No. 827,759. PATENTED AUG. 7, 1906.

H. J. SMITH.

GAS ENGINE.

APPLICATION FILED FEB. 2, 1903.

2 SHEETS—SHEET 1.

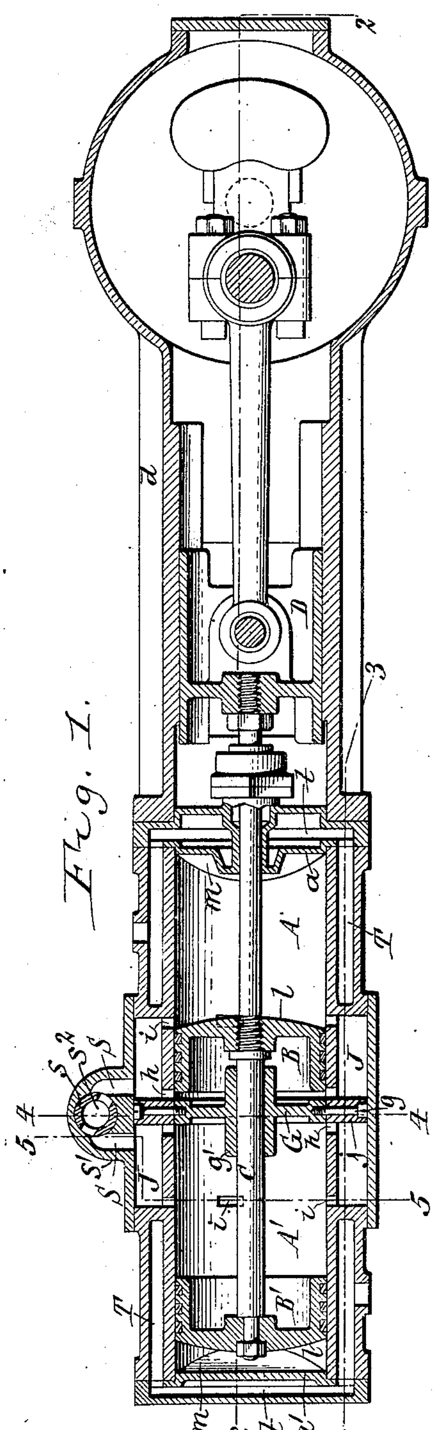

Fig. 1.

