(No Model.) 3 Sheets—Sheet 1.

B. C. VANDUZEN.

GAS ENGINE.

No. 448,597. Patented Mar. 17, 1891.

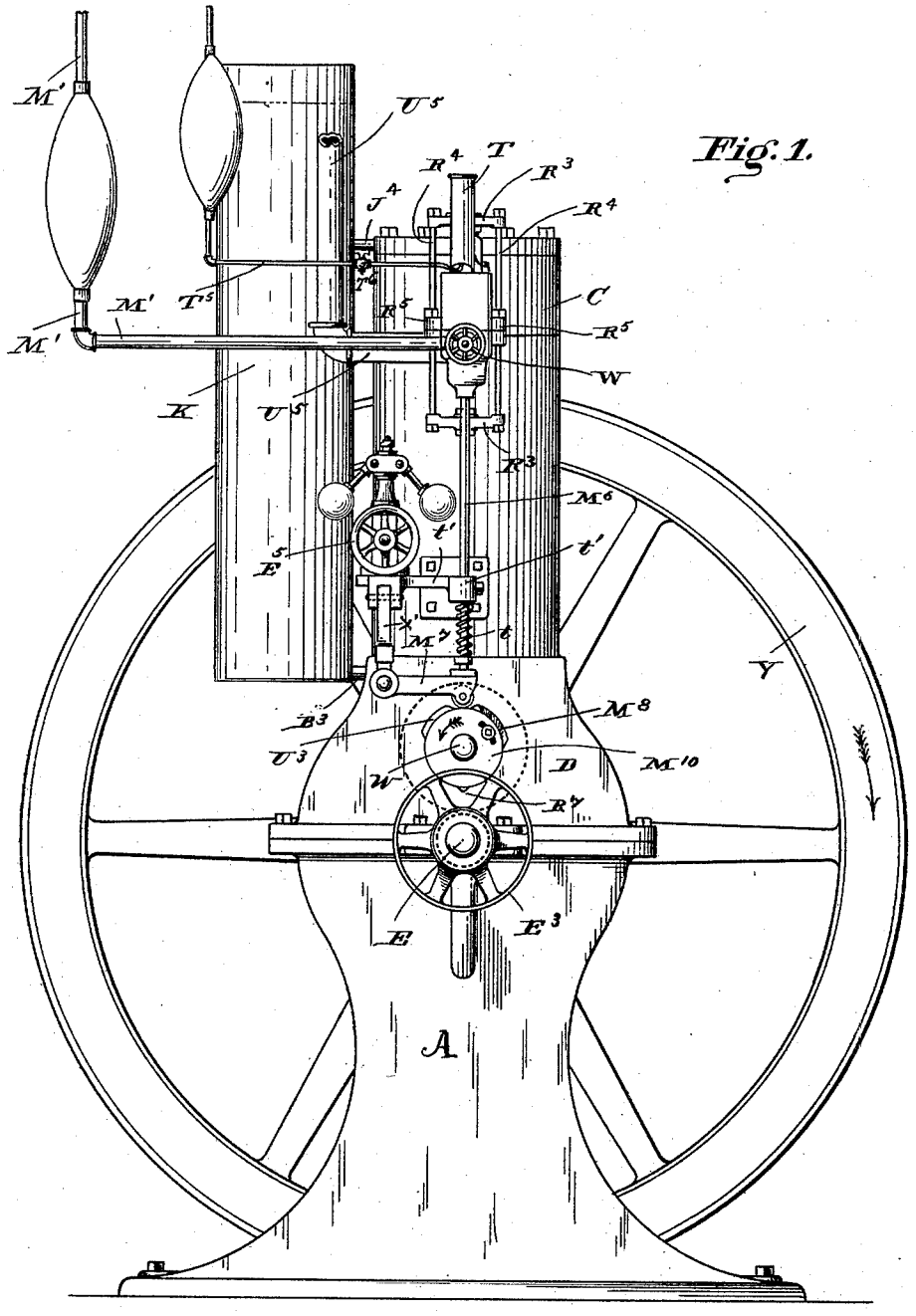


Fig. 1.

Attest.
K. Smith.
C. H. Parce.

Inventor.
Benjamin C. Vanduzen
per Wm. Hubbell Fisher,
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

