No. 634,529. Patented Oct. 10, 1899.

A. LEE.

GAS ENGINE.

(Application filed Apr. 25, 1898.)

(No Model.) 2 Sheets—Sheet 1.

FIG. 6.

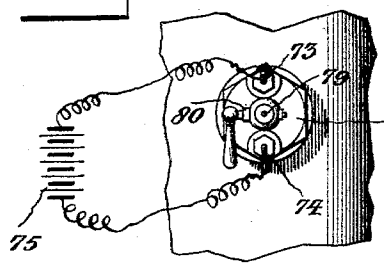


FIG. 4.

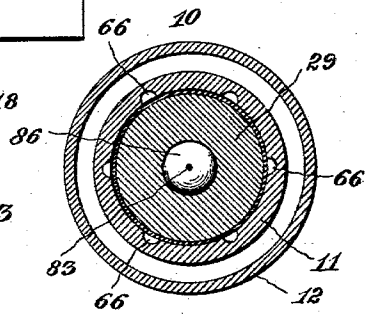


FIG. 1.

Witnesses

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(No Model.) 2 Sheets—Sheet 2.

FIG. 3.

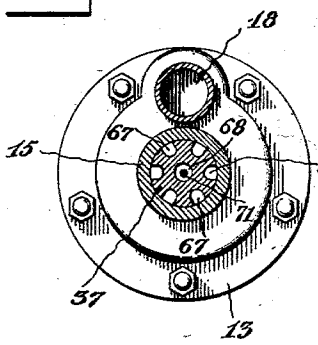


FIG. 2.

FIG. 5.

Witnesses

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UNITED STATES PATENT OFFICE.

ALFRED LEE, OF NEW WHATCOM, WASHINGTON.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 634,529, dated October 10, 1899.

Application filed April 25, 1898. Serial No. 678,776. (No model.)

To all whom it may concern:

Be it known that I, ALFRED LEE, a citizen of the United States, residing at 900 High street, New Whatcom, State of Washington, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

My invention relates to gas and similar engines, and has for its object to provide a simple, compact, and efficient construction and arrangement of parts, whereby a high speed of movement may be secured, the same being of the two-cycle rear-compression type, wherein an explosion is produced for each stroke of the piston.

A further object of the invention is to provide improved means whereby the products of combustion may be thoroughly exhausted from the combustion-chamber prior to the admission of a new charge of the explosive agent, this exhaust of the products of combustion being accomplished by admitting a scavenger charge of air under pressure at the proper point in the stroke of the piston, and, furthermore, to provide a novel arrangement of supply and exhaust passages, whereby the construction is simplified and the number of valves reduced to the minimum.

A further object of the invention is to provide such means for supplying the combustion or explosion chamber with motive agent that a liquid fuel may be employed, the same being vaporized in its passage to the explosion-chamber and admitted thereto in a gaseous state.

Furthermore, my invention relates to means in connection with an igniter whereby the efficiency of operation of the latter may be ascertained by the engineer.

Further objects and advantages of this invention will appear in the following description, and the novel features thereof will be particularly pointed out in the appended claims.

In the drawings, Figure 1 is a vertical central sectional view of an engine constructed in accordance with my invention, the plane of the section being at right angles to the axis of the crank-shaft. Fig. 2 is a vertical sectional view of the engine, taken parallel with and in the plane of the axis of the crank-shaft. Fig. 3 is a horizontal section taken on the plane indicated by the lines 3 3 of Figs. 1 and 2, the piston being in the elevated position indicated in Fig. 2. Fig. 4 is a horizontal section taken in the plane indicated by the line 4 4 of Fig. 1. Fig. 5 is a detail vertical section on the plane indicated by the line 5 5 of Fig. 2. Fig. 6 is a front view of the igniter mechanism.

Similar reference characters indicate corresponding parts in all the figures of the drawings.

