No. 875,938. PATENTED JAN. 7, 1908.

C. T. LITCHFIELD.

GAS ENGINE.

APPLICATION FILED MAY 14, 1906.

3 SHEETS—SHEET 1.

Fig. 1.

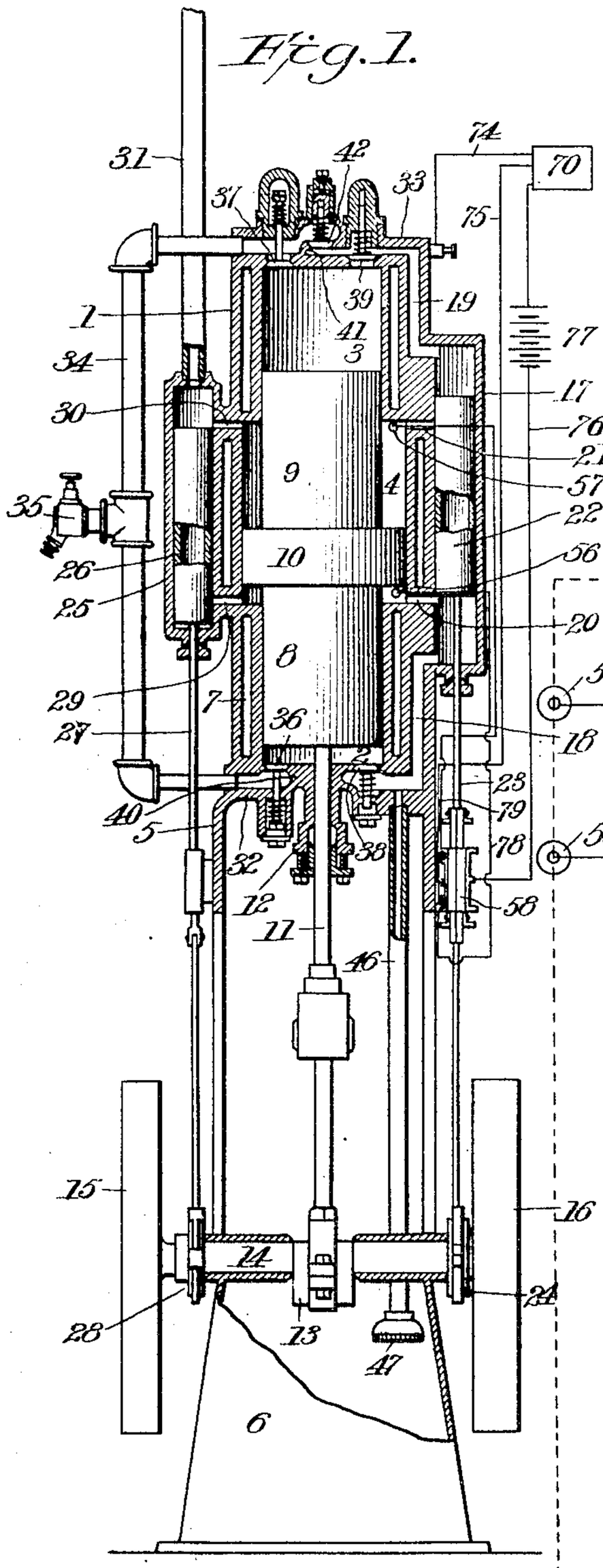


Fig. 2.

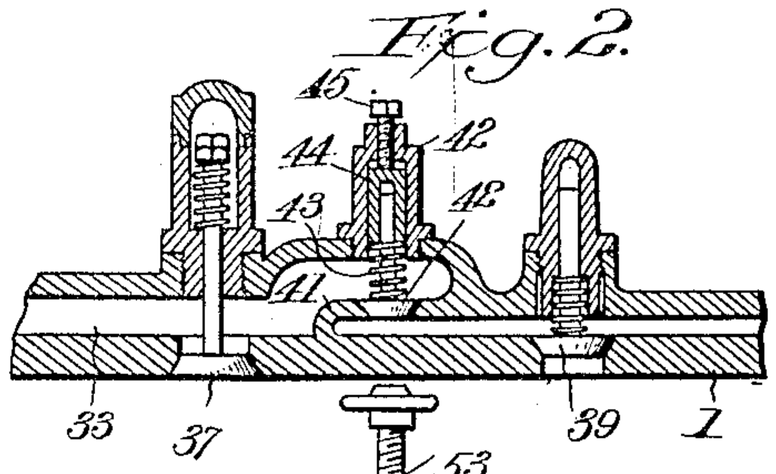
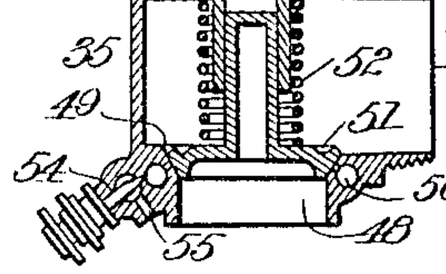


Fig. 3.