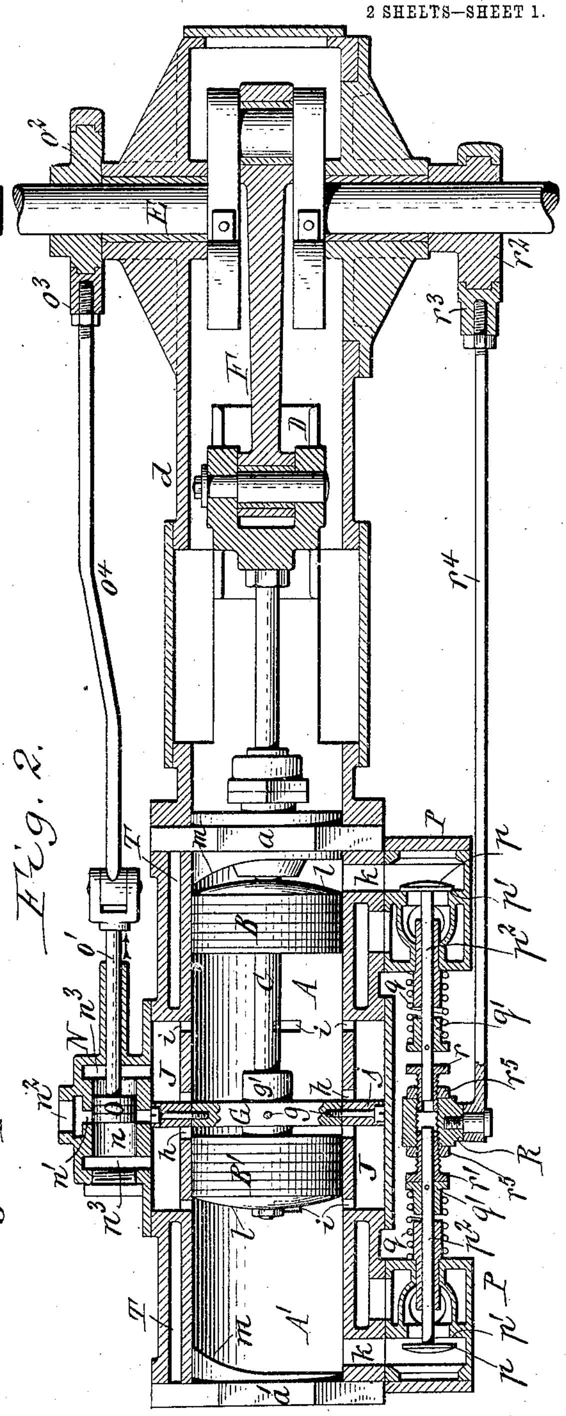

Fig. 2.

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2 SHEETS—SHEET 2.

Fig. 3.

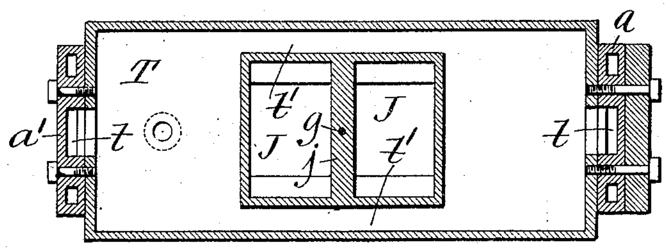


Fig. 4.

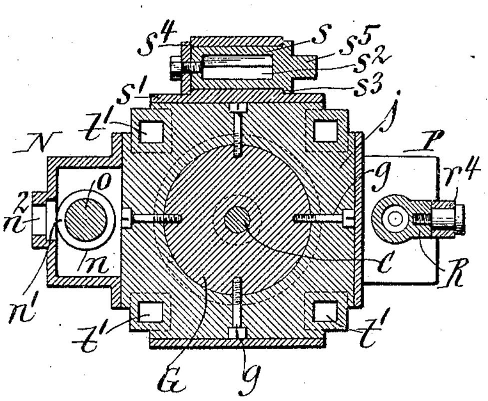


Fig. 5.

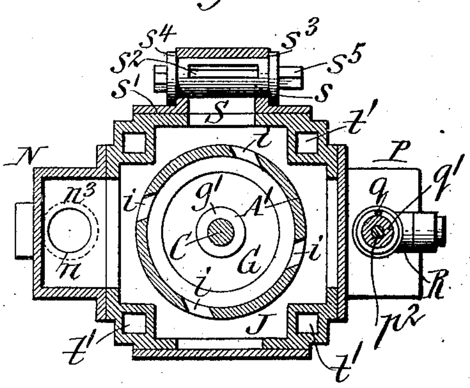
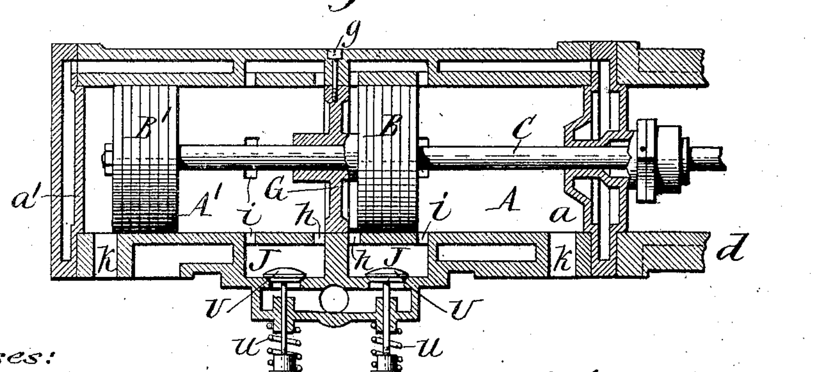


Fig. 6.



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# UNITED STATES PATENT OFFICE.

HARRY J. SMITH, OF BUFFALO, NEW YORK.

## GAS-ENGINE.

No. 827,759. Specification of Letters Patent. Patented Aug. 7, 1906.

Application filed February 2, 1906. Serial No. 141,408.

*To all whom it may concern:*

Be it known that I, Harry J. Smith, a citizen of the United States, residing at Buffalo, in the county of Erie and State of New York, have invented new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention relates more particularly to a two-cycle gas-engine having double-acting cylinders, although some of the features are applicable to other types of engines.