The casing of the engine embodying my invention consists, essentially, of a body portion 10, having an inner cylinder 11, surrounded by a jacket 12, which is spaced from the cylinder to form an intervening water-chamber, a casing-head 13, fitted in the construction illustrated upon the upper end of the body portion of the casing and having a reduced guide 14 and a tubular casing-head extension 15, bolted or otherwise secured to the casing-head, the interior of said extension forming a vapor-chamber 16. In the base of the extension 15 and surrounding the bore thereof is an annular exhaust-chamber 17, with which communicates an exhaust-pipe 18, the exhaust-chamber being in communication with the above-mentioned guide 14 in the casing-head. The casing is extended downward and its bore enlarged to form a crank-pit 19, fitted with removable heads 20, in the centers of which are formed journal boxes or bearings 21 for the crank-shafts 22. The crank 23, which preferably consists of parallel disks, is arranged in the crank-pit, said crank-disks being connected transversely by a wrist-pin 24. Also in the side walls of the crank-pit I have shown removable side plates 25, which close the core-openings designed to give access to the interior of the crank-pit without removing the heads 20, in which the crank-shaft is mounted, and also fitted in an opening in the bore of the crank-disk and forming the center of the base 26 is a tapered block 27. I desire to utilize the crank-pit first as an air-compression chamber and also as a lubricating-chamber, the compression of air therein being accomplished by means of a piston 28, of which the head 29 fits snugly in the cylinder and is adapted to reciprocate toward and from the crank-pit to communicate motion through a pitman 30 to the crank.

During the upward or outward stroke of the piston air is admitted to the crank-pit through an air-supply port 31, controlled by an inlet-valve 32, which is yieldingly held in its seat by any suitable means, gravity in the present instance being depended upon for this purpose, the valve being arranged to operate vertically and to close in a downward direction. Obviously the application of pressure to the contents of the crank-pit during the downward stroke of the piston serves to retain this inlet-valve seated and prevent a reduction of pressure through the port 31. Core-openings 33 in the sides of the casing are fitted with covering-plates 34, and communicating with the interior of the water-jacket are inlet and outlet pipes 35 and 36 for the admission and exhaust of water or other cooling agent to maintain the piston-cylinder at a suitable working temperature. The piston in addition to its head 29 is provided with a reduced extension or stem 37 of a diameter corresponding with that of the above-mentioned guide 14 in the head of the cylinder, suitable contractile packing-rings 38 being seated in said guide to surround the piston extension or stem and prevent the exhaust of pressure through the guide. The upper end of the piston stem or extension is adapted to operate in the vapor-chamber 16, and to maintain a suitable fluid-tight contact with the walls thereof it is provided with packing-rings 39, explosive gas or vapor being admitted to the chamber 6 through a port 40, preferably at its upper end, said port being fitted with an inlet-valve 41, normally and yieldingly held seated by a spring 42, bearing at one end against an adjustable stop 43, threaded upon the stem of the valve and located exteriorly of the vapor-chamber. This inlet-port is supplied by an induction-tube 44, having an open inlet end adapted to receive atmospheric air and also having arranged therein a fuel-supply nozzle 45, which is of less diameter than the induction-tube to provide for the simultaneous admission of fuel and air into said tube. Said supply-nozzle is in turn in communication with a fuel-pumping mechanism 46, of which any desired construction may be employed. In the drawings, however, I have illustrated a preferred form of pumping mechanism embodying a pump-cylinder 47, interiorly in communication with a fuel-supply pipe 48, (see Fig. 5,) a plunger 49 operating in said pump-cylinder, and an operating-pin 50, connected by an arm 51^a with the plunger and adapted to be repressed once for each stroke of the cylinder-piston 28 by means of a pressure-block 51, carried by a fly or balance wheel 52, fixed to the crank-shaft 22. Also in operative relation with the pump-plunger 49 is an actuating-spring 53, whereby as the pressure-block 51 represses the operating-pin 50 this actuating-spring is compressed, and upon the release of the operating-pin 50 said spring advances the pump-plunger to discharge the contents of the pump-cylinder through the nozzle 45.

Inasmuch as the length of stroke of the pump-plunger regulates the amount of discharge from the nozzle 45 at each advance movement of said plunger and as it is desirable to vary the amount of discharge to suit the requirements of the engine, I employ an adjustable stop 54, consisting of a sleeve adjustably fitted in a yoke 55 and forming a guide and bearing for the operating-pin 50, said yoke being bolted or otherwise secured in a suitable manner to the casing of the engine, as, in the construction illustrated, to the adjacent journal-box 21 of the crank-shaft. The extremity of this stop-sleeve is arranged in the path of a shoulder 56 on the operating-pin, and by adjusting the sleeve a forward movement of the pump-plunger may be checked at any desired point. In practice I prefer to thread said stop-sleeve in the yoke 55 and fitted at its outer end with a wrench-seat 57, and also to reduce to the minimum the friction due to the contact of the block 51 with the operating-pin I preferably construct said block as a roller carried by a suitable spindle 58.