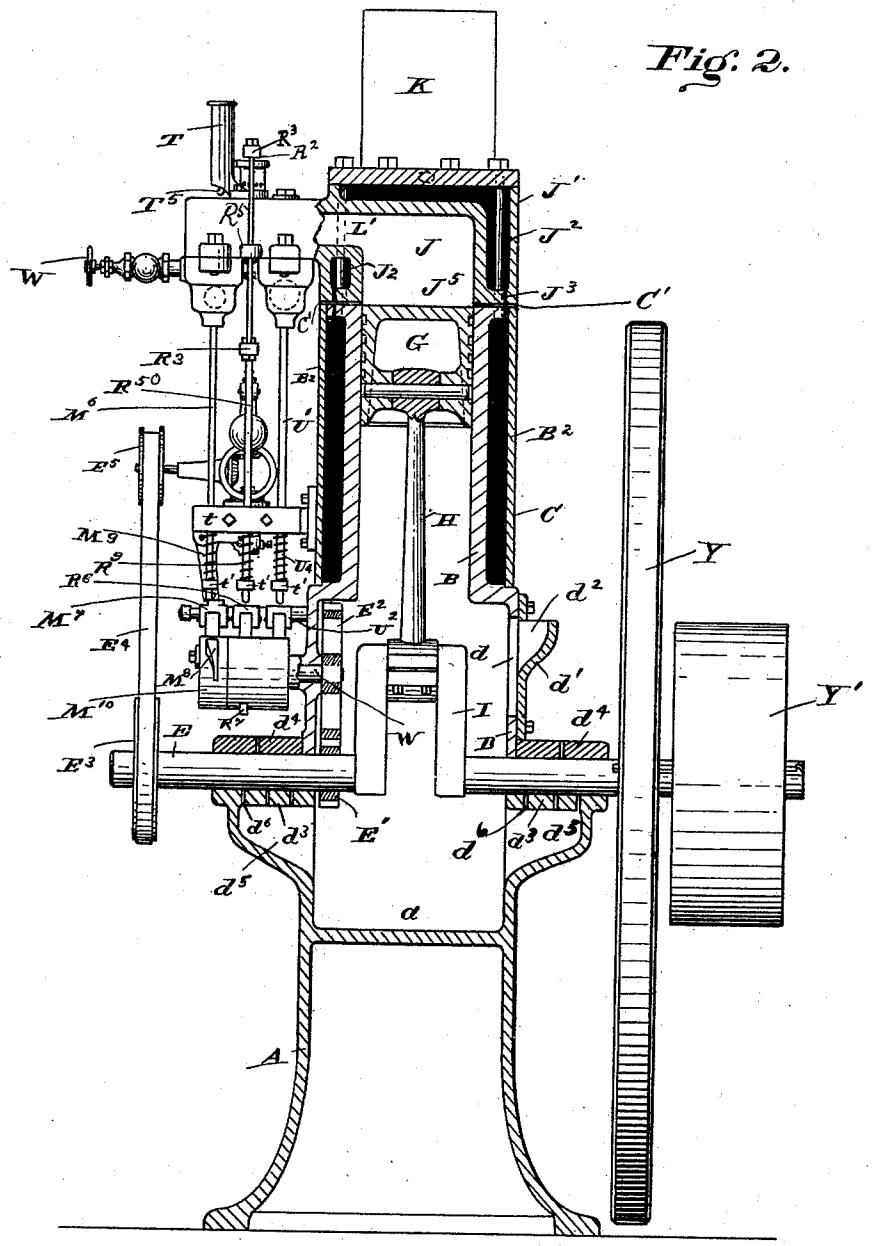
(No Model.) 3 Sheets—Sheet 2.

B. C. VANDUZEN.

GAS ENGINE.

No. 448,597. Patented Mar. 17, 1891.

Fig. 2.



Attest.
K. Smith.
C. A. W. Parer.

Inventor.
Benjamin C. Vanduzen
per Wm. Hubbell Fisher,
Atty.

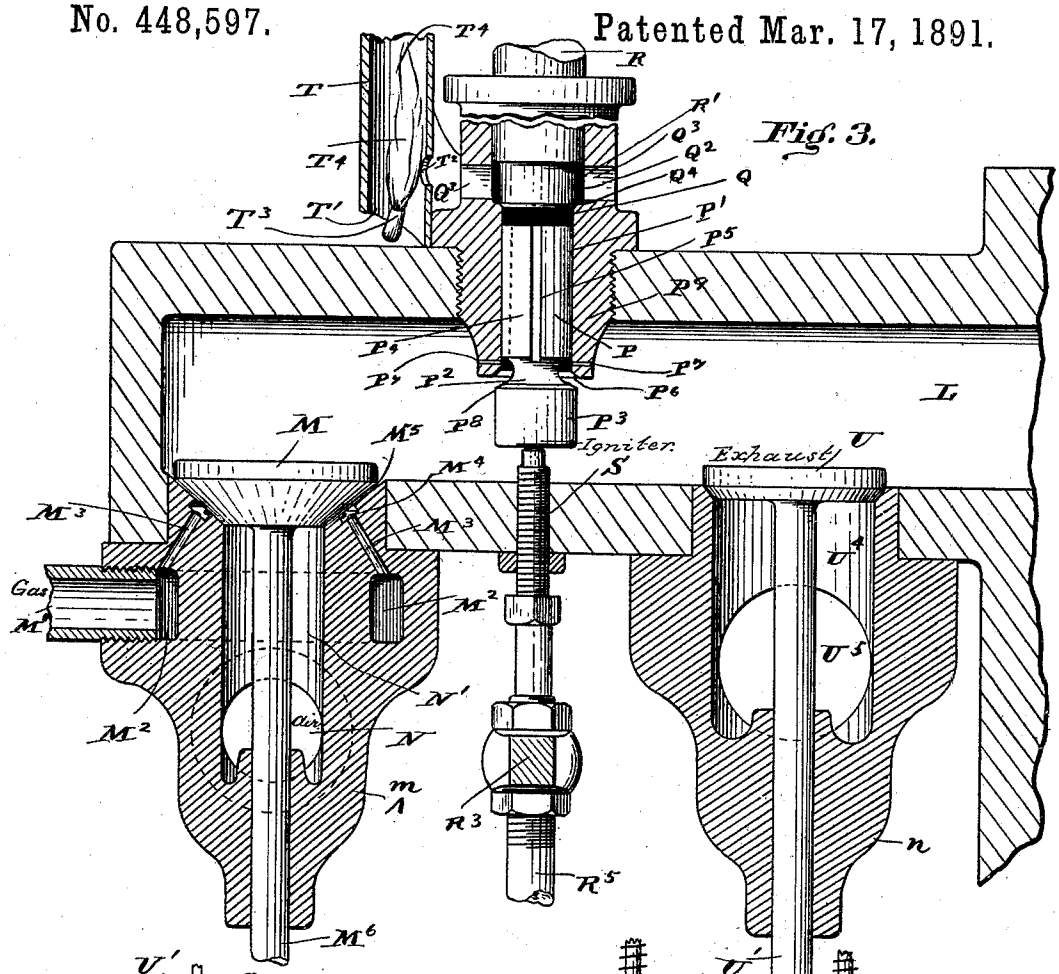
THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