One of the objects of this invention is to produce a gas-engine which is simple and cheap in construction, in which the parts may be easily assembled, as well as dismembered for inspection and repairs, and one which is comparatively small and light for the amount of power developed.

Another object of this invention is to improve the means for regulating the supply of fresh gas and effecting the compression of the same and to improve the means for exhausting the spent gas.

The further objects of this invention are to provide a gas-engine having a more even crank effort or turning movement and fewer parts and to utilize the expansion of gases caused by combustion to a low limiting-pressure before exhausting.

In the accompanying drawings, consisting of two sheets, Figure 1 is a longitudinal sectional elevation of my improved gas-engine. Figs. 2 and 3 are horizontal sections in lines 2 2 and 3 3, Fig. 1. Figs. 4 and 5 are vertical cross-sections in the correspondingly-numbered lines in Fig. 1. Fig. 6 is a longitudinal section showing a modification of my improvements in gas-engines.

Similar letters of reference indicate corresponding parts throughout the several views.

Referring to the construction shown in Figs. 1 to 5, A A′ represent two horizontal working cylinders arranged one behind the other; B B′, two pistons reciprocating in the cylinders, respectively; C, a rod connecting the pistons; D, a cross-head sliding on longitudinal ways of the engine-frame *d* and connected with the front end of the piston-rod C; a crank-shaft E, journaled in bearings on the frame; and F a pitman connecting the crank of the shaft with the cross-head. Although the two cylinders may be made separate, the same are preferably cast in one continuous tubular shell or barrel, which is closed at its front and rear ends by heads *a a′* and is divided centrally by a transverse disk or circular partition G, forming the two working cylinders A A′. The partition may be held in place within the barrel by a driving fit; but for greater security a positive fastening is employed, such as dowel pins or screws *g*, which extend radially through the barrel from the outer side thereof and enter the periphery of the partition, as shown in Figs. 1, 2, and 4. On the central part of the partition is arranged a hub *g′*, through which passes the rod connecting the pistons B B′. This manner of constructing the cylinders is very simple and permits of producing the same at low cost because both cylinders can be bored at one operation. Furthermore, the alinement of both cylinders is always assured, and when necessary both pistons can be removed for inspection or repairs through the rear end of the cylinder-barrel after detaching the partition, piston-rod, and the rear head, thereby avoiding the necessity of dismounting the cylinders from the engine-frame for this purpose. The outer end of each cylinder constitutes the firing-space in which the charge of explosive fuel is ignited, and the piston therein is driven inwardly with a working stroke, while the pumping space at the inner end of each cylinder, together with the piston, serves as a pump for delivering the fuel under pressure into the firing-space. Each of the cylinders is provided at its inner end with one or more fuel-pumping ports *h*, which extend through the cylinder adjacent to the partition, and also with one or more fuel-transferring ports *i*, which extend through the cylinder between the pumping-ports and the outer end of the cylinder. The distance between the fuel-ports *h i* is so determined that when a piston is in its innermost position in a cylinder the fuel-ports are located adjacent to the inner and outer sides of the piston; and the latter does not cover either set of these ports. The two sets of fuel-ports are preferably arranged in peripheral rows and equidistant around the cylinder, and the two sets of fuel-ports of each cylinder are connected by a peripheral transfer or connecting passage J, surrounding the inner end of the cylinder. The transfer-passages of both cylinders are arranged side by side and are separated by a partition *j*, which consists of an external annular flange or rim formed centrally on the cylinder-barrel. Fuel is supplied to each of the transfer-passages by any suitable controlling means which permits the fuel to enter this passage through the supply-conduit, but prevents the same from leaving the passage through the same. Each of the cylinders is provided at its outer end with an exhaust port or passage $k$, through which the products of the spent fuel are discharged. This port is controlled by a valve device of any suitable construction.