While the above-described means for varying the supply of fuel to the vapor-chamber is sufficient to obtain an approximate adaptation of power to the load, it is also desirable to provide automatic means whereby an approximately uniform speed of movement of the mechanism may be maintained under variations of load during the operation of the mechanism, and hence in practice I employ a governor for varying the path of movement of the pressure-block 51 with relation to the extremity of the operating-pin 50. In the construction illustrated this governor consists of a lever 59, having a terminal weight 60, which is yieldingly held in its normal position adjacent to the axis of movement of the crank-shaft by means of a governor-spring 61, of which the tension may be varied by means of adjusting-nuts 62, threaded upon a stem 63. This governor-arm is fulcrumed at 64 upon the balance or fly wheel 52, and in it is mounted the spindle 58 of the pressure-block 51, whereby as the speed of rotation of the fly-wheel increases and the weighted end of the governor-lever recedes from the axis of movement by centrifugal force the block 51 is withdrawn more or less from the plane of the extremity of the operating-pin 50 to impart less movement to said pin, and hence less movement to the pump-plunger. In case of a sudden reduction of load the movement of the governor-lever may be such as to entirely withdraw the pressure-block from operative relation with the operating-pin 50, and thus allow the engine-piston to make one or more strokes without a supply of fuel.

The influx of air through the pipe 44 necessary to induct fuel from the supply-nozzle 45 into the vapor-chamber and at the same

time partially or wholly vaporize said fuel is accomplished by the downward or inward movement of the piston extension in the vapor-chamber, the mixture of fuel and air being admitted to the vapor-chamber through the port 40 during the movement of the piston under the influence of an explosion in the chamber 65, formed by the portion of the interior of the cylinder between the plane of the piston-head 29 and the casing-head 13. Also during this downward or inward stroke of the piston the air which has been inducted into the compression-chamber formed by the crank-pit through the inlet-port 31 is being compressed. As the piston-head approaches the limit of its downward or inward stroke it exposes or opens a series of cylinder inlet-channels 66, formed in the wall of the cylinder, said channels being in communication at their lower ends with the crank-pit. Thus at the moment of opening the channels 66 the compressed air in the crank-pit passes the piston-head and constitutes a scavenger charge of air, which drives the products of combustion in the explosion-chamber through cylinder outlet-channels 67, which are formed in the piston extension, and into the exhaust-chamber 17, said channels 67 being so arranged in the piston extension as to occupy a position in the guide 14, and hence connect the upper end of the explosion-chamber with the exhaust-chamber at the moment that the cylinder inlet-channels 66 are exposed. The capacity of the crank-pit and the compression of air therein during the downward or inward stroke of the piston are such that when the scavenger charge of air is liberated by the exposure of the cylinder inlet-channels 66 all of the products of combustion are expelled into the exhaust-chamber, and the explosion-chamber, or the portion of the cylinder above the piston-head, contains only pure air adapted for immediate admixture with a charge of explosive agent, which when the piston is at the limit of its downward movement is contained in the vapor-chamber 16.

Formed in the piston extension is a longitudinal conveyer-channel 68, in communication at its upper end with the vapor-chamber 16 and provided at its lower end with lateral ports 69, controlled by an inwardly-opening valve 70, of which the stem 71 extends through the conveyer-channel to a point near its upper end and is connected with a valve-seating spring 72, designed to normally cut off communication between the vapor-chamber and the interior of the cylinder. Obviously during the downward stroke of the piston the pressure of the contents of the cylinder serves to maintain the valve 70 in a seated position; but when after the liberation of the scavenger charge of air the piston starts upon its outward movement and progresses in that direction sufficiently to close the channels 66 and 67 the pressure applied by the upper end of the piston extension to the contents of the vapor-chamber is sufficient to overcome the tension of the spring 72 and unseat the valve 70 to allow the mixture of gas and air in said vapor-chamber to pass through the conveyer-channel 68 and into the explosion-chamber of the cylinder. The path of the piston is such as to entirely discharge the contents of the vapor-chamber into the cylinder, and at the proper point in the outward movement of the piston an igniter is actuated to explode the contents of the cylinder, and thus impart a succeeding downward or inward movement to the piston.