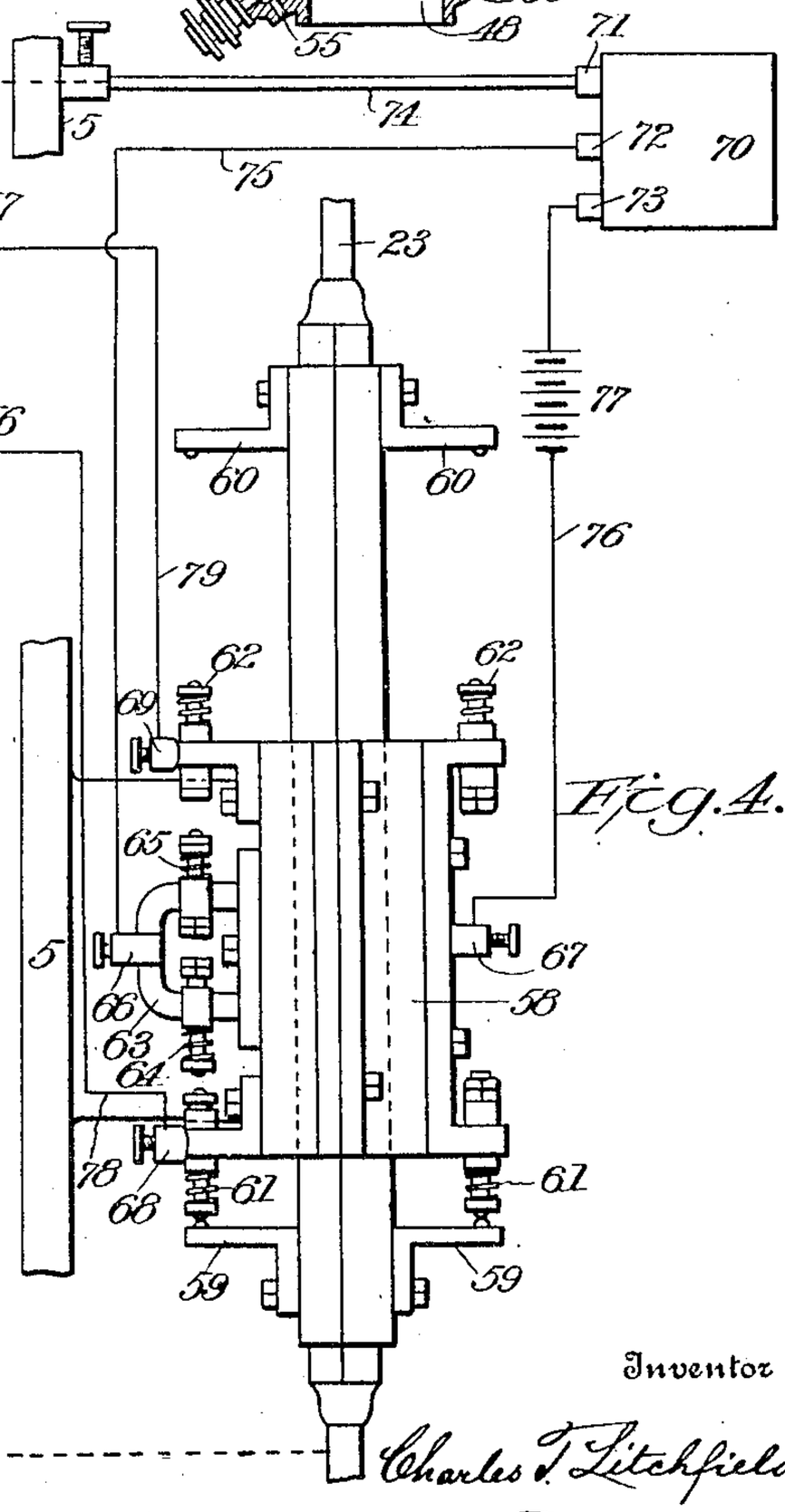


Fig. 4.

Witnesses

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3 SHEETS—SHEET 2.

Fig. 7.

