time the explosive mixture is driven from the chamber of the piston through a passage 10^a into the chamber 9^a, the valve 11^a being mechanically opened through the instrumentality of the lever 31 and its connections. As soon as the piston reaches its forward limit of movement it begins the return or rearward stroke, and the exhaust-valve 50 is mechanically opened through the mechanism heretofore described. During this rearward movement of the piston another charge of explosive mixture is drawn into the cylinder-chamber through the induction-pipe, passage, and port 61, 62, and 63, respectively. As soon or approximately as soon as the piston has reached its rearward limit of movement an explosion takes place in the auxiliary chamber 9^a through the instrumentality of the electrode 66, connected with the said chamber. This explosion communicates with the cylinder-chamber by way of a passage 42^a and the port controlled by the valve 41^a, the said valve being opened by the lever 39 and its connections. The force of the explosion drives the piston forward and forces the charge of explosive mixture in the cylinder-chamber into the chamber 9, and during its continued use the operation heretofore described is repeated.

Attention is called to the fact that the gear 23 contains twice as many cogs as the gear 22. Hence the cam-gear 23 only makes one revolution for two revolutions of the crank-shaft 20, and this is as it should be, since the exhaust-valve, which is directly controlled by a cam on the crank-shaft, must open during every revolution of the crank-shaft or complete reciprocation of the piston, while the valves 11, 11^a, 41, and 41^a are each only opened once during each two revolutions of the crank-shaft. In other words, assuming that when the piston has reached its rearward limit of movement the explosion takes place in the auxiliary chamber 9 and the valve 41 is opened to allow the explosive force to act on the piston, driving the latter forwardly, the valve 11^a will be opened to allow the explosive-mixture to enter the chamber 9^a. Then when the piston reaches its rearward limit of movement the next time an explosion will take place in the chamber 9^a, and the valve 41^a will be opened to allow the explosive force to act on the piston and drive it again forwardly, and during this forward movement the valve 11 will be again opened to allow the explosive mixture to enter the chamber 9.

The mechanism for controlling the valves 40 and 41^a is such that during the rearward stroke of the piston the chamber 9 or 9^a, in which the explosion has taken place, remains open to the cylinder to allow the products of combustion to exhaust as thoroughly as possible into the atmosphere.

In further explanation of the construction and arrangement of the valves 41 and 41^a attention is called to the fact that these valves are so constructed and arranged that while the explosive force in the auxiliary or explosion chamber communicates with the valve through a proper passage there is no tendency of this force to move the valve in either direction, since the valve is of balanced construction—that is to say, the inner surface of the bushing surrounding the valve-stem proper is exactly of the same surface area as the opposite surface of the valve, and the valve is so arranged that the explosive force acts simultaneously on these two opposing surfaces of equal area. Hence there is no tendency to open this valve. If it were not for this balanced construction of the valve, an exceedingly powerful spring would be required in order to prevent the valve from opening during the action of the explosive force thereon. It is not intended that the springs 43 are of sufficient strength to prevent the valves from opening. The only object of these springs is to hold the valves normally seated in the absence of fluid-controlling influence and prevent them from accidental movement. The normal condition of these valves is closed, and the springs 43 simply hold them in this position; but it is not supposed that they are of sufficient strength to resist the action of a high explosive force generated in the auxiliary chambers by the ignition of the explosive mixture therein. Hence the necessity for the balanced structure. This balanced feature is highly important in a mechanism of this class, since it is often necessary to ignite the explosive mixture in the auxiliary chambers considerably in advance of the opening of the valve to allow the explosive force to enter the cylinder-chamber. This condition is necessary when run-

ning the engine at high speed. In this case the explosive force may be ignited in the auxiliary chamber a full stroke in advance of the piston or when the piston is a full stroke from the extremity of the cylinder where the valve is located and where the explosive force is to commence its action thereon. In running the engine at lower speeds the ignition of the explosive mixture in the auxiliary chambers is regulated accordingly, the time of the ignition in advance of the piston's arrival at the extremity of the cylinder where the force is to begin action thereon gradually diminishing as the speed diminishes.

The necessity for the variation of the time of igniting the explosive force in the auxiliary chambers in advance of the piston makes it exceedingly important that the means for controlling the ignition in these chambers shall be entirely independent of the operation of the valve mechanism.