Various forms of igniting devices may be employed in connection with the mechanism above described; but that form which I have illustrated and prefer to employ in this connection embodies terminals 73 and 74, in circuit with a battery 75 and a circuit-breaking tongue 76, pivotally mounted upon the terminal 73 and having a shoulder 77 for normal contact with the extremity of the terminal 74. This tongue is arranged in the path of a stud, pin, or other projection 78, carried by the piston and head, and it is obvious that when said projection comes in contact with the tongue and lifts the shoulder of the latter from the terminal 74 a spark is produced which serves to ignite the inflammable contents of the explosion-chamber and impart an inward impulse to the piston. The terminal 74 is adjustable to vary the position of the circuit-breaking tongue, and thus the point at which the projection 78 will come in contact with said tongue, whereby the desired compression of the contents of the explosion-chamber may be effected prior to the explosion thereof. Furthermore, in order that the position of the circuit-breaking tongue and the efficiency of the spark produced at the moment of breaking the circuit may be viewed from the exterior of the engine I employ a peep-channel 79, in alinement approximately with the extremity of the terminal 74 and having a valve 80, whereby said channel may be closed. Furthermore, to facilitate the removal of the igniting mechanism from the engine-casing, whereby repression or adjustment thereof may be made without dismounting other members of the mechanism, I preferably seat the terminals with the connected circuit-breaking tongue upon a plug 81, which is removably fitted, as by threads, in a suitable opening in the side wall of the casing, the above-described peep-channel 79 with its controlling-valve being arranged in said plug.

I preferably construct the piston in sections, of which the head and the extension form separate members connected by a coupling-plug 83. As hereinbefore indicated, I desire to utilize the crank-pit as a lubricating-chamber from which oil may be conveyed to the piston and to the joint between said piston and the pitman, and hence in the drawings the pitman is shown as constructed with an oil-duct 83, having its lower inlet end fitted with a tube 84, of which the inner end constitutes a seat for a valve 85, adapted to close during the

outward movement of the piston and to open for the admission of oil during the inward movement of the piston and when the lower extremity of said tube 84 is submerged in the oil at the bottom of the crank-pit. The pitman is preferably connected with the piston by a ball-and-socket joint, of which the ball 86 is formed on the extremity of the pitman, and the oil-duct 83 extends through the ball and communicates at its upper end with a transverse oil-passage 87, formed in the piston and communicating terminally with an annular oil-channel 88, formed in the surface of the piston. Furthermore, in order to reduce to the minimum the friction due to the rotation of the crank-shaft I preferably avoid the use of stuffing-boxes and in lieu thereof arrange annular gibs 89 in the heads 20 of the crank-pit to bear at their inner edges against the exterior surfaces of the disks forming the crank, said gibs being yieldingly held in operative relation with the crank-disks by means of actuating-springs 90. Also in the exterior surfaces of the gibs are arranged packing-rings 91 for contact with the adjacent surfaces of the cavities in which the gibs are fitted. A further function of these gibs is to maintain the crank-disk accurately centered between the heads 20 of the crank-pit, and thus prevent axial movement of the crank-shaft, which will tend to cause frictional contact of the crank-disks with said crank-pit heads.

The operation of the mechanism, including the induction of the fuel in the form of a spray to adapt it to be taken up by an influx of air through the feed-tube 44, will be readily seen from the foregoing description, and it should be further understood that even if the vaporization of the fuel is only partially accomplished by this influx of air the complete vaporization thereof will ensue during the passage of the contents of the vapor-chamber through the conveyer-channel 68 of the piston on its way to the interior of the explosion-chamber by reason of the fact that the piston is maintained at a vaporizing temperature by the explosions in the chamber 65. Thus before the fuel can reach the explosion-chamber it is in a state of vapor and is intimately mixed with the air with which it has been inducted and is ready for further mixture with the atmospheric contents, consisting of the scavenger charge of air in the explosion-chamber.

While I have described in detail various accessory means—such as an igniter, a pump, a speed-regulator, and a lubricating device, these being the preferred devices for securing an efficient operation of the mechanism embodying my invention—it will be understood that I do not desire to be limited to the construction of these parts, as it is obvious that others of like function may be substituted therefor without detracting from the efficiency of the general organization of the engine, and, furthermore, it will be understood that various other changes in the form, proportion, and the minor details of construction may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention.

Having described my invention, what I claim is—

1. A gas-engine having a cylinder, and a communicating air-compression chamber provided with a valve-controlled inlet-port, and a piston operating in the cylinder and having a stem, said cylinder being provided with piston-controlled inlet-passages in communication with the air-compression chamber, and also having piston-controlled outlet-passages formed in said stem and adapted for exposure simultaneously with the inlet-passages, in combination with means for admitting a motive agent to the cylinder subsequent to the opening of said inlet-passages, substantially as specified.