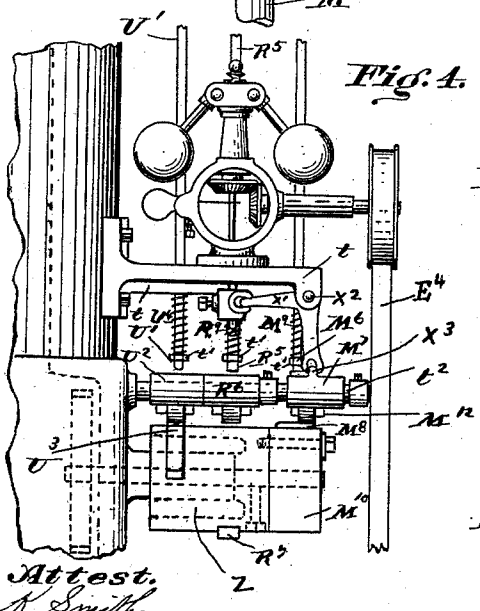
(No Model.) 3 Sheets—Sheet 3.

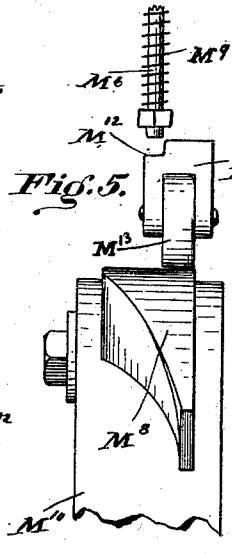
B. C. VANDUZEN.

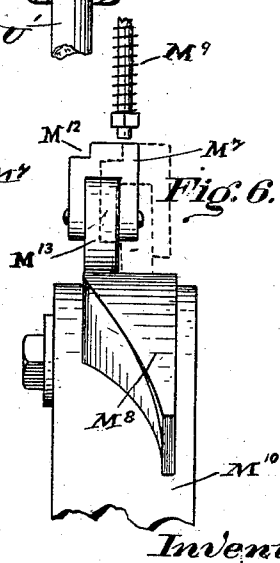
GAS ENGINE.

No. 448,597. Patented Mar. 17, 1891.









Attest.
K. Smith.
C. H. Parker.

Inventor:
Benjamin C. Vanduzen
per Wm. Hubbell Fisher,
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

BENJAMIN C. VANDUZEN, OF WINTON PLACE, OHIO, ASSIGNOR OF ONE-HALF TO EZRA W. VANDUZEN, OF NEWPORT, KENTUCKY.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 448,597, dated March 17, 1891.

Application filed February 2, 1888. Serial No. 262,812. (No model.)

To all whom it may concern:

Be it known that I, BENJAMIN C. VANDUZEN, a citizen of the United States, and a resident of Winton Place, in the county of Hamilton and State of Ohio, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

The several features of my invention and the advantages arising from their use, conjointly or otherwise, will be apparent from the following description.

In the accompanying drawings, forming part of this specification, Figure 1 is an elevation of that side of the gas-engine embodying my improvement which is on the left hand in Fig. 2. Fig. 2 is a vertical central section of the bed-plate, cylinder, water-casing, piston, and exploding-chamber and spur-wheels in the crank-chamber, the other parts of the engine being shown in elevation, the view being taken in front of the engine. Fig. 3 represents a vertical enlarged section of the valve-chamber, ports, and lighting-chamber, and the ignitor or igniting device, the several valves and the devices for adjusting the valve of the ignitor being shown in elevation. Fig. 4 is a rear elevation of the governor and the devices for working the valves and the ignitor. Figs. 5 and 6 are enlarged front views of parts of the devices for operating the valve which admits the gas and air to the engine, and showing the construction of the cam whereby the governor is enabled to control the speed of the engine by regulating the amount of combustible gas and air admitted to the engine.

A represents the preferred form of bed-plate or support cast in one piece, together with the lower half of the journal-bearings of the crank-shaft.

The cylinder and the upper half of the crank-case D are cast in one piece, provided with an opening d, whereby convenient entrance can be had to the interior of the crank-case. This opening d is covered by a cap d'. As it is desirable to provide an opening for the free ingress and egress of air to and from the interior of the cylinder below the piston, I utilize this opening d for the purposes last named, forming the upper part of the cap d' with the opening d^2, so that while the cap covers the greater portion of the opening d the passage d^2 is present for the free ingress and egress of air, as aforementioned.

