(No Model.)

5 Sheets—Sheet 1.

C. L. GROHMANN.

GAS ENGINE.

No. 574,535. Patented Jan. 5, 1897.

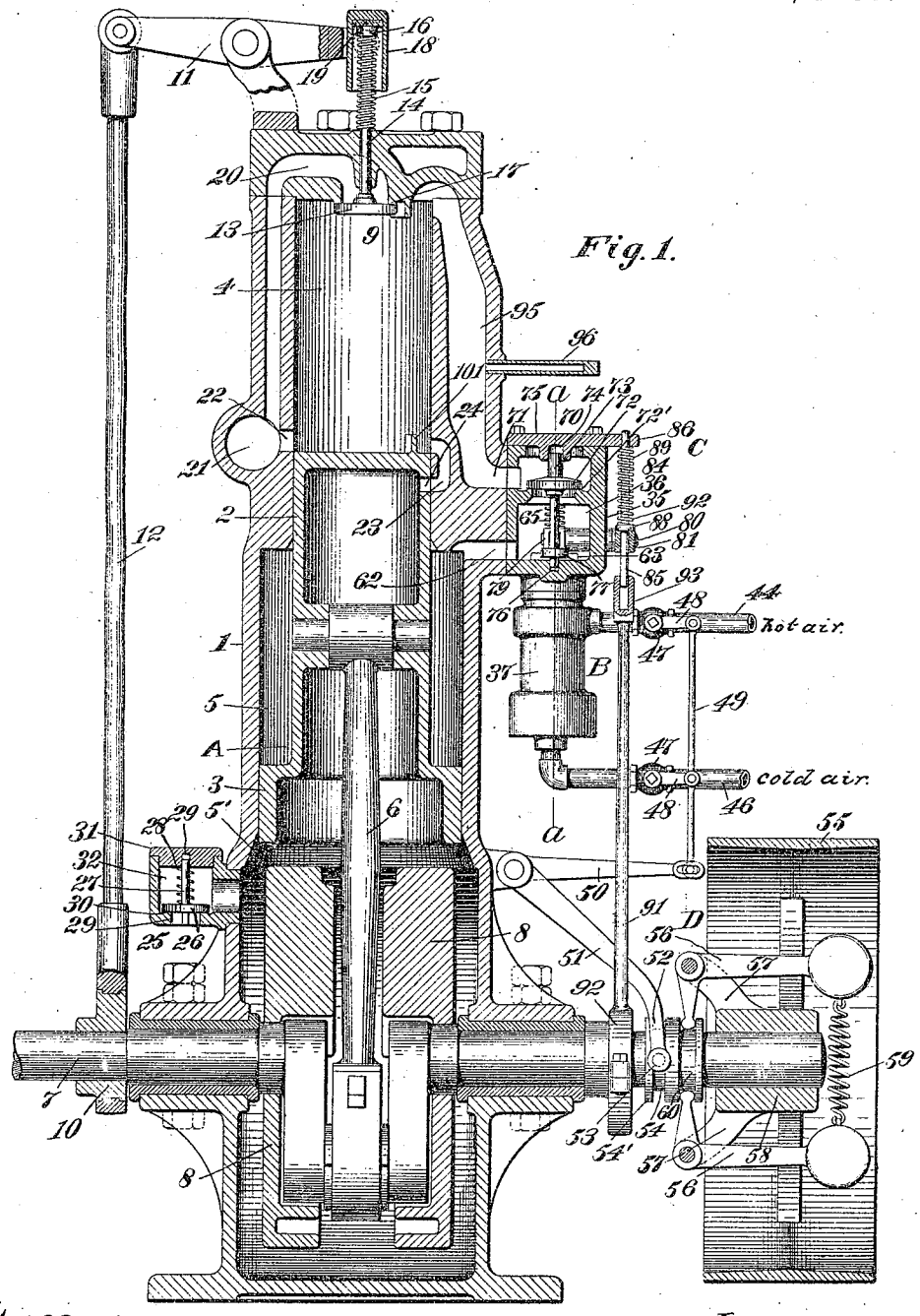

Fig. 1.