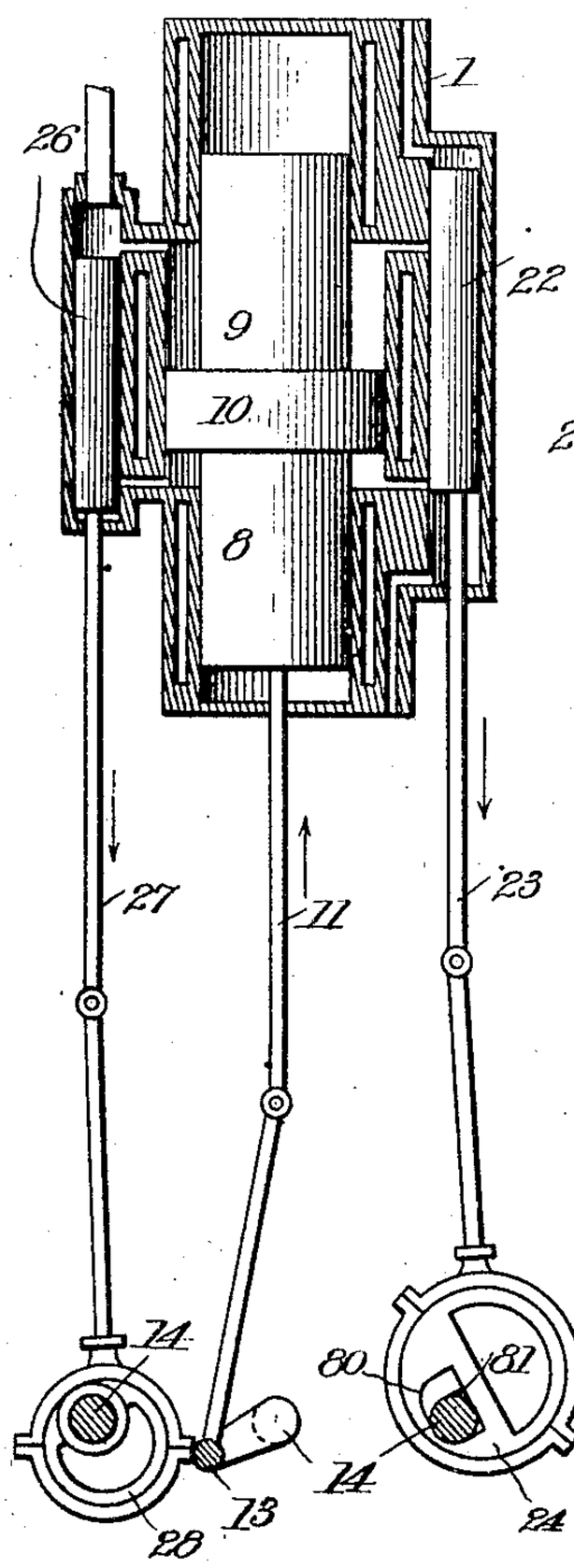


Fig. 6.

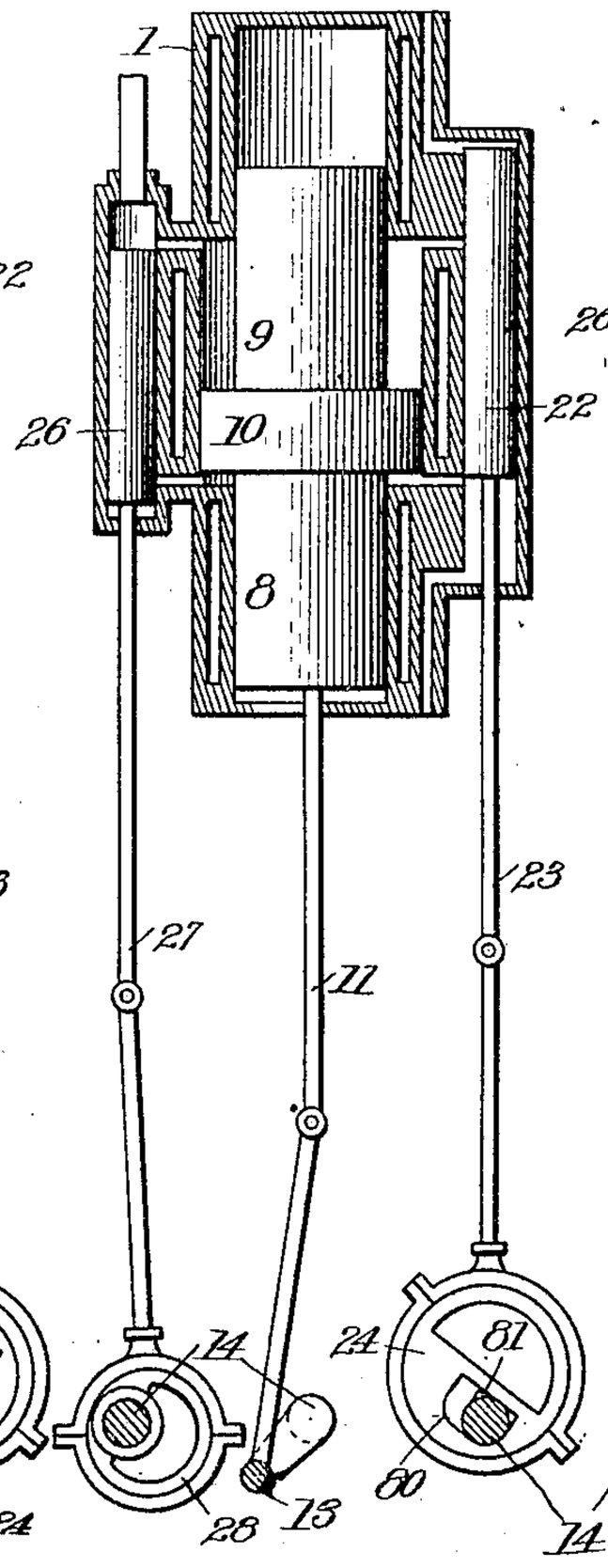
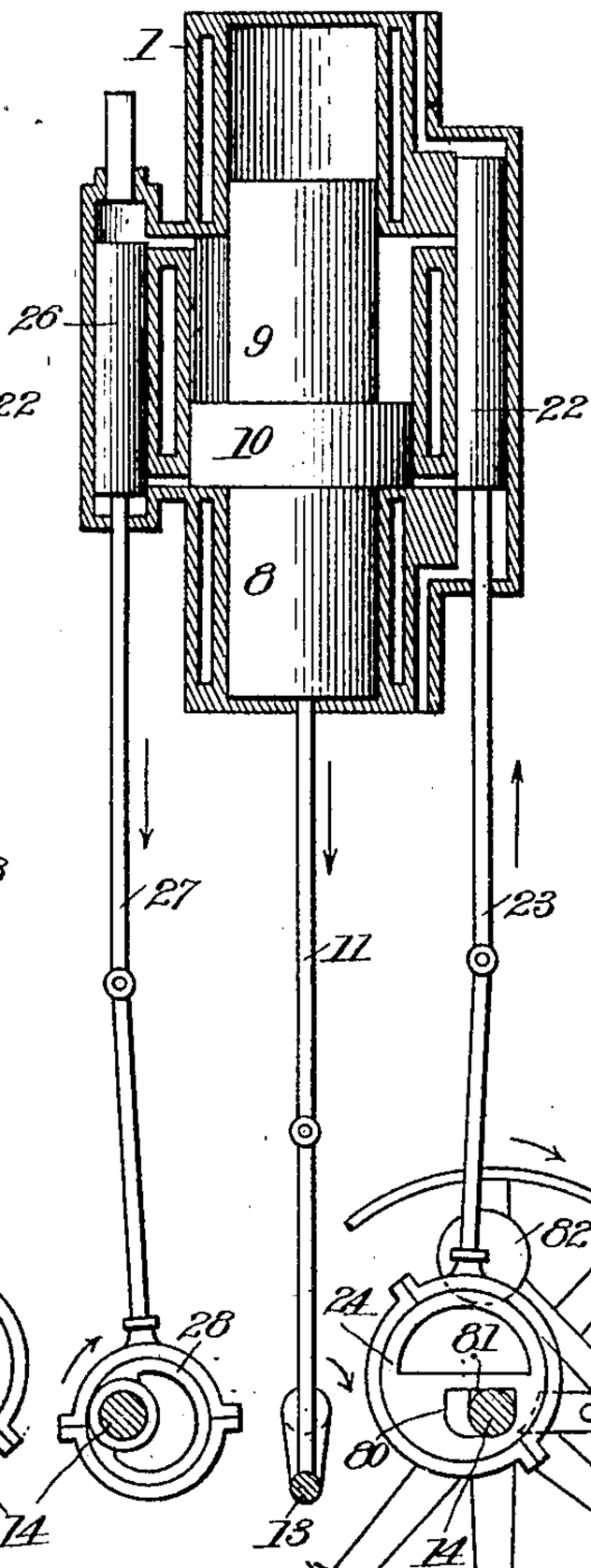