In the upper part of the bed-plate A—namely, that part which forms the lower half of the crank-chamber D—I provide a chamber which contains oil and water. The object of this oil and water is to lubricate the interior of the cylinder B and the crank-wrist and the spur-wheels E′ E^2 and the crank-shaft E and its journal-bearings d^3, including the caps d^4. A space d^5 is provided under each of the journal-bearings d^3, and is connected with the chamber a, containing the lubricant above mentioned, by means of openings d^6, leading from the interior of the journal-bearings d^3 into their adjacent respective space d^5. Thus the lubricant of the journals and the crank-shaft E, after lubricating said shaft and journals, passes down through the openings d^6 into the space d^5, and then into the chamber a, to be again used in lubricating the engine.

G represents a piston provided with suitable packing working in cylinder B. The connecting-rod H is pivotally connected at one end to the piston and at the other end to the crank-shaft I in any suitable manner. The crank I as it revolves strikes and dips into the lubricant in chamber a and lifts and distributes this lubricant on the interior of the cylinder and on the spur-wheels and journal-bearings of the crank-shaft, as well as on its own pivotal connections with piston and crank.

The casing C surrounds the cylinder B, and the space between this casing and the cylinder forms a water-space B^2, which is filled with water for the purpose of keeping the cylinder cool while the engine is in operation. This casing is preferably cast, as shown, in one cylindrical piece and separate from the cylinder. The cylinder can therefore be cast without a core for the water-space, and the casing can be readily slipped over the cylinder and adjusted in place.

On the top of the cylinder B is located the exploding-chamber J, and this chamber is provided with a water-jacket J′, preferably cast with this chamber, and a water-space J^2 is

present between the jacket and the chamber. This space J^2 is connected to the water-space B^2, surrounding the cylinder, by means of small holes or passages J^3, passing through the upper end wall of the water-space B^2 and the lower end wall of the water-space J^2. Thus the cylinder and exploding-chamber are almost entirely surrounded by water. The lower part of the water-space B^2 is connected to an inlet-pipe B^3, and the upper portion of the water-space J^2 is connected to the exit-pipe J^4. This inlet-pipe B^3 may be connected with any suitable supply of water. A water-tank K is preferably present, as shown, and pipe B^3 is connected to the lower part of its interior and pipe J^4 to the upper portion of its interior.

It is my object to prevent the cylinder and piston from becoming overheated, as when these parts are overheated the lubricant would be destroyed. At the same time it is also desirable that the cylinder and piston be kept at a uniform temperature, the degree of said temperature being that of about 212° Fahrenheit. The temperature of water in the jackets and in the tank is soon raised in temperature to 212°. The cylinder and piston will be prevented from being heated to a temperature higher than 212°, for the reason that the water at this degree of temperature will evaporate and the extra heat will pass off with the evaporation of water. At the same time the tank will furnish a continual supply of water to the water-spaces B^3 J^4, and thus keep them full.

The valve-chamber L is connected to the exploding-chamber J by a passage-way or port L′, located at the extreme upper part of the exploding-chamber J. This chamber J is purposely made deep, so that the lower portion J^5 of it shall be considerably below the point where the passage-way L′ enters said chamber.

The object of this construction and arrangement is as follows: The upper surface of the piston is intentionally made imperforate, so that when the mixture of air and gas has been exploded in the chamber J there will remain in the chamber *a* a certain amount of residual or consumed gas, which, being heavier than the fresh supply of mixed air and combustible gas, will remain on the face of the piston and in the lower part of the chamber J. As the piston descends, this residual or consumed gas follows the piston and the combustible mixture of gas and air enters the exploding-chamber, and filling that also passes down into the cylinder B and fills the space in the cylinder above the residual or consumed gases. Now as the piston rises the combustible gas and air above the piston will be compressed in the exploding-chamber J, the residual or consumed gases lying next to the piston. When the combustible gases are ignited, an explosion ensues. The residual or consumed gases form a cushion between the impact of the explosion and the face of the piston, thus enabling any inertia of the latter to be gradually and effectively utilized. These gases not only form a cushion, but perform the office of a non-conductor of heat and prevent the heat generated by the explosion of the combustible mixture of gas and air from reaching the piston. The piston therefore remains cooler than it would were the combustible mixture in contact with the piston and there exploded. As the volume of residual or consumed gases increases, a part of the consumed gases will rise above the lower edge of the passage L′. This part will be duly drawn off by the exhaust. Nevertheless there will be always present in the lower part of the chamber J and next to the piston a thick layer of these residual or consumed gases. This latter will perform the function of the cushion aforementioned, each part or piece containing a valve-seat and the parts connected therewith be preferably made in a single piece supported from the valve-chamber L.

M′ indicates the inlet-port, whereby combustible gas (preferably coal-gas) is supplied to the engine. This inlet communicates with the annular chamber M^2. From the latter extend small ways or ports M^3, which terminate in an annular groove M^4, lying in the face of the valve-seat.