During the first part of the outward stroke of each piston gaseous fuel is drawn from the respective transfer-passage J through the pumping-ports $h$ into the inner end of the cylinder, and when the piston has passed outwardly beyond the transferring-ports $i$ fuel is also drawn from the transfer-passage through the latter ports into the same end of the cylinder until the piston reaches the end of its outward or suction stroke. Assuming that an explosion now occurs of a charge of fuel which has previously been delivered into the outer end of the cylinder, the piston as the result will be forced inwardly with a working stroke. During this inward movement of the piston the charge of fuel in the inner end of the cylinder and in the transfer-passage J, connected therewith, is compressed. When the piston has nearly reached the end of its working stroke, the exhaust-valve is opened, permitting the spent gases to escape from the cylinder at the outer end thereof. Immediately after the exhaust-valve has opened, the piston passes inwardly beyond the fuel-transferring ports $i$ and uncovers the same. This permits the compressed charge of new fuel to escape from the inner end or pumping-space of the cylinder through the pumping-ports $h$ into the transfer-passage J and then pass, together with the gas in the latter, through the transferring-ports $i$ into the outer end or firing-space of the cylinder. The gas enters this end of the cylinder adjacent to the outer side of the piston and moves outwardly in the same, whereby the spent gases are driven through the exhaust at the outer end of the cylinder. After the piston covers the fuel-transferring ports $i$ during the subsequent outward movement of the same the exhaust-valve is closed, which causes the piston to compress the charge of fresh fuel confined in the firing-space and at the same time draw another charge of fuel into the pumping-space of the cylinder. When the piston is at or near the end of its outward movement, the compressed charge of new gas mixture is ignited, whereby the piston is again driven inwardly, and the cycle of operations is repeated as before described.

When an engine having duplex cylinders, as shown, is fully in operation, the exploding mixture in the firing-space of one cylinder moves the piston therein inwardly and the piston in the other cylinder outwardly, which causes the piston under fire to compress a charge on the inner side of the same, while the other piston is drawing a charge of mixture into the inner end of its cylinder and compressing a charge of mixture in the outer end of the same preparatory to igniting the last-mentioned charge and driving the corresponding piston inward with a working stroke. The two pistons are thus alternately acted upon by an exploding mixture, and both pistons are positively moved inwardly and outwardly in the cylinders, thereby giving an impulse during every stroke, as in a steam-engine, which tends to produce better balancing of the engine.

Inasmuch as the inertia of the reciprocating parts of the engine is cushioned or neutralized by compression of a gaseous mixture at the end of either stroke, it is possible to run the engine at a relatively high speed, rendering the same particularly desirable for operating a direct-connected electric generator and similar adaptations.

In order to prevent any of the fresh gas from commingling with the spent gas and escaping through the exhaust with the latter, it is necessary to maintain the fresh gas as it enters the firing-space of the cylinder in a substantially solid body or plug which is interposed between the inner side of the piston and the body of spent gas. This is best accomplished by forming the transferring-fuel ports $i$ tangentially in the cylinder, as shown in Fig. 5, whereby the fresh gas is caused to enter the cylinder tangentially through the several ports $i$ and whirl or gyrate in the cylinder about the axis thereof, forming a vortex of fresh gas which tends to keep the same in a mass or layer distinct or separate from the body of spent gas. As the volume of fresh gas in the firing-space of the cylinder gradually increases the same advances toward the outer end of the cylinder with a spiral movement and displaces or pushes the spent gas in front of the same outwardly through the exhaust. This spiral movement of the incoming fresh gas is promoted by means of a convex deflecting-face $l$, formed on the outer side of the piston, which face also serves to fill the cavity in the center of the vortex, whereby the spent gas in front of the fresh gas is more effectually expelled from the cylinder.

For the purpose of reducing the liability of spent gas lodging in the outer end of the cylinders each of the outer cylinder-heads is provided with a deflecting or guide face $m$, which is inclined or curved convexly from that side of the cylinder opposite the exhaust toward the head of the same, as represented in Figs. 1 and 2. This deflecting-face causes the spent gas as it moves outwardly in the cylinder to be turned or directed laterally toward the exhaust, thereby facilitating the discharge of the spent gas and reducing the deterioration of the fresh gas to a minimum, whereby the efficiency of the engine is increased.