Fig. 5



Witnesses

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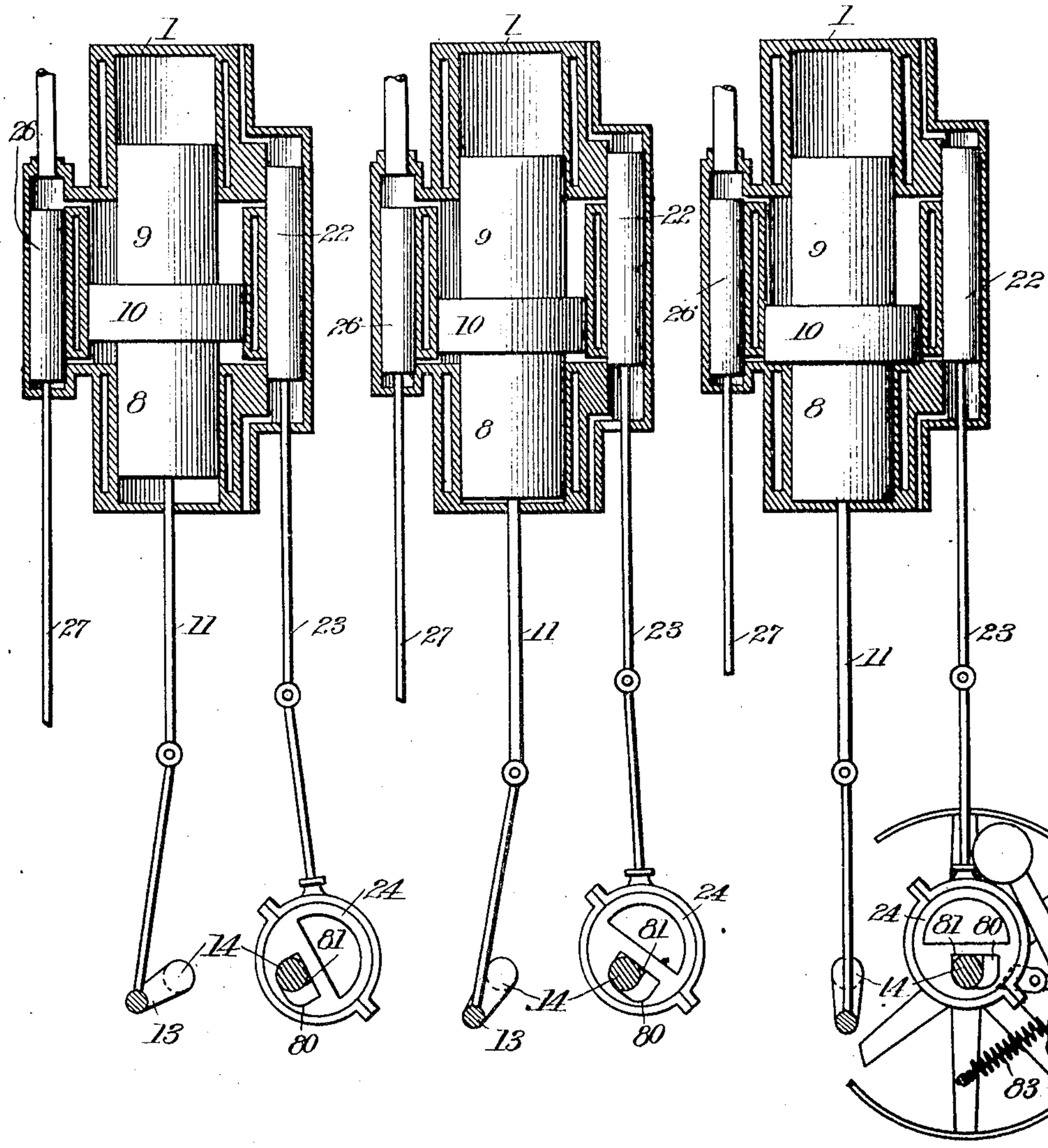
3 SHEETS—SHEET 3.