N indicates the inlet for air, which communicates with the upright passage N′, which latter opens directly at the edge of the valve-seat. M is a valve, here shown as conical, having the faces of its seat beveled to receive it. A flat valve having a flat seat may be substituted for the conical valve and its beveled seat. The combustible gases entering from port M′ pass into the annular chamber or passage-way M^2, then through the ports M^3 into the annular groove M^4, and as the valve M is lifted from its seat the gas moves up around the valve and into chamber L. The air having thus previously entered port N and having filled passage and port N′, then as the valve M is lifted passes up and around the valve at the same time that the combustible gas is passing up and around said valve, and the air and gas come into contact at the annular groove M^4 and are most thoroughly mixed before they enter the chamber L, and thus combined enter the valve-chamber L and pass around the valve of the ignitor and carry all of the residual or consumed gas before them into chamber J. Thus only the pure combustible mixture of gas and air is present in chamber L. In exploding-chamber J this mixture of combustible gas and air lies above and upon but without disturbing the residual or consumed gas lying below upon piston G in the lower part of the exploding-chamber J.

It may be here remarked that the annular groove M^4 is not essential to the above-named process of mixing the combustible gas and air, but is preferably present for a mechanical reason—viz., to better grind the valve-seat, so as to form a close-fitting joint with its valve.

The construction and operation of the ignitor

and its adjustment are as follows: A valve P closely fits and reciprocates within a cylindrical tube P′. This valve is provided with an annular groove P^2 and a head P^3. The main portion P^4 of the valve has longitudinal grooves P^5 at one end opening into the annular groove P^2 and at the other end opening into the chamber Q directly above the valve. The upper part of the chamber Q is enlarged at Q^2, and through the walls of this second chamber Q^2 are one or more passage-ways Q^3, connecting the chamber Q^2 with the external atmosphere. Through the chamber Q^2 plays the valve R, provided at its lower end with an annular depression R′, which depression, when the valve R is depressed to its seat, still allows of a free passage-way from the external air to the chamber Q^2 through the opening or openings Q^3. This depression R′ is not essential and may be dispensed with, and if the valve R is raised above the floor of the opening or openings Q^3 the lighter will ignite the combustible mixture of gas and air in the chamber Q. The annular chamber Q^2 is not essential, but is preferably present, as it enables the ignition to take place all around the lower part of valve. When the valve R is depressed, it is seated on the seat Q in the cylindrical passage-way or chamber Q and completely cuts off all connection between the chamber Q^2 and its sub-chamber Q. The valve P rests upon a suitable support, preferably an adjustable one, as shown in Fig. 3, which adjusting device consists of the screw S, screwed up through the lower part of the valve-chamber L. The lighter-chimney T is located near passages Q^3, leading from the outer air to the chamber Q^2, and is provided with an opening T′ for the admission of air to the said chimney at a point below the flame, and also provided with another opening T^2, located preferably opposite the upper part of the adjacent passages Q^3. The nozzle T^3 of an inlet gas-tube T^5 projects within chimney T, and the gas issuing from said nozzle fills the said chimney T, and when lighted assumes the form of the flame T^4 in said tube. A stop-valve T^6 in the tube T^5 is present to admit, cut off, and regulate the supply of gas to the nozzle T^3.

The operation of this part of my device is as follows: The valve M having been lifted at the proper time, as aforementioned, and the mixture of gas and air being compressed in the exploding-chamber and in the valve-chamber, and the valve R being lifted, this compressed mixture of gas and air in chamber L raises the valve P till the upper face or seat P^8 of the head P^3 reaches the lower face or seat P^6. At this moment the combustible mixture passing through the passage-ways P^5 issues from under valve R through the passages Q^3 and is ignited from the flame T^4 of the lighter. All the openings for the passage of combustible gas and air from chamber L to chamber Q are now cut off, except through the small opening or openings P^7. The combustible gas and air pass through these small openings and into the annular groove P^2, and thus find their way through longitudinal passage-ways P^5 into the chambers Q and Q^2 and issue from passages Q^3. This mixture of gas and air issuing from these passages Q^3 is reached through the opening T^2 by the flame in chimney T and burning backward instantly ignite the mixture of gas and air in the chambers Q^2 and Q. Thereupon the valve R immediately descends to its seat Q^4. The gas and air entering from chamber L through opening or openings P^7 and passage-ways P^5 equalize the pressure above and below the valve P, and the latter drops by its own weight, thus opening the connection between the valve-chamber L, groove P^2, and passage-ways P^5 to chamber Q and the burning gas and air in passage-ways P^5, and burning backward lights the gas and air in groove P^6, and this in turn lights the gas and air in valve-chamber L and exploding-chamber J. This entire operation is the work of an instant. The combustible mixture of gas and air in chambers L and J having been exploded moves the piston downward, and thus operates the engine. The chamber in which valve P moves, valve-face P^6, and the passage-ways P^7, chambers Q Q^2, valve face or seat Q^4, passages Q^3, and the opening through which valve R plays, are preferably present in a single case, which may be termed the "ignitor-case." The lower extension of this case below the roof of chamber L is indicated by the letter P^9 and has the valve-face P^6 and the openings P^7. If the valve P is depressed too far, the gas and air rushing through the groove P^2 and the ways P^5 fail to move the valve down; but when the valve P is raised so that the opening between the lower face P^8 of the groove P^2 and the face P^6 of the seat is quite narrow, then the friction of the gas and air rushing into this groove from chamber L and through the ways P^5, together with the direct upward pressure of the compressed air and gas in chamber L on the head P^3 of the valve P, will raise the latter till its further ascent is prevented by the lower face P^8 of the groove P^2 striking against the face P^6. The rapidity with which the valve rises will depend in some measure upon how wide the opening between the lower face P^8 of the groove P^2 and the face P^6 is made by means of the adjustment of the screw S.