The preferred means for controlling the supply of fresh fuel to the cylinders is constructed as follows: N represents a valve-chest which covers openings in the outer side of transfer-chambers J J. This chest is provided with a horizontal cylindrical valve-seat $n$, the central part of which is connected by a main fuel-inlet port $n'$ with a fuel-supply nipple $n^2$, while its opposite ends are connected by passages $n^3$ $n^3$ with the transfer-chambers J J, respectively. O represents a piston or slide valve reciprocating in said valve-seat and adapted to control the communication between the fuel-supply and the working cylinders. This valve is secured to a slide-rod $o'$, which is guided on the valve-chest and is operated by an eccentric $o^2$, mounted on the crank-shaft and having its surrounding strap $o^3$ connected with the valve-rod by a pitman $o^4$. In the position of the parts shown in Fig. 2 the working pistons are about to begin their movement toward the left-hand end of the cylinders, and the fuel-valve, which is moving toward the right, still covers the fuel-supply port. As the working pistons make a complete stroke toward the left the fuel-valve completes its stroke toward the right and uncovers the fuel-port, whereby the fuel-supply is placed in communication with the left-hand cylinder and then moves far enough to the left so as to again cover this port, thereby permitting fuel to be drawn from the supply through the port $h$ into the inner end of the left cylinder by the piston therein and then cutting off this supply, so that the charge is compressed in the inner end of the left-hand cylinder during the subsequent inward movement of its piston. While the pistons are making a complete stroke toward the right, the fuel-valve first moves toward the left and uncovers the fuel-port, placing the fuel-supply in communication with the right-hand cylinder, and then moves toward the right and again covers said port, whereby the right-hand piston is permitted to draw a charge of fuel from the supply through the port $n'$ into the inner end of its cylinder, and then the supply is cut off preparatory to compressing the charge which has been received. While the fuel-valve opens the main fuel-port for admitting fuel into one cylinder communication is cut off between the fuel-supply and the other cylinder, so that the charge in the latter can be compressed by its piston, which at this time is being moved inwardly. By thus positively opening and closing the valve which controls the supply of gaseous mixture better regulation and economy is obtained than by the use of a fuel-supply valve which is opened by the suction of a piston.

The preferred form of valve mechanism for controlling the exhaust from the cylinder is constructed as follows: P P represent exhaust valve-chests, each of which contains an exhaust port or passage forming a continuation of the exhaust port or passage $k$ at the outer end of one of the cylinders. $p$ $p$ represent exhaust-valves which control said exhaust-ports and each of which when moved outward or in the direction of the exhaust bears against a seat $p'$ around its exhaust-port and closes the same, while upon moving the valve inwardly away from its seat the exhaust-port is opened. Each of the exhaust-valves is mounted on a guide rod or stem $p^2$, which is arranged lengthwise and guided in the inner part of its valve-chest. The exhaust-valves are yieldingly held in a closed position by springs $q$, bearing at opposite ends against the valve-chests and collars or shoulders $q'$ on the valve-rods. The rods of both exhaust-valves project toward each other and are arranged lengthwise in line. R represents a longitudinally-reciprocating head provided with tappets $r$ $r'$, which are adapted to engage alternately with the collars $q'$ of the rods carrying the exhaust-valves for opening the latter. These tappets are preferably constructed in the form of externally-screw-threaded sleeves, each of which receives the inner end of one exhaust-valve rod and screws into the corresponding side of the head R. Upon moving the latter lengthwise in either direction the tappet on its advancing side engages the collar of the companion valve-rod and opens the respective exhaust-valve. The tappet-head is actuated by means of an eccentric $r^2$, mounted on the crank-shaft and having its surrounding strap $r^3$ connected with the tappet-head by a pitman $r^4$. The extent of movement of the tappet-head is always the same; but the position of the tappets may be varied by turning them forward or backward in the head. By this means the slack or dead movement between the tappets and the valve-rod collars may be varied for adjusting the time of opening of the exhaust-valves, as may be necessary, to produce the best results. After the tappets have been adjusted they are held in position by jam-nuts $r^5$. As shown in the drawings, the fuel-valve mechanism and the exhaust-valve mechanism are arranged on the horizontally-opposite sides of the cylinders.