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(No Model.) 5 Sheets—Sheet 2.

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Fig. 2.

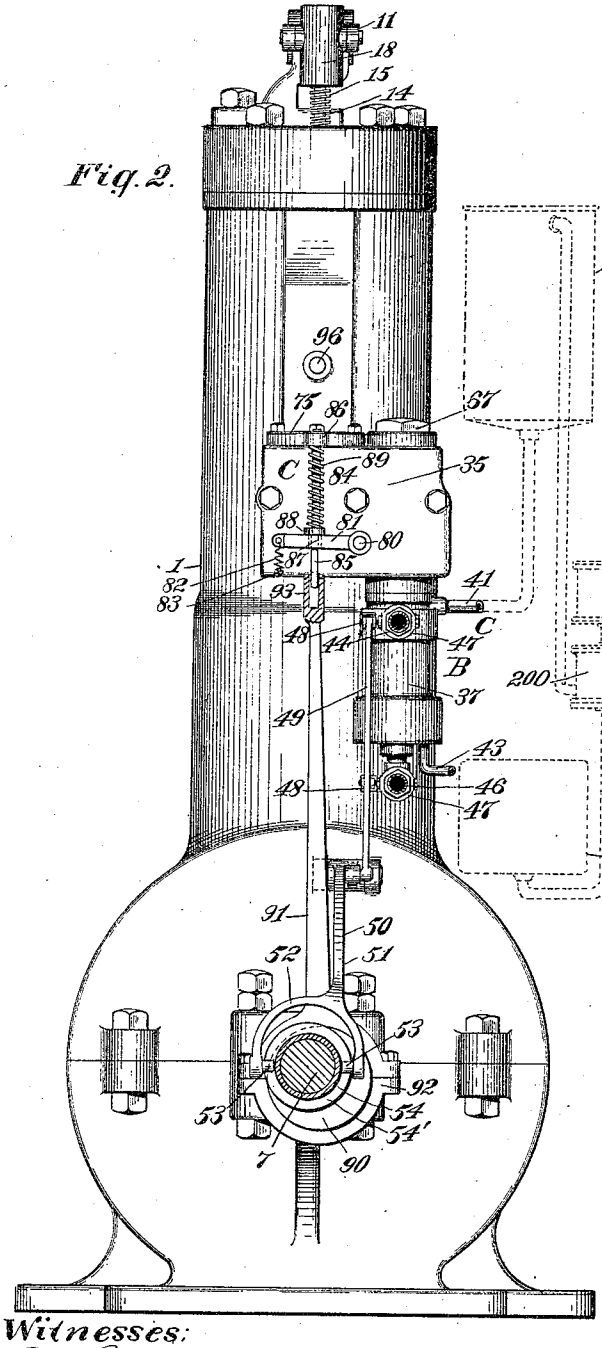
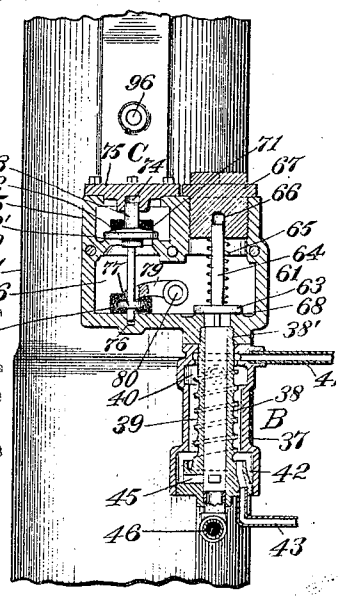


Fig. 3.



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(No Model.) 5 Sheets—Sheet 3.

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Fig. 4.