The preferred means for operating the lighter and the inlet-valve M and the exhaust-valve N is as follows: The stem M^6 of the valve M extends downward until it is in proximity to its operating-lever M^7, resting on cam M^8. So, also, the stem U′ of the valve U is extended downward until it is in proximity to its operating-lever U^2, resting on its cam U^3. The stem R^2 of the valve R of the igniting device extends up and is connected to the upper cross-piece of the yoke R^3 R^3 R^4 R^4, the said rods R^4 of which yoke reciprocate through

the guides R^5, preferably attached to the valve-chest or other supporting device. The stem R^{50} extends from the lower cross-piece R^3 downward until it rests upon its operating-lever R^6, which latter in turn rests upon its operating-cam R^7. Provision for adjusting the valve R is made in the adjusting screw and nuts R^8 on rod R^5. Each of the rods M^6, R^{50}, and U′ carries springs lettered, respectively, M^9, R^9, and U^4, compressed between the stationary arm *t* and a projection *t′*, preferably adjustable on the lower end of the rod. The rods M^6, R^{50}, and U′ reciprocate through this arm *t*, which latter serves as a guide for them. On the shaft W, journaled in the side of the upper half of the crank-box D, are the cam-carriers, lettered, respectively, M^{10} and Z, the cam-carrier M^{10} carrying the cam M^8 and the cam-carrier Z carrying the cams R^7 and U^3.

I will now proceed to describe the mode and means whereby the governor is enabled to regulate the speed of the engine and also to cut off all admission of combustible gas and air to the engine when the latter is not running. The cam M^8 has a flat peripheral surface rising away from the periphery of the cam-carrier for a short distance. The upper surface of the cam is straight on one side and parallel to the line of direction in which the cam-carrier and cam revolve. The other side of this upper surface is parallel to the other side for a short distance, and then begins to approach the latter and continues to do so to the rear end of the cam. That side of the cam which is continually running obliquely to the line of direction of the revolution of the cam-carrier is beveled or inclined outward, so that the bottom of this part of the cam is wider than the top of the cam. The lever M^7 is arranged to slide longitudinally on the journal-stud t^2. This lever M^7 has a friction-wheel M^{13}, and the latter runs on the cam-carrier and onto and over the cam when the latter is in the same vertical plane with it. The governor is suitably located, preferably attached to the guide or plate *t*. From the governor extends the usual bell-crank lever X′, fulcrumed at X^2. The other end of the lever X′ is notched, and this notch embraces a stud X^3 on the other end of the sliding lever M^7. When the engine is running, the wheel M^{12} of the lever M^9 rides onto the cam M^8 at every revolution of the cam-carrier. As the cam-carrier M^{10} revolves, the cam M^8 comes under the lever M^7, and as the wheel rides up on the cam this lever M lifts the valve-stem M^6 and the valve M and admits the combustible mixture of air and gas into the valve-chamber L. The amount of this combustible mixture introduced into the engine will, other things being equal, determine the force and the rapidity with which the piston descends and determine the capacity of the engine for work. The longer the valve M is open the more of the combustible mixture will be admitted. As the speed of the engine slackens, the balls of the governor will drop and the governor, through the agency of lever X′, will move the lever M^7 to the right, and thus bring cam M^8 under the lever M^7 in the position shown in Fig. 5. The lever M now moves along a longer part of the high portion of the cam M^8, and will then be raised for a longer period than when the left-hand-side portion of this cam was applied to said lever. Consequently the valve M will be longer elevated and a greater quantity of the mixture of air and gas will enter the engine and its working-power will be increased. When the engine is running too fast, the balls of the governor rise and the lever M^7 is moved to the left, (see the dotted lines in Fig. 6,) and the cam M^{10} is brought under the lever M^7 in the position there shown. The lever M^7 will ride upon the short upper portion of the cam M and then slip down the beveled side of the cam, and thus drop the valve M on its seat and cut off the inflow of combustible gas and air to the engine sooner than when the lever M^7 rode upon the full length of the upper surface of the cam M, as shown in dotted lines in Fig. 6.

Midway between the positions shown in solid and dotted lines in Fig. 6, with a proper amount of work to do, is the working position of the cam M^8. Upon a decrease of work to perform, the engine will increase in speed, whereupon the governor moves the lever M^7, so as to decrease the amount of combustible mixture fed to the engine, and thus decrease its speed. Upon an increase of work to be performed the engine, will slacken its speed and the governor then moves the lever M^7, so as to increase the amount of combustible gas and air fed to the engine, and thus increase its speed to the rate the engine is intended to run. When the engine stops for any reason—as, for instance, if the light T^4 in chimney T is intentionally extinguished or should accidentally go out, or the engine should miss exploding for several revolutions, the engine will stop. It is possible that the engine may stop when the lever M^7 is raised by the cam M^8 and valve M is admitting the combustible mixture of gas and air to the valve-chamber. This mixture after filling the valve-chamber and exploding-chamber and cylinder will then leak out down under and past the valve M into passage N′, and thence into passage N and thence into the atmosphere. In order to prevent such a mishap, I provide the following means: The left-hand upper corner M^{12} of the lever M^7 is cut away, as shown in Figs. 5 and 6. When the engine stops, the balls of the governor drop all the way down and move the lever M^7 all the way to the right, as shown in Fig. 5. In this position the lever M^7 does not raise the valve-stem M^6 and the valve M rests upon its seat and shuts off all passage of the combustible mixture into or from the engine. If the lever M^7 be constructed without a recess in its upper corner and is still desired to provide for allowing the valve M in every position of the engine when the latter