In order to regulate the speed of the engine, the volume of fuel in each charge may be varied by the following means: S represents a by-pass which connects the pumping-spaces of both cylinders and which may be opened or closed by a regulating-valve $s$. This by-pass is preferably formed in a chest $s'$, which closes openings in the upper part of both transfer-passages, and the by-pass terminates at its opposite ends in said transfer-passages, as shown in Fig. 1. The regulating-valve, preferably of cylindrical form, turns in a correspondingly-shaped seat which extends across the by-pass and is provided with a diametrical port $s^2$, which upon turning the valve may be moved more or less into register with the by-pass. The regulating-valve is held in place by a shoulder $s^3$ at one of its ends engaging with a shoulder at the corresponding end of its valve-seat and a disk $s^4$, secured to the opposite end of the regulating-valve and engaging with the shoulder at the same end of the valve-seat, as shown in Figs. 4 and 5.

Upon turning the regulating-valve so that the by-pass is closed communication between the pumping-spaces of both cylinders is cut off and the pistons alternately draw into the cylinders a charge of fuel of maximum volume, whereby the greatest compression of the same is effected and the highest efficiency of the engine is obtained. If the regulating-valve is turned so that the by-pass is opened more or less, the charges of fuel are permitted to escape from one cylinder to the other while undergoing compression, whereby the volume of fuel which is delivered into the firing-spaces of the cylinders is throttled and the output of the engine is reduced. Assuming that the regulating-valve is partly open and that the pistons are moving from left to right, as shown in Fig. 1, the fuel contained in the inner end or pumping-space of the left-hand cylinder is partially expelled by the piston therein through the by-pass and drawn into the pumping-space of the right-hand cylinder by the piston therein. The result of this movement of part of the gas from the left to the right cylinder is that the left piston acts upon a reduced volume of gas and subjects the same to less compression, which charge upon being transferred to the firing-space of the left cylinder produces an explosion that is less effective in propelling the left piston during the following inward stroke. Since the right piston during its outward movement draws a part of the fuel from the left cylinder through the by-pass to the right cylinder, the suction of this piston on the main fuel-supply and the amount of fuel drawn from the same is correspondingly reduced. As the pistons move from right to left a part of the fuel in the right cylinder is transferred to the left cylinder, resulting in a corresponding reduction in the effectiveness of the charge of fuel which remains in the right cylinder and is exploded in the outer end thereof. It will thus be seen that by opening the regulating-valve more or less a greater or less quantity of fuel is moved idly back and forth between the cylinders which does not undergo compression and that a proportionally smaller quantity of new fuel is drawn in through the main supply for each charge, whereby the output of the engine is reduced accordingly. The turning of the regulating-valve for graduating or relieving the charges of fuel and varying the speed of the engine may be effected by any suitable means. As shown in Figs. 4 and 5, this valve is provided at one end with a stem $s^5$, which is constructed to receive a wrench or other hand-tool for turning the same. If desired, this valve may be shifted automatically for throttling the gas-supply in proportion to the load by connecting the valve with a governor which is operated in any well-known manner.

Owing to the constant exposure of the cylinder-partition G to the cooling effect of the fresh incoming gaseous mixture, the same is not liable to become unduly heated and cramp the piston-rod passing through the same. If for any reason the joints between the cylinder-partition and the piston-rod and cylinder-barrel should become leaky, no harm would result therefrom, inasmuch as this merely adds to the capacity of the by-pass and can be compensated for by shutting the regulating-valve sufficiently to offset whatever leakage exists. The connection between the pumping-spaces of the cylinders by means of the by-pass performs the additional function of equalizing the suction and compression of the gaseous mixtures in both cylinders whereby uniform operation of the engine is obtained.

T T represent water-jackets which surround the periphery of the working cylinders and communicate with water-jackets $t$ $t$ in the heads of the cylinders. Each of the peripheral water-jackets extends from the outer end of a cylinder to the transfer-passage of the same. The peripheral water-jackets of both cylinders are connected by one or more longitudinal circulating-tubes $t'$ for permitting the water to pass from one of the cylinder-jackets to the other. These tubes extend through the transfer-passages of both cylinders and through the partition $j$ between the same, as shown in Figs. 3, 4, and 5. In order to avoid obstructing the transfer-passages, the outer walls of the cylinder water-jackets and the transfer-passages are substantially square or rectangular in cross-section, and the connecting-tubes, preferably four in number, are located in the corners of these jackets and passages, as shown in Figs. 4 and 5. By thus connecting the water-jackets of both cylinders the water can flow from one to the other, thereby avoiding separate water connections for the same. Furthermore, in producing the mold for casting the cylinders and their water-jackets the cores which form the tubes $t'$ serve as means for sustaining the inner ends of the water-jacket cores, which latter otherwise would be difficult to retain in the proper position for casting.