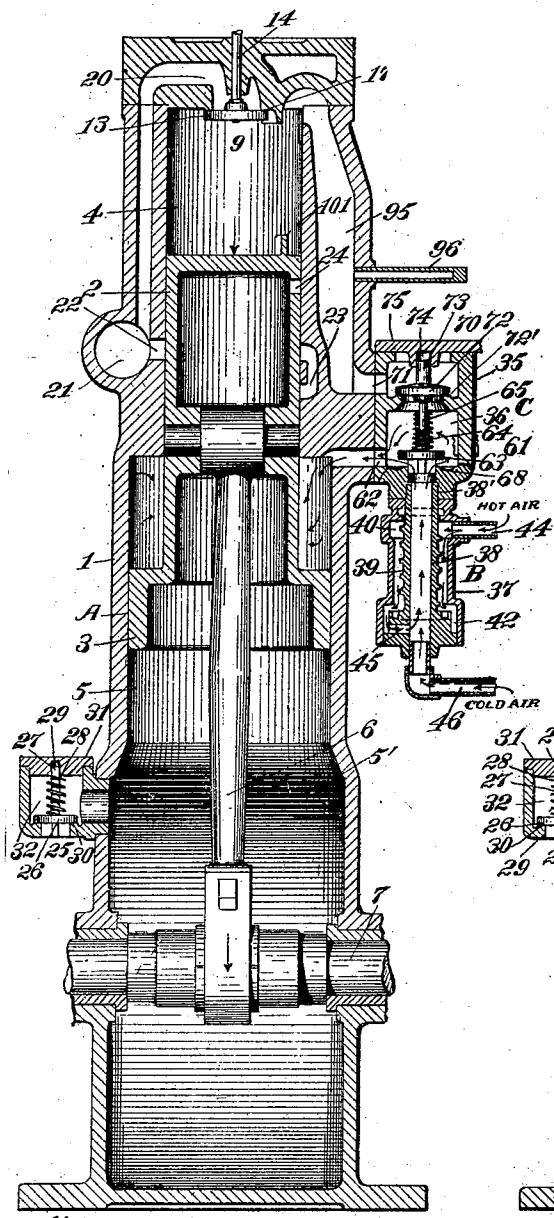
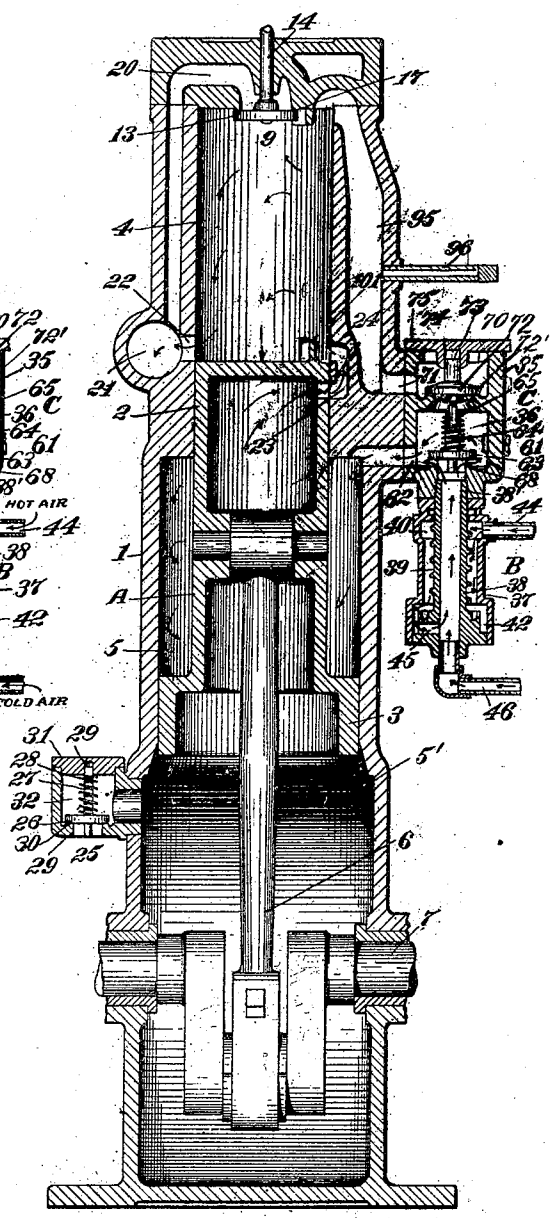


Fig. 5



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(No Model.) 5 Sheets—Sheet 4.