is stopped to drop, the lever M^7 may be arranged to slide on its journal still farther to the right, in which event the stem M^6, when the lever M^7 is slid clear to the left, will drop past the side of the latter and the valve M will drop on its seat.

In starting the engine the fly-wheel is revolved, and after the cam M^8 passes from under the lever M^7 the latter is moved to the left, so that when the cam M^8 again comes under the lever M^7 the stem will ride upon the upper surface of the lever M^7. Various means for accomplishing this may be employed. One device for the purpose consists of a suitable fulcrumed lever of **V** shape in cross-section, the end of which is pressed down between the levers M^7 and R^6, and thus keeps the governor raised and the lever M^7 in working position until the engine has fully started. This lever is then removed from between said levers M^7 and R^6.

It may be here remarked that the views taken in Figs. 5 and 6 represent the lever M^7 immediately before it is to ride up upon the cam M^8. The lever M^7 is in the same position in relation to cam M^8 in Figs. 5 and 6 as it is in Fig. 1. Each of the levers M^7, R^6, and U^2 is preferably provided with a friction-wheel, as shown, which rotates upon its adjacent cam-carrier and cam as said cam-carrier revolves. The shaft W is rotated by suitable means, the preferred mechanism for rotating the shaft being a spur-wheel E^2 geared into the spur-wheel E′, the latter being fixed upon and rotated by and concentric with the crank-shaft E. These gear-wheels E′ E^2 are intentionally located within the crank-box D for the purpose of rendering the engine more compact, keeping said gear-wheels free from dirt, also enabling them to be duly oiled. The governor is preferably operated by a band-pulley E^4, rotated by shaft E, which latter, through the agency of belt E^4, rotates pulley E^5, which latter in turn operates the governor. In Fig. 1 the belt E^4 is omitted, in order to exhibit more clearly the mechanism lying behind said belt. On this crank-shaft E at the other side of the engine is the customary fly-wheel Y and the usual pulley Y′.

I will now proceed in general to describe the mode in which my machine operates. The gas is now admitted through the nozzle T and there ignited. The fly-wheel Y is so turned as to bring the engine into the position where the lever M^7 is about to be raised by cam M^8, as shown in Figs. 1, 2, and 4 and in dotted lines in Fig. 6 The combustible gas is then admitted by turning the stop-valve W. The rotation of the fly-wheel is now continued, and the cam M^8 lifts lever M^7 and valve M, thereby admitting the combustible mixture of gas and air to the valve-chamber and the exploding-chamber and cylinder. Meanwhile the piston G has descended, and as it rises again it compresses the combustible mixture which has just filled the cylinder and the chambers L and J. In the meantime the valve R, through the agency of its stems and cam R, is lifted and the valve P rises instantly. At this moment the crank-I is passing its upper center and the lighter-flame T^4 in the chimney T ignites the gas in chambers Q and Q^2, the valve R descends, the valve P drops, and the mixture of gas and air in the valve-chamber L and exploding-chamber J is ignited, and the piston G is thereby propelled downward by the force of this explosion and the engine is now working without extraneous aid. As the fly-wheel continues to turn, the piston begins to rise and the cam U^3 and the lever U^2 operate to lift the stem U′, and with it the exhaust-valve U, from its seat. Nearly all of the residual or consumed gases lying in chamber L and those in exploding-chamber J lying above the lower line of passage-way L′, connecting the exploding-chamber to the valve-chamber L as the piston rises, pass out under the exhaust-valve U down through the passage-way U^4 into the pipe U^5, and thus pass freely into the external atmosphere. As the piston starts to descend, the valve U is closed and the valve M is opened, and the valve-chamber and exploding-chamber and cylinder are again charged with the mixture of gas and air. As the piston reaches the limit of its downward movement, the valve M has closed. As the piston again reaches the limit of its upward movement, the combustible mixture in the engine has been compressed. The valve R now rises, the valve P also instantly rises, and the combustible mixture in chambers Q Q^2 ignited, the valve R descends, the valve P drops, and the combustible compressed gas and air in chambers L and J is ignited and explodes and forces the piston down with power, and said piston communicates its second positive impulse to the fly-wheel and machinery to be operated. As it again rises, the exhaust is opened, and in this manner these successive steps in the process of operating it are repeated, the piston receiving its forceful impulse every fourth stroke—namely, it is forced down after the explosion. This constitutes the first stroke. Next it rises while exhausting all of the consumed gas and air, except a layer aforementioned, close to the piston. This constitutes the second stroke. As it again descends, the cylinder and the exploding and valve chambers receive their fresh supply of combustible mixture. This constitutes the third stroke. As the piston again rises, the combustible mixture of gas and air is compressed, and this constitutes the fourth stroke. Now at the beginning of its fifth stroke—that is, its next series of four strokes—it again receives its forceful positive downward impulse through an explosion of the mixture of gas and air compressed within it.