Fig. 10. Fig. 9. Fig. 8.



Witnesses

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UNITED STATES PATENT OFFICE.

CHARLES T. LITCHFIELD, OF SPOKANE, WASHINGTON, ASSIGNOR TO MONO-CYCLE GAS ENGINE AND MANUFACTURING COMPANY, OF SPOKANE, WASHINGTON, A CORPORATION OF WASHINGTON.

GAS-ENGINE.

No. 875,938. Specification of Letters Patent. Patented Jan. 7, 1908.

Application filed May 14, 1906. Serial No. 316,804.

To all whom it may concern:

Be it known that I, CHARLES T. LITCHFIELD, a citizen of the United States, residing at Spokane, in the county of Spokane and State of Washington, have invented a certain new and useful Improvement in Gas-Engines, of which the following is a full, clear, and exact description.

This invention relates to explosive gas engines.

A three-part cylinder, connected with a reservoir, contains a three-part piston, by which the motive agent is compressed and utilized as power, under control of inlet and exhaust valves; and provision is made for automatically regulating the pressure of the motive agent, all as I will proceed now more particularly to set forth and finally claim.

In the accompanying drawings, illustrating the invention, in the several figures of which like parts are similarly designated, Figure 1 is an elevation and partial longitudinal section. Fig. 2 is a cross-section of part of the upper cylinder head, showing particularly the by-pass pressure regulating valve. Fig. 3 is a longitudinal section of the mixer. Fig. 4 is an elevation illustrating the sparking mechanism. Figs. 5, 6, 7, 8, 9 and 10 are sectional diagrams illustrating the operation hereinafter explained in detail.

1 is a cylinder, having at opposite ends chambers 2 and 3 of the same diameter, and constituting compression chambers, and between them is a chamber 4 of larger diameter than the end chambers and constituting an explosion or power chamber. The cylinder is mounted upon a frame 5 which is erected upon a reservoir 6, and preferably is provided with a water-jacket 7. The piston is, like the cylinder, of three integral parts 8, 9 and 10 adapted to work respectively in the chambers 2, 3 and 4 of the cylinder, the parts 8 and 9 being of slightly greater length than the chambers 2 and 3 of the cylinder which they fit, and their ends solid to fit close up to the cylinder heads and the part 10 being of considerably less length than the part of the cylinder within which it works and its working faces being solid to fit close up to its cylinder heads. The piston has a piston rod 11 which enters the cylinder through a suitable stuffing box 12, and is connected with a crank 13 on the main shaft 14 which is mounted in the frame 5 above the reservoir 6 and is supplied with a fly wheel 15 and a band wheel 16.

17 is an inlet valve casing arranged at one side of the cylinder and communicating with the opposite ends of the cylinder by means of channels 18 and 19, and with opposite ends of the larger portion of the cylinder by means of ports 20 and 21 and containing a hollow inlet valve 22 connected by a valve rod 23 with an eccentric 24 on the shaft 14. Channels 18 and 19 communicate through hollow valve 22.

25 is a valve casing arranged on the opposite side of the cylinder and containing a hollow exhaust valve 26 connected by a rod 27 with the eccentric 28 on shaft 14. This casing 25 opens into opposite ends of the larger part of the cylinder 1 through ports 29 and 30 and has an exhaust pipe 31 with which these ports communicate through valve 26.

The channel 18 opens into the hollow head 32 at the lower end of the cylinder, and the channel 19 opens into the hollow head 33 at the top of the cylinder, and these hollow heads are connected by a pipe 34 having the mixer 35 through which the supply of gas enters.

36 and 37 are the suction valves and 38 and 39 are the discharge valves, a suction valve and a discharge valve being in each head of the cylinder. The valves 36 and 38 are separated by a solid portion 40 through which the piston rod 11 passes, while the valves 37 and 39 are separated by a diaphragm 41 in which is a by-pass valve 42. The several suction valves and discharge valves are here shown and may be of the ordinary spring check-valve variety. The by-pass valve 42 is also of spring check-valve form, but, as shown more in detail in Fig. 2, its spring 43 is surmounted by a cap 44 and the pressure is regulated by a set-screw 45, so that this by-pass valve may be adjusted to operate at any desired degree of pressure. The chamber 2 in the cylinder is connected by a pipe 46 through the hollow head 32 with the reservoir 6, and the lower end of this pipe is provided with a gauze screen 47 to prevent any flames from leaking back into the reservoir.

The mixer 35 comprises a casing adapted

to be coupled to the pipe 34 and having an air inlet 48 in which is a valve-seat 49 surrounded by a channel 50 opening into the valve-seat.

51 is a check-valve normally seated in the seat by a spring 52, the extent of opening of said check-valve being regulated by a set-screw 53.