It may be further stated that the valves 11 and 11ª for controlling the entrance of the explosive mixture to the auxiliary chambers are also balanced and of the same construction as the valves 41 and 41ª, as heretofore explained. These valves 11 and 11ª are therefore opened by mechanical means, the compression of the fluid incident to the movement of the piston with the cylinder-chamber having no tendency to move the said valves in the one direction or the other. This makes it practicable to time the opening of the valves with the utmost accuracy, and therefore accurately maintain the proper relation between the opening of these valves and the opening of the valves 41 and 41ª.

In further explanation of the necessity for igniting the explosive mixture in the auxiliary chambers in advance of the piston it may be stated that it requires an appreciable time after ignition of the explosive mixture to generate the maximum explosive force, and when the engine is running at high speed this time is equal or approximately equal to the full time required for the piston to travel from one end of the cylinder to the other. It may also be stated that this time is only a small fraction of a second when the engine is running at a speed of two thousand revolutions per minute. In this event the time required for the piston to travel from one extremity of the cylinder to the other is approximately one sixty-sixth of a second.

It may be stated also that the valves 11, 11ª, 41, and 41ª of my improved engine are all arranged to open inwardly. Hence when the valves are seated the explosive force acting thereon from the auxiliary chambers or from the cylinder-chamber can have no opening action. These valves are therefore arranged when closed to resist the action of the explosive or other fluid force from both directions.

Having thus described my invention, what I claim is—

1. In an explosive-engine, the combination with a cylinder and piston, of two auxiliary chambers separated from the cylinder-chamber but in communication with both extremities of the latter by suitable passages, valves for controlling said passages, means for igniting the explosive mixture in the auxiliary chambers, and means for opening the valves to allow the explosive force to pass to the cylinder-chamber from one of the auxiliary chambers simultaneously with the passage of the explosive mixture from the cylinder-chamber to the other auxiliary chamber, the valves for admitting explosive force from the auxiliary chambers to the cylinder being independent of the means for regulating the ignition of the explosive mixture in the auxiliary chambers, whereby the time relation between the ignition of the gases in the auxiliary chambers and the admission of the explosive force therefrom to the cylinder may be varied at will.

2. An explosive-engine including a main cylinder and piston, two auxiliary chambers communicating at their opposite extremities with the opposite extremities of the cylinder, means for controlling said communication whereby the explosive mixture from the cylinder is admitted alternately to the auxiliary chambers, and the explosive force from the auxiliary chambers alternately to the cylinder, and means for igniting the explosive mixture in the auxiliary chambers, the arrangement of the igniting means and the means for admitting the explosive force to the cylinder being such that the time relation between the ignition of the mixture in the auxiliary chambers and the admission of the explosive force to the cylinder may be varied at will.

3. The combination in an explosive-engine with a cylinder and piston, of two auxiliary chambers each of which is in communication with both ends of the cylinder by suitable passages, valves for controlling said passages, means for igniting the explosive mixture in the auxiliary chambers at properly-timed intervals, and means for controlling the said valves so timed that while the explosive force is passing from one auxiliary chamber to the cylinder-chamber, the explosive mixture from the cylinder-chamber is being forced into the other auxiliary chamber by the piston, the valves controlling the admission of the explosive force to the cylinder being balanced whereby the explosive force in the auxiliary chambers has no influence thereon.

4. In an explosive-engine, the combination with a cylinder and piston, of two auxiliary chambers each of which is in communication with both ends of the cylinder by suitable passages, valves for controlling said passages,

means for igniting the explosive mixture in the auxiliary chambers at properly-timed intervals, and means for controlling the said valves so timed that while the explosive force is passing from one auxiliary chamber into the cylinder, the explosive mixture from the cylinder-chamber is being forced into the other auxiliary chamber by the piston, each of the valves controlling the admission of the explosive force to the cylinder, having two opposing surfaces of equal area, exposed to the explosive force of an auxiliary chamber, when the valve is closed whereby the said force has no tendency to move the valve in either direction.