It may be here remarked that in consequence of the rapid firing of the combustible mixture in the valve-chamber L the exhaust-valve U will become very hot. This I regard as a positive advantage in operating my engine.

The heat from this valve is imparted to the compressed combustible mixture passing over it through chamber L on its way to the cylinder. Thus the temperature of the combustible mixture is raised and the explosion develops greater energy than it would were its own temperature and that of the valve-chamber and exploding-chamber and cylinder at a lower degree of temperature, and economizes a certain amount of heat in the operation of the engine.

It may be here remarked that the valve U is preferably one having a beveled face fitting into a seat having beveled sides, as shown; but the valve may be a flat one or of any other suitable configuration, the seat being adapted to the valve. At each explosion a certain amount of heat is imparted to the walls of the valve-chamber L, and to the valves M and P as well as to exhaust-valve U. The fresh combustible mixture of gas and air entering through the valve M takes up a portion of the heat from the walls of the chamber and from the valves. This absorption of waste heat not only renders the operation of the engine more economical, but also prevents the valve from becoming overheated, and thus precipitating the ignition of the combustible mixture in the engine. For this purpose I have arranged the valve P and valve U so that the inflowing combustible mixture shall come into contact with them and pass around or over them on its way to the cylinder.

To prevent the heat of the walls of the exploding-chamber from being communicated to the walls of the cylinder, I keep the former out of contact with the latter by a layer of asbestus C′, introduced between the lower end of the walls of the exploding-chamber and the upper end of the walls of the cylinder. At the same time I keep the water-spaces of both the chamber and the cylinder in communication with one another by means of the small openings J, heretofore mentioned. I purposely avoid covering the valve-chamber with a water-jacket, as I desire to keep this chamber as hot as possible to impart this heat to the inflowing combustible mixture, and thus economize heat, as aforementioned.

For the purpose of carrying out that feature of my invention which enables me to employ a certain portion of the residual or consumed gases as a cushion interposed between the piston and the fresh incoming supply of combustible mixture of gas and air as aforementioned, the cylinder should be vertical and be located above the crank-shaft. It should be here remarked that the crank-shaft makes two revolutions while the cam-carrier makes one revolution. A recess may be present in the lower part of the interior of chamber P′ and take the place of the recess or groove P^2 on valve P.

While the various features of my invention are preferably employed together, one or more of them may be employed without the remainder, and in so far as applicable one or more of said features may be used in connection with gas-engines other than the one herein specifically specified.

What I claim as new, and desire to secure by Letters Patent, is—

1. The inlet-passage communicating with the exploding-chamber, a reciprocating valve P, having a stem with side grooves and a head within the inlet-passage, and igniting means above the valve-stem, whereby the flame from outside may communicate along the valve-stem to the inlet-passage, in combination, substantially as described.

2. The combination, with the inlet-passage, of a valve, as P, having a head in the passage and a grooved stem, a chamber above said valve P, a valve reciprocating in and controlling said chamber, and igniting means in proximity to the grooved valve-stem, substantially as described.

3. The combination of the inlet-passage, the valve P, having a head in said passage and a grooved stem, a chamber above said valve-stem which is opened or closed by a reciprocating valve R, and a burner in proximity to said chamber and in position to ignite the gas escaping around the grooved stem when the chamber is opened by movement of valve R, substantially as described.

4. The combination of the inlet-passage, the valve P, having a grooved stem and a head in said passage, igniting means near the valve-stem, and an adjustable support for the valve, whereby its initial position is determined.

5. The combination, with the inlet-passage, of an inlet or supply-controlling valve M, a rod extending from said valve, a rotating cam in proximity to said rod, said cam having actuating-surfaces of different lengths, and an intermediate lever between the cam and rod, said lever movable into position to lift the valve-rod and valve for a longer or shorter time, according to the cam-surface which actuates it, substantially as described.

6. The combination of the supply-controlling valve and its stem, a moving cam in proximity to said stem having bearing-surfaces of different lengths, a lever between the cam and valve-stem, the governor, and a connection from the governor to said lever, whereby the governor determines the position of the lever and the lever determines the length of cam-surface (and therefore of time) which is operative to open the valve.

7. The combination of the inlet-controlling valve, its stem, and operating-cam, an intermediate lever cut away at one side, and operative connections from the governor to said lever, whereby the lever is shifted entirely out of contact with the valve-stem when the engine stops, so that the valve will be closed automatically, substantially as described.

8. The combination of the supply-valve, stem, and controlling-cam having surfaces of different lengths to operate said stem, the exhaust-valve and a cam to operate the same, and the ignition-controlling valve and cam,

said cams being in proximity and having the described relation to the different valve-stems, substantially as described.

9. The combination, with the valve P, having its head in the supply-passage, of the adjusting-screw S, extending into the valve-chamber and forming a rest for said valve P, substantially as described.

10. The combination of the cam R^7, lever R^6, stem R^5, and valve R, having a yoke connected to said stem, and means for depressing said valve R, substantially as described.

BENJAMIN C. VANDUZEN.

Attest:

M. C. SIMON,

G. A. W. PARER.