54 is a needle-valve controlling a port opening into channel 50, and 55 is a nipple to which is connected the pipe leading from the supply of liquid fuel. At each suction stroke of the engine, the valve 51 is lifted and air drawn in through the inlet 48 together with a portion of atomized liquid fuel, the two being mixed, and the quantity of liquid fuel being regulated by the adjustment of the needle-valve 54. This construction of the mixer is not original with this invention and while it is preferred, the invention is not limited to its use.

The sparking devices are located within the larger chamber 4 of the cylinder and indicated conventionally at 56 and 57. The sparking circuit apparatus is shown in detail in Fig. 4, and comprises these features:—58 is a box or bearing for the rod 23, and for convenience the rod may be squared for the length of its travel in the bearing 58. This rod is supplied on opposite sides of the bearing with a pair of contacts 59 and 60, and the bearing is provided with complemental pairs of spring contacts 61 and 62. Between one of the pairs of contacts 61 and 62, and on the bearing, is a stand 63 containing the contacts 64 and 65, and a binding post 66. On the other side of the bearing is a binding post 67. The binding posts 68 and 69 are arranged adjacent one of the pairs of contacts 61 and 62. 70 is a sparking coil and condenser, having primary and secondary negative poles 71, a secondary positive pole 72, and a primary positive pole 73. From the poles 71 wires 74 lead to the engine frame 5, and from the secondary positive pole 72 a wire 75 leads to the binding post 66 and from the pole 73 a wire 76 leads to a battery 77, and thence to the binding post 67. A wire 78 leads from the binding post 68 to the sparking device 56, and a wire 79 leads from the binding post 69 to the sparking device 57. As the rod 23 is reciprocated, its contact elements 59 and 60 make contact with the contacts 61 and 62, respectively, and thus make and break the circuit, and successively ignite the charges on opposite sides of the piston member 10.

Referring now to the diagrams Figs. 5 to 10 inclusive, the eccentric 24, instead of having a head with a bore fitting on shaft 14 and fastened thereto, has a slot 80 whose upper corners are square, and the lower corners round, and at the point where the shaft 14 passes through this slot in the eccentric said shaft is made with a flat portion 81 equal in length to the thickness of the eccentric, and this flat portion acts as a guide to drive the eccentric while allowing the eccentric to travel across the axis of the shaft for the purpose of decreasing the throw of the eccentric. Fig. 5 shows the eccentric at full throw, and Fig. 6 shows it at minimum throw. Motion across the axis of the shaft to control the throw of the eccentric is imparted to the eccentric by a governor comprising a weighted lever 82 operated in one direction by centrifugal force, and operated in the other direction by a spring 83, at a time when the speed of the engine decreases, the spring at that time being of sufficient strength to overcome the centrifugal force of the weight. The first supply of fuel is pumped in by turning over the wheel by hand a sufficient number of times, the gas entering the channels of the heads of the cylinder alternately and passing into the cylinder through the valves 36 and 37 and being compressed in the chambers 2 and 3 of the cylinder and discharged through the ports covered by the valves 38 and 39, and passing by pipe 46 into the reservoir 6. The valve 42 is set to resist a given pressure, and when that pressure is exceeded, as it will be in the operation of the engine, the valve automatically opens and allows a free circulation of the gas through the channels between valves 37 and 39 until a normal pressure is restored. A quantity of compressed gas is admitted to the cylinder on opposite sides of the piston member 10 by means of the valve 22, and the supply is cut off at the proper time by the same valve. The stroke of the valve, and, consequently, the length of time the valve uncovers the admission port is regulated by the action of the governor. The uniform initial pressure is obtained from the reservoir and passages which are stored with compressed gases. The piston members 8 and 9 always draw in and compress a given quantity of gas, but the piston member 10 does not always receive a like quantity behind it owing to the action of the governor, and consequently, there would be sometimes during the operation of the engine an over-supply and the pressure would gradually increase. This difficulty is obviated by the by-pass pressure regulating valve 42.

The area of the solid end of each of the piston members 8 and 9 is equal to the annular area of the piston member 10. If, therefore, the gas compressed in front of the piston member 9 were immediately admitted into the annular space in front of the piston member 10 when said piston has completed a quarter of its stroke it would fill the annular space at the same pressure as it left the chamber of piston member 9. A quar-

ter stroke of piston member 10 is the maximum portion of stroke allowed for charging the chamber 4 with compressed gas. During this period of the stroke the pressure due to compression by the piston members 8 and 9 drives the piston member 10 forward until the valve 22 cuts off the supply by closing the port. The charge is then ignited by the described sparking mechanism or other equivalent or substitute means, and the piston member 10 is forced through the balance of its stroke by expansion due to the combustion of compressed gases. The length of admission portion of stroke is varied by the governor in its variation of the throw of the eccentric, and consequently, the travel of the valve 22 is correspondingly varied. During the quarter stroke, the chamber 4 becomes a combustion chamber, whose capacity is varied as the point of cut-off varies, but it is always in relatively the same proportion as the quantity of gas admitted.

The reservoir and channels must be filled with compressed gas at the required pressure before the initial movement or starting of the engine, and this can be effected by blocking out the weight in the governor so as to close the admission port by valve 22, as shown in Fig. 8, and turning the engine by hand, whereupon the piston members 8 and 9 will draw in and compress the gas to requisite pressure. The governor is then restored to its normal state, and the engine turned over center, and the battery thrown into operation.