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Fig. 6.

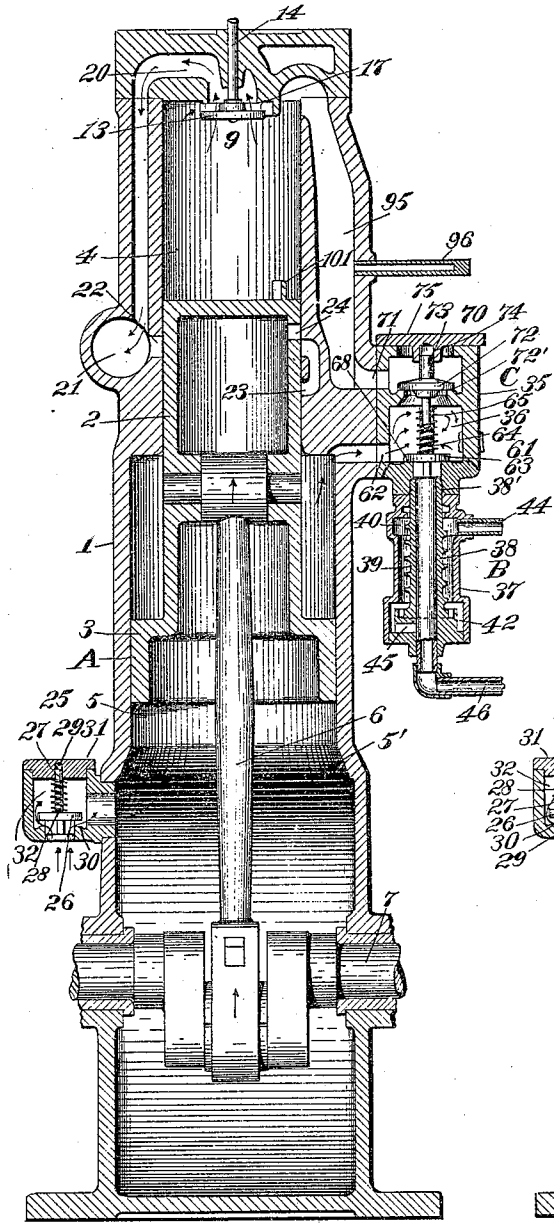
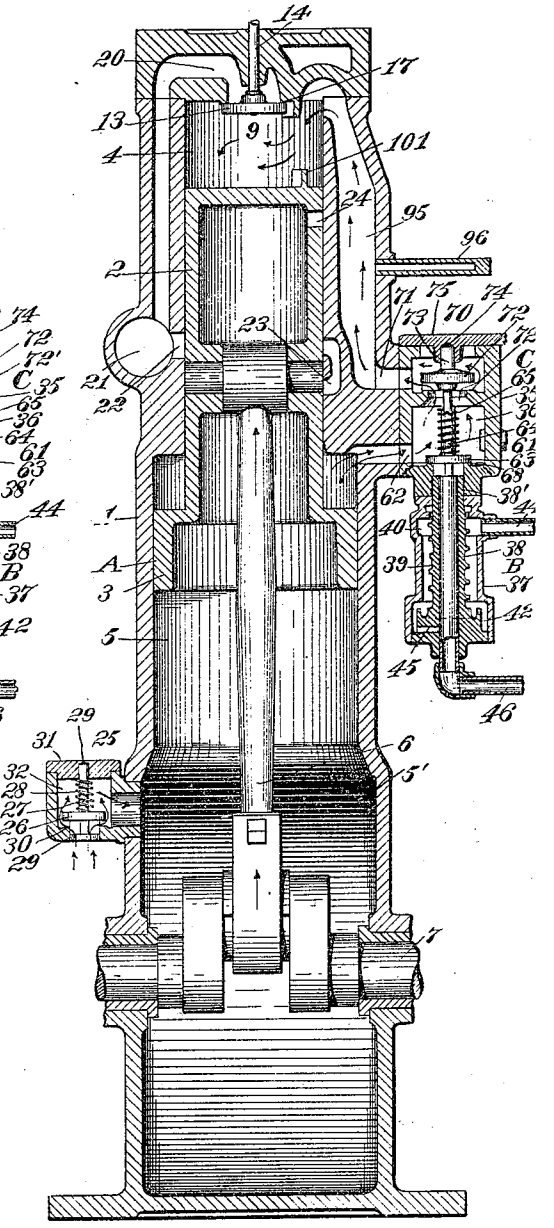