Ignition of the charges of fuel may be effected by igniters of any suitable construction, which are arranged in the firing-spaces of both cylinders or in passages communicating therewith.

Although the construction shown in Figs.

1 to 5 represents the best embodiment of the various improvements, some of the features may be varied without departing from the essence of my invention. For instance, as shown in Fig. 6, no by-pass and regulating-valve are employed between the pumping-spaces of the cylinders, nor are the pistons and the cylinder-heads provided with curved deflecting-faces. Instead of a single valve operated definitely this figure also shows independent puppet-valves U for controlling the admission of fuel to the cylinders, said valves being closed by springs *u* and opened by the suction of the pistons.

I claim as my invention—

1. A gas-engine comprising a cylinder, a piston reciprocating in the same, said cylinder having a fuel-port at one end, an exhaust-port at its opposite end and a transfer-port connected with the fuel-port and arranged to be uncovered by the piston at the end of its forward stroke, a fuel-valve controlling the fuel-supply, an exhaust-valve controlling the exhaust, and an actuating mechanism for the exhaust-valve constructed to permit of varying the operation of the same, substantially as set forth.

2. A gas-engine comprising a cylinder, a piston reciprocating in the same, said cylinder having a fuel-port at one end, an exhaust-port at its opposite end and a transfer-port connected with the fuel-port and arranged to be uncovered by the piston at the end of its forward stroke, a fuel-valve controlling the fuel-supply, an exhaust-valve controlling the exhaust, and a shaft having a crank operatively connected with the piston and eccentrics operatively connected with said fuel and exhaust valves, substantially as set forth.

3. A gas-engine comprising a cylinder, a piston reciprocating in the same, said cylinder having a fuel-port at one end, an exhaust-port at its opposite end and a transfer-port connected with the fuel-port and arranged to be uncovered by the piston at the end of its forward stroke, a reciprocating fuel-valve controlling the fuel-supply, a reciprocating exhaust-valve controlling the exhaust and mounted on a guide-rod, a spring engaging a collar on the rod and operating to close the exhaust-valve, a tappet constructed to engage said collar for opening the exhaust-valve, a reciprocating head on which said tappet is adjustably mounted, and a crank-shaft having eccentrics operatively connected with the fuel-valve and said head, substantially as set forth.

4. A gas-engine comprising a cylinder and a piston, said cylinder having an exhaust-port at one end, a fuel-port at its opposite end and a transfer-port connected with said fuel-port and opening tangentially into the firing-space of the cylinder immediately in rear of the piston at the end of its working stroke, and said piston having a convex face on its firing side, whereby the fuel entering the cylinder tangentially and striking the convex face of the piston is caused to whirl about the axis of the cylinder and move spirally toward the exhaust for expelling the spent gas, substantially as set forth.

5. In a gas-engine, the combination of a cylinder provided at one end with a fuel-supply, an exhaust-port on one side of its opposite end and a deflecting-face which extends obliquely from the side of the cylinder opposite the exhaust to the adjacent head of the cylinder, and a piston arranged in the same, substantially as set forth.

6. A gas-engine comprising a barrel having a continuous cylindrical bore, a stationary circular partition secured centrally in the barrel and dividing the same into two cylinders and provided with a central opening, heads applied to opposite ends of the cylinders, pistons arranged in the cylinders and dividing each of the latter into an inner pumping-chamber and an outer firing-chamber, a rod connecting said pistons and passing through the opening of said partition, exhaust-valves controlling said exhaust-ports, and an actuating mechanism for said exhaust-valves constructed to permit of varying the operation thereof, each of said cylinders having a fuel-port at its inner end, an exhaust-port at its outer end, and a transfer-port connected with the fuel-port and arranged to be uncovered by the respective piston at the end of its inward movement, substantially as set forth.

7. In a gas-engine, the combination of two opposing cylinders each having a pumping-space and fuel-ports at its inner end and a firing-space and an exhaust-port at its outer end, a valve-seat connected at opposite ends with the fuel-ports of both cylinders and provided between its ends with a fuel-supply port, a slide-valve engaging with said seat and operating to place said supply-port alternately in communication with the fuel-ports of the cylinders, and pistons arranged in the cylinders, substantially as set forth.