As the valve through the action of the governor determines the duration of admission of gas and the closing of the port, so does it vary the point of time at which the gas is ignited, and this should be at the same time the port is closed, and this is earlier or later in the stroke of the piston in accordance with the variation of the point of cut-off. The charge is ignited when the valve and piston are in the position shown in Fig. 7, and under heavy load.

Fig. 5 shows the eccentric at full throw, and Fig. 6 shows the eccentric at minimum throw. Motion across the axis of the crank shaft to control the throw of the eccentric, is imparted to the eccentric by the weighted lever 82 of the governor in one direction owing to centrifugal force, and by the pull of the spring 83 in the other direction. In Fig. 5 the crank is on the forward center and the piston is at the end of the forward stroke, and the valve 22 is just ready to uncover the admission port. In Fig. 6 the crank is advanced a portion of its revolution, and the piston is moved a corresponding distance on its return stroke, and the valve has uncovered the admission port. In Fig. 7 the crank is still further advanced, and the piston continued in its forward movement before the valve has again covered or closed the admission port, the charge having been admitted. The igniting device then becomes operative and the charge is exploded, with the result of the piston being driven forward a complete stroke, and the working faces of the piston being closed or solid and fitting close up to the cylinder heads there is little or no clearance left between the working faces of the piston and the cylinder heads, and hence the cylinders are practically completely exhausted, and on the return stroke of the piston after each explosion, the burned gases or products of combustion in the combustion chambers are practically all expelled from the cylinder, and the initial movement of the piston on the working stroke draws in, or rather receives by pressure a fresh mixture of gases, not weakened by mixture with burned gases remaining in the combustion chamber, thus obtaining a completely renewed charge for the combustion chamber and getting more power from the explosion of the charge.

Figs. 8, 9 and 10 show the piston and the valve at the same periods of stroke as Figs. 5, 6 and 7; when the eccentric is at its minimum throw, and at this time there is no admission of gas, because the valve does not uncover the admission port, and the piston, therefore, having no charge upon it, acts as a brake by causing a so-called vacuum to be formed in the cylinder behind it, thereby retarding the motion of the piston until the exhaust port is uncovered, and when that takes place the cycle of movements is repeated.

Further description of the sparking mechanism and the action of the admission and exhaust valves and of the three part piston, is believed to be unnecessary in view of the graphic showing of the cycle of movements in Figs. 5 to 10.

As already indicated, the invention is not limited to the use of the particular mixer or the particular sparking or igniting mechanism, or to the governor, and it is also to be understood that other variations are within the principle of the invention.

What I claim is:—

1. A gas engine, having a three-part cylinder, the center portion being of larger diameter than the ends and constituting the explosion chamber, and the end portions of less diameter and serving as compression chambers, a three-part piston arranged in said cylinder, the ends of said piston being of substantially the length of the ends of the cylinder and the intermediate portion being of less length than the portion of the cylinder with larger diameter, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid

clearance and thereby completely exhaust the cylinders, said compression chambers provided with admission and discharge ports, an admission valve and an exhaust valve for the explosion chamber upon opposite sides of the piston, a piston rod, a shaft to which said piston rod is connected, and connections between the admission and exhaust valves and said shaft.

2. A gas engine, comprising a cylinder having ends of one diameter constituting compression chambers, and an intermediate portion of larger diameter constituting the explosion chamber, a piston whose ends are of substantially the internal area of the ends of the cylinder and the intermediate portion being of less length than the explosion chamber, suction and discharge valves in the ends of the compression chambers, a reservoir connected with the cylinder, a gas supply connected with the ends of the compression chambers, whereby the reciprocation of the piston serves to draw in gas into the compression chambers to compress it and discharge it into the reservoir, and an admission valve and an exhaust valve together controlling the supply of compressed gas to the explosion chamber of the cylinder and its piston for operating the engine.

3. A gas engine; comprising a cylinder having ends of one diameter constituting compression chambers, and an intermediate portion of larger diameter constituting the explosion chamber, a piston whose ends are of substantially the internal area of the compression ends of the cylinder and the intermediate portion being of less length than the explosion chamber, suction and discharge valves in the outer ends of the compression chambers, a reservoir connected with the compression chambers, a gas supply connected with the outer ends of the compression chambers, whereby the reciprocation of the piston serves to draw in gas into the compression chambers, compress it and discharge it into the reservoir, an admission and an exhaust valve controlling the supply of compressed gas to the intermediate explosion chamber upon opposite sides of the piston for operating the engine, and a by-pass valve for automatically regulating the pressure.

4. A gas engine, comprising a cylinder having ends of one diameter constituting compression chambers, and an intermediate portion of larger diameter constituting the explosion chamber, a piston whose ends are of substantially the internal area of the ends of the cylinder and the intermediate portion being of less length than the explosion chamber, suction and discharge valves in the ends of the compression chambers, a reservoir connected with the cylinder, a gas supply connected with the ends of the compression chambers, whereby the reciprocation of the piston serves to draw in gas into the compression chambers, compress it and discharge it into the reservoir, an admission valve and an exhaust valve controlling the supply of compressed gas to the intermediate explosion chamber upon opposite sides of the piston for operating the engine, and a by-pass valve interposed between the suction and discharge valves for automatically regulating the pressure of the gas supply.