Fig. 7.



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(No Model.) 5 Sheets—Sheet 5.

C. L. GROHMANN.

GAS ENGINE.

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Fig. 10.

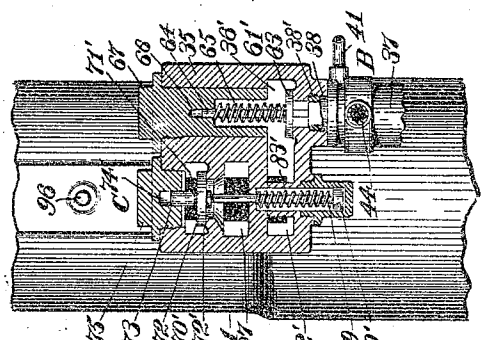


Fig. 9.

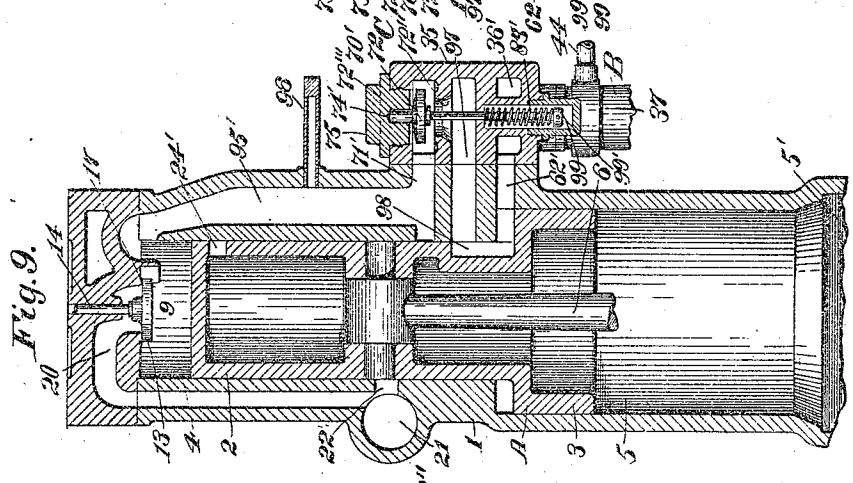
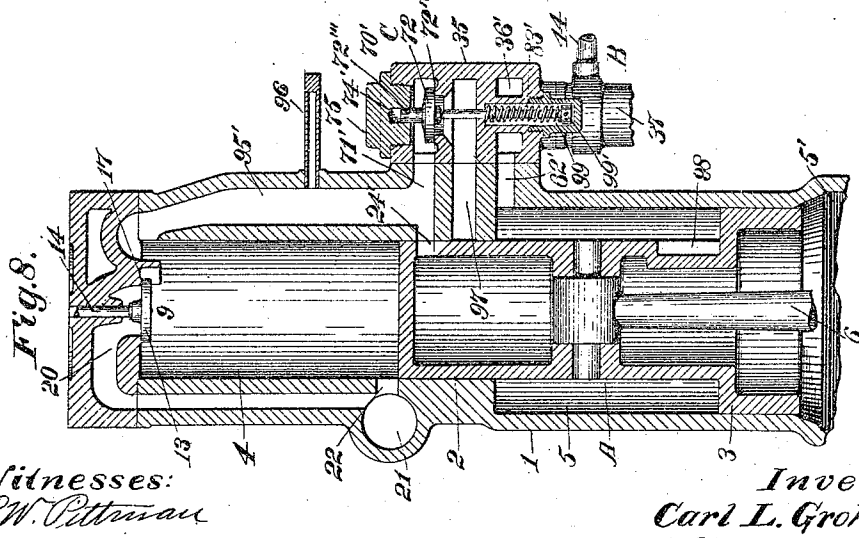