8. In a gas-engine, the combination of two opposing cylinders, each having a pumping-space and fuel-ports at its inner end and a firing-space and an exhaust-port at its outer end, a valve-seat connected at opposite ends with the fuel-ports of both cylinders and provided between its ends with a fuel-supply port, a slide-valve engaging with said seat and operating to place said supply-port alternately in communication with the fuel-ports of the cylinders, pistons arranged in the cylinders, a crank-shaft connected with the pistons, and an eccentric arranged on said shaft and operatively connected with said slide-valve, substantially as set forth.

9. A gas-engine comprising two opposing cylinders each having a port, a valve applied

to each of said ports and provided with a rod; the rods of both valves projecting toward each other and having collars, a spring bearing against each of said collars and operating to close the respective valve, tubular tappets receiving said rods and coöperating with said collars for opening said valves, a reciprocating head upon which said tappets are adjustably mounted, and pistons arranged in said cylinders, substantially as set forth.

10. In a gas-engine, the combination of two opposing cylinders each of which has a pumping-space and a fuel-supply at its inner end and a firing-space and an exhaust-port at its outer end, an exhaust-valve applied to each exhaust-port and provided with an inwardly-extending rod, a spring engaging with a collar on said rod for closing the valve, tappets of tubular form receiving said rods and coöperating with the collars thereon for opening the valves, a reciprocating head upon which said tappets are adjustably mounted, and pistons arranged in the cylinders, substantially as set forth.

11. In a gas-engine, the combination of two opposing cylinders each of which has a pumping-space and a fuel-supply at its inner end and a firing-space and an exhaust-port at its outer end, an exhaust-valve applied to each exhaust-port and provided with an inwardly-extending rod, a spring engaging with a collar on said rod for closing the valve, tappets of tubular form receiving the rods of both valves and coöperating with the collars thereon for opening the valves, a reciprocating head upon which said tappets are adjustably mounted, pistons arranged in the cylinders, a crank-shaft connected with the pistons, and operative connections between said shaft and head, substantially as set forth.

12. In a gas-engine, the combination of two cylinders each having a pumping-space at one of its ends and a firing-space at its opposite end, a by-pass connecting the pumping-spaces of both cylinders, a valve for controlling said by-pass, and pistons arranged in the cylinders, substantially as set forth.

13. In a gas-engine, the combination of two cylinders each having a pumping-space at one of its ends and a firing-space at its opposite end, a by-pass connecting the pumping-spaces of both cylinders and containing a cylindrical seat, a rotary valve applied to said seat and provided with a diametrical port, and pistons arranged in the cylinders, substantially as set forth.

14. In a gas-engine, the combination of two opposing cylinders, each having a pumping-space and fuel-pumping ports at its inner end, a firing-space and an exhaust-port at its outer end, fuel-transferring ports arranged between its ends, and a transfer-passage connecting the pumping and transferring ports, a by-pass connecting the transfer-passages of both cylinders, a valve for controlling said by-pass, and pistons arranged in the cylinders, substantially as set forth.

15. In a gas-engine, the combination of two opposing cylinders each having a pumping-space and fuel-ports at its inner end, a firing-space and an exhaust at its outer end, and a passage extending around the inner part of the cylinder and connecting its fuel-ports, a water-jacket extending around the outer part of each cylinder, a water-circulating tube connecting the water-jackets of both cylinders and extending through the transfer-passages of the same, and pistons arranged in said cylinders, substantially as set forth.

16. In a gas-engine, the combination of two opposing cylinders each having a pumping-space and fuel-ports at its inner end, a firing-space and an exhaust at its outer end, and a passage for connecting the fuel-ports extending around the inner part of the cylinder and having an outer wall of rectangular form, a water-jacket extending around the outer part of each cylinder, longitudinal water-circulating tubes connecting the water jackets of both cylinders and arranged in the corners of the transfer-passages, and pistons arranged in the cylinders, substantially as set forth.

Witness my hand this 30th day of January, 1903.

HARRY J. SMITH.

Witnesses:
THEO. L. POPP,
EMMA M. GRAHAM.