5. In an explosive-engine, the combination with a suitable cylinder and piston, of an exhaust-valve connected with the cylinder, an induction-valve connected with the cylinder, the induction-valve being opened by suction during the rearward movement of the piston, two auxiliary chambers adapted to hold the explosive mixture, means for igniting the explosive mixture in the auxiliary chambers at properly-timed intervals, the auxiliary chambers being connected with both ends of the cylinder-chambers by suitable passages, valves for controlling said passages, means for opening the exhaust-valve to allow the exhaust to escape during the rearward movement of the piston, and means for operating the valves controlling the passages between the auxiliary chambers and cylinder-chamber, the operation of the said valves being so timed that while the explosive force is passing from one auxiliary chamber to one end of the cylinder, the explosive mixture is being forced out of the other end of the cylinder into the other auxiliary chamber, the explosions occurring alternately in the two auxiliary chambers, the valves for controlling the admission of the explosive force to the cylinder being balanced whereby the explosive force has no influence thereon when closed.

6. In an explosive-engine, the combination of a cylinder, a piston therein, a crank-chamber, a crank-shaft passing therethrough, a pitman connecting the crank of the shaft with the stem of the piston, auxiliary chambers located in suitable proximity to the cylinder-chamber and communicating with both ends thereof by inlet and exit passages, two valves connected with one head of the cylinder for controlling the inlet-passages to the auxiliary chambers, two valves mounted on the opposite head of the cylinder for controlling the exit-passages from the auxiliary chambers, an operating-lever mounted adjacent each pair of valves, the lever-fulcrum being between the individual valves of each pair, and suitable mechanism actuated from the crank-shaft for alternately operating the valves of each pair, the operation of the valves being so timed that when the exit-valve of either auxiliary chamber is open, the inlet-valve of the other auxiliary chamber is open.

7. In an explosive-engine, the combination of a cylinder, a piston therein, a crank-chamber, a crank-shaft therein, a suitable connection between the piston and the crank-shaft, the cylinder being provided with suitable inlet and exhaust passages, the said passages being both open during the rearward movement of the piston and both closed during the forward movement thereof, two auxiliary chambers located in suitable proximity to the cylinder, each auxiliary chamber having a passage leading from each of its extremities to the corresponding extremities of the cylinder, one of these passages for each auxiliary chamber being an inlet-passage and the other passage being an outlet-passage, normally-closed valves mounted at one end of the auxiliary chambers to control the inlet-passages to said chambers, and valves located at the opposite extremities of the auxiliary chambers for controlling the exit-passages, a lever for controlling each pair of valves, a cam-gear actuated from the crank-shaft, and suitable connections between the cam-gear and the valve-operating levers whereby the inlet-valve of either auxiliary chamber and the exit-valve of the other auxiliary chamber are open at the same time, the other two valves in the meantime remaining closed.

8. In an explosive-engine, the combination with the main chamber and piston, of a plurality of auxiliary chambers, means for compressing the explosive mixture in the auxiliary chambers, means for controlling the ignition of the said fluid within the said chambers, the auxiliary chambers being connected with the piston-chamber by suitable passages, and valves for controlling said passages whereby the explosive force is allowed to enter the piston-chamber from the auxiliary chambers at proper intervals, the said valves being independent of the means for controlling the ignition of the explosive mixture in the auxiliary chambers.

9. In an explosive-engine, the combination with the main chamber and piston, of a plurality of explosion-chambers communicating with the main chamber by valve-controlled passages, means for supplying the explosion-chambers with an explosive mixture, means for igniting the explosive mixture within the said chambers, means for admitting the explosive force to the main chamber from the several explosion-chambers successively and at proper intervals to impart the reciprocating movement to the piston, the means for admitting the explosive force from the explosion-chambers to the main chamber, being controlled independently of the means for igniting the explosive force in the explosion-chambers whereby the time

relation between the said ignition and admission events may be varied at will.

10. In an explosive-engine, the combination of a cylinder, a piston therein, auxiliary chambers located in suitable proximity to the cylinder-chamber and communicating with both ends thereof by inlet and exit passages, two valves for controlling the inlet-passages to the auxiliary chambers, two valves for controlling the exit-passages from the auxiliary chambers, and suitable mechanism actuated from the crank-shaft for alternately operating the valves of each pair, the operation of the valves being so timed that when the exit-valve of either auxiliary chamber is opened, the inlet-valve of the other auxiliary chamber is opened.

In testimony whereof I affix my signature in presence of two witnesses.

MARTIN C. KESSLER.

Witnesses:
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W. J. LA TOURRETTE.