5. A gas engine, having a three-part cylinder, the ends of which are supplied with suction and discharge valves and serve as gas compressing chambers, and the intermediate portion of which serves as the explosion chamber, a three-part piston arranged in said cylinder, the opposite ends of which serve as compressing pistons, and the intermediate portion of which serves as a power piston, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, a valve for admitting the compressed gas to the explosion chamber upon opposite sides of the piston, a shaft with which the piston and the valve are connected, an eccentric interposed between the valve connection and the shaft, and a governor for controlling the position of the eccentric.

6. A gas engine, having a three-part cylinder, the ends of which are supplied with suction and discharge valves and serve as gas compressing chambers, and the intermediate portion of which serves as the explosion chamber, a three-part piston arranged in said cylinder, the opposite ends of which serve as compressing pistons, and the intermediate portion of which serves as a power piston, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, a valve for admitting the compressed gas to the explosion chamber upon opposite sides of the piston, a shaft with which the piston and the valve are connected, a shifting eccentric interposed between the valve connection and the shaft, and a governor for controlling the position of the shifting eccentric.

7. A gas engine, having a three-part cylinder, the ends of which are supplied with suction and discharge valves and serve as gas compressing chambers, and the intermediate portion of which serves as the explosion chamber, a three-part piston arranged in said cylinder, the opposite ends of which serve as compressing pistons, and the intermediate portion of which serves as a power piston, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance to thereby

completely exhaust the cylinders, a valve for admitting the compressed gas to the explosion chamber upon opposite sides of the piston, a shaft with which the piston and the valve are connected, an eccentric interposed between the valve connection and the shaft, a governor for controlling the position of the eccentric, and a sparking mechanism actuated by the valve rod.

8. A gas engine, comprising a three-part cylinder, having ends of a common diameter constituting compression chambers, means to admit mixed air and gas into said compression chambers, channels leading from the ends through the cylinder, a reservoir connected with said channels, said cylinder also having an intermediate portion of larger diameter than its ends and constituting an explosion chamber, a reciprocating three-part piston having its ends arranged in the ends of the cylinder and serving as compressing pistons, and an intermediate portion arranged in the explosion chamber, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, an admission valve interposed in the said channels and controlling the admission of compressed gas into the explosion chamber upon opposite sides of the piston, and an exhaust valve for said explosion chamber.

9. A gas engine, comprising a three-part cylinder having ends of a common diameter constituting compression chambers, means to admit mixed air and gas into said compression chambers, channels leading from the ends through the cylinder, a reservoir connected with said channels, said cylinder also having an intermediate portion of larger diameter than its ends and constituting an explosion chamber, a reciprocating three-part piston having its ends arranged in the ends of the cylinder and serving as compressing pistons, and an intermediate portion arranged in the explosion chamber, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, an admission valve interposed in the said channels and controlling the admission of compressed gas into the explosion chamber upon opposite sides of the piston, an exhaust valve for said explosion chamber, and a rotary shaft with which the piston and the valves are connected.

10. A gas engine, comprising a three-part cylinder having ends of a common diameter constituting compression chambers, means to admit mixed air and gas into said compression chambers, channels leading from the ends through the cylinder, a reservoir connected with said channels, said cylinder also having an intermediate portion of larger diameter than its ends and constituting an explosion chamber, a reciprocating three-part piston having its ends arranged in the ends of the cylinder and serving as compressing pistons, and an intermediate portion arranged in the explosion chamber, the said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, an admission valve interposed in the said channels and controlling the admission of compressed gas into the explosion chamber upon opposite sides of the piston, an exhaust valve for said explosion chamber, a rotary shaft with which the piston and the valves are connected, and an eccentric interposed between the shaft and the admission valve connection.

11. A gas engine, comprising a three-part cylinder having ends of a common diameter constituting compression chambers, means to admit mixed air and gas into said compression chambers, channels leading from the ends through the cylinder, a reservoir connected with said channels, said cylinder also having an intermediate portion of larger diameter than its ends and constituting an explosion chamber, a reciprocating three-part piston having its ends arranged in the ends of the cylinder and serving as compressing pistons, and an intermediate portion arranged in the explosion chamber, said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, an admission valve interposed in the said channels and controlling the admission of compressed gas into the explosion chamber, an exhaust valve for said explosion chamber, a rotary shaft with which the piston and the valves are connected, a shiftable eccentric interposed in the connection between the admission valve and the rotary shaft, and a governor for controlling the position of the eccentric.

12. A gas engine, having a three-part cylinder and connections for admitting mixed air and gas to its opposite ends, the intermediate portion of the cylinder being of larger diameter than its ends and forming a power chamber, a three-part reciprocating piston arranged in said cylinder, the ends of said piston being of substantially equal length to the ends of the cylinder, and the intermediate portion arranged in the power chamber and its annular area being equal to the area of one of the ends of the piston, said piston having solid working faces adapted to fit close up to their respective cylinder heads to avoid clearance and thereby completely exhaust the cylinders, means to control the admission and exhaust from the power chamber, and a

reservoir communicating with the ends of the cylinder, the said ends of the cylinder and the complemental portions of the piston serving as gas compressing means, and the power chamber and the complemental portion of the piston serving as the actuating mechanism.

In testimony whereof I have hereunto set my hand this 8th day of May A. D. 1906.

CHARLES T. LITCHFIELD.

Witnesses:
O. P. HENDRIXSON,
J. E. GRIFFITH.