2. A gas-engine having a cylinder and a communicating crank-pit forming an air-compression chamber provided with a valved air-induction port, a crank arranged in said crank-pit, a piston arranged in the cylinder and connected with said crank, a stem for the piston, passed outwardly of the cylinder inlet-channels in the walls of the cylinder in communication with the crank-pit and controlled by the piston, piston-controlled exhaust-passages, formed in said stem and means for admitting a motive agent to the cylinder subsequent to the opening of said inlet-passages, substantially as specified.

3. A gas-engine having a cylinder and a piston, a crank-pit having its contents exposed to the compressive force of the piston and provided with a valved air-induction port, a crank arranged in the crank-pit and having its shaft extending through openings in the walls of the crank-pit, means for communicating motion from the piston to the crank, piston-controlled cylinder inlet and outlet passages, of which the former are in communication with the interior of the crank-pit, and gibs for cutting off communication between the interior of the crank-pit and the openings through which the crank-shaft extends, in combination with means for admitting a motive agent to the cylinder subsequent to the opening of said inlet-passages, substantially as specified.

4. A gas-engine having a cylinder and a piston, a crank-pit having its contents exposed to the compressive force of the piston and provided with a valved air-induction port, a crank arranged in the crank-pit and having its shaft extending through openings in the walls of the crank-pit, means for communicating motion from the piston to the crank, piston-controlled cylinder inlet and outlet passages, of which the former are in communication with the interior of the crank-pit, and gibs mounted in the walls of the crank-pit around said openings therein and bearing against opposite sides of the crank to cut off

communication between the interior of the crank-pit and said openings, in combination with means for admitting a motive agent to the cylinder subsequent to the opening of said inlet-passages, substantially as specified.

5. A gas-engine having a cylinder and a piston, a crank-pit having its contents exposed to the compressive force of the piston and provided with a valved air-induction port, a crank arranged in the crank-pit and having its shaft extending through openings in the walls of the crank-pit, a pitman connecting the piston with said crank and provided with a valved oil-duct opening into the crank-pit, said piston having an oil-passage, in communication with said oil-duct, and terminating at the bearing-surface of the piston, piston-controlled-cylinder inlet and outlet passages, of which the former are in communication with the interior of the crank-pit, and packing devices for cutting off communication between the interior of the crank-pit and the openings through which the crank-shaft extends, in combination with means for admitting a motive agent to the cylinder subsequent to the opening of said inlet-passages, substantially as specified.

6. A gas-engine having a cylinder and piston, the piston being provided with an extension operating in a guide in the cylinder-head, an exhaust-chamber in communication with said guide and normally cut off from communication with the cylinder by the piston extension, the piston-controlled-cylinder outlet-channels for establishing communication between the cylinder and the exhaust-chamber, and means for admitting a scavenger charge of air, under pressure, to the cylinder when said outlet-channels are in communication with the cylinder and exhaust-chamber, in combination with means for admitting a motive agent to the cylinder subsequent to the closing of said outlet-channels, substantially as specified.

7. A gas-engine having a cylinder and piston, the piston being provided with an extension operating in a guide in the cylinder-head, an exhaust-chamber in communication with said guide and normally cut off from communication with the cylinder by the piston extension, piston-controlled-cylinder outlet-channels for establishing communication between the cylinder and the exhaust-chamber, and piston-controlled means for admitting a scavenger charge of air, under pressure, to the cylinder when said outlet-channels are in communication with the cylinder and exhaust-chamber, in combination with means for admitting a motive agent to the cylinder subsequent to the closing of said outlet-channels, substantially as specified.

8. A gas-engine having a cylinder and piston, the piston being provided with an extension operating in a guide in the cylinder-head, an exhaust-chamber in communication with said guide and normally cut off from communication with the cylinder by the piston extension, cylinder outlet-channels formed in the piston extension for connecting the interior of the cylinder with said exhaust-chamber, and means for admitting a scavenger charge of air, under pressure, to the cylinder when said outlet-channels are in communication with the cylinder and exhaust-chamber, in combination with means for admitting a motive agent to the cylinder subsequent to the closing of said outlet-channels, substantially as specified.

9. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, and a valved conveyer-passage in the piston extension for establishing communication between the vapor-receiving chamber and the cylinder, in combination with means for admitting motive agent to the vapor-receiving chamber, substantially as specified.

10. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber, a conveyer-passage in the piston extension communicating at one end with the vapor-receiving chamber and at the other end with the cylinder, and a pressure-actuated valve for controlling said conveyer-passage, in combination with means for admitting motive agent to the vapor-receiving chamber, substantially as specified.

11. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber, a conveyer-passage in the piston extension communicating at one end with the vapor-receiving chamber and at the other end with the cylinder, and a pressure-actuated spring-closed valve for controlling said conveyer-passage, in combination with means for admitting motive agent to the vapor-receiving chamber, substantially as specified.

12. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved induction-passage in communication with the vapor-receiving chamber, and means for admitting fuel to the induction-passage, substantially as specified.

13. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and means for admitting fuel to the induction-passage in the path of air passing therethrough, substantially as specified.

14. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the

piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and means for admitting liquid fuel to the induction-passage in the path of air passing therethrough, substantially as specified.

15. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and means for periodically admitting fuel to the induction-passage in the path of air passing therethrough, substantially as specified.

16. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and a pump for discharging fuel into the induction-passage in the path of air passing therethrough, substantially as specified.

17. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and a pump for discharging fuel into the air-induction passage in the path of, and in the direction of movement of, air passing therethrough, substantially as specified.

18. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and a pump mechanism for spraying fuel into the induction-passage in the path of air passing therethrough, substantially as specified.

19. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and means for periodically discharging fuel into the induction-passage simultaneously with the movement of the piston extension in receding from the communicating end of the induction-passage, substantially as specified.

20. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and governor-controlled pump mechanism for discharging fuel into the induction-passage in the path of air passing through the latter, substantially as specified.

21. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and governor-controlled pump mechanism having a nozzle arranged in the inlet end of the induction-tube adjacent to an air-influx passage, substantially as specified.

22. A gas-engine having a cylinder and piston, the latter being provided with an extension, a vapor-receiving chamber in which the piston extension operates, piston-controlled means for establishing communication between the vapor-receiving chamber and the cylinder, a valved air-induction passage in communication with the vapor-receiving chamber, and governor-controlled pump mechanism having a nozzle arranged in the inlet end of the induction-passage, and of less diameter than said passage to form a surrounding air-influx channel, substantially as specified.

23. A gas-engine having an air-chamber and a vapor-receiving chamber, and an intermediate combustion-chamber, a piston operating in the combustion-chamber and adapted to compress the contents of the air-chamber during its forward movement when actuated by pressure in the combustion-chamber, a stem for the piston entering the vapor-chamber and adapted to compress the vapor therein for a portion of its motion in an opposite direction, a vapor-chamber adapted to communicate at times with the combustion-chamber and having means for admitting a vapor thereto and independent piston-controlled passages in the cylinder-wall and piston-stem for connecting said vapor and air chambers with the combustion-chamber, substantially as specified.

24. A gas-engine having an air-compression chamber, a combustion-chamber, a vapor-receiving chamber and an exhaust-chamber, a piston operating in the combustion-chamber, piston-controlled passages for connecting the air compression and exhaust chambers with

the combustion-chamber, and a further passage formed in the piston for establishing communication between the vapor-chamber and the combustion-chamber, substantially as specified.

25. A gas-engine having an air-compression chamber, a combustion-chamber, a vapor-receiving chamber and an exhaust-chamber, a piston operating in the combustion-chamber, independent piston-controlled passages for connecting the air compression and exhaust chambers with the combustion-chamber at the limit of movement in one direction of the piston, and another valve-controlled passage formed in the piston for establishing communication between the vapor-chamber and the combustion-chamber during the movement of the piston in the opposite direction, substantially as specified.

26. A gas-engine having a combustion-chamber, an air-compression chamber and a vapor-receiving chamber, a piston operating in the combustion-chamber, air inlet and exhaust passages for respectively connecting the air-compression chamber with the combustion-chamber and the combustion-chamber with an exhaust-port, said passages being piston-controlled and adapted to be opened when the piston reaches the limit of its power-stroke, and a conveyer-passage formed in the piston, for establishing communication between the vapor-receiving chamber and the combustion-chamber during the compression-stroke of the piston, and having a yielding check-valve for closing said conveyer-passage during the power-stroke of the piston, substantially as specified.

In testimony that I claim the foregoing as my own I have hereto affixed my signature in the presence of two witnesses.

ALFRED LEE.

Witnesses:
T. E. CADE,
FEARLLITA C. STADELMAN.