Fig. 8.



Witnesses:
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UNITED STATES PATENT OFFICE.

CARL L. GROHMANN, OF HARTFORD, CONNECTICUT.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 574,535, dated January 5, 1897.

Application filed March 31, 1896. Serial No. 585,647. (No model.)

To all whom it may concern:

Be it known that I, CARL L. GROHMANN, a citizen of the United States, residing in Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Gas-Engines, of which the following is a specification.

This invention relates to gas-engines, and more particularly to that class known as "explosive" gas-engines; and the object of the invention is to provide an engine which, as compared with analogous devices of this charater, will be simple and effective in construction, and to furnish the same with an improved organization of piston and valve mechanisms, in connection with improved and effective means for making and supplying gaseous fluid to the engine, whereby an explosion at each revolution of its crank-shaft is obtained, thus constituting a continuously-operating engine without requiring a multiplicity of independently-actuating pistons.

In the drawings accompanying and forming a part of this specification, Figure 1 is a vertical sectional view of this improved engine, partly in elevation. Fig. 2 is a right-hand side view thereof, showing in dotted lines a liquid-reservoir, a pump, and an overflow-tank in operative connection therewith and having the pulley-wheel and governor removed. Fig. 3 is a vertical cross-sectional view of the valve-chest and evaporator, taken in line *a a*, Fig. 1, and looking toward the left hand. Figs. 4, 5, 6, and 7 are vertical sectional views similar to the view shown in Fig. 1 with portions of the operating mechanism removed and illustrating different positions of the piston and the valve mechanisms. Figs. 8 and 9 are vertical sectional views similar to Fig. 1 with parts of the device removed and showing another construction of means for regulating the flow of gaseous fluid from the compression-chamber to the working chamber of the piston-cylinder; and Fig. 10 is a cross-sectional view of the valve-chest, substantially taken in lines *a a*, Fig. 1, and looking toward the left hand and showing a part of the piston-cylinder in elevation.

Similar characters designate like parts in all the figures of the drawings.

This improved explosive gas-engine comprises in a general way a closed casing or cylinder embodying a compression and a working chamber, and in which a compound piston, (designated generally by A,) comprising a working piston and a compression-piston, reciprocates, an evaporator or gas-producing device (designated generally by B) and operatively connected with suitable means for supplying it with a suitable fluid, means or mechanism (designated generally by C) for controlling the flow of gaseous fluid from the compression-chamber of the piston-cylinder to the working chamber thereof, and suitable means (designated generally by D) for regulating the action of the engine.

It will be understood that the various details of construction—such, for instance, as the particular construction and disposition of the valves—may be widely varied without departure from the scope of my invention.

In the preferred form thereof herein shown and described the engine—which, in the present instance, is shown as of the "upright" pattern—comprises a closed casing of any suitable construction, preferably, however, in the nature of a cylinder 1 and preferably of differential diameters. Reciprocating within this cylinder is a compound, preferably chambered, piston A, comprising a working piston 2 and a compression-piston 3, which, however, in its preferred form is constructed as one member and which may be provided in the usual manner with suitable ring-packings (not shown) adjacent to the working faces thereof. This compound piston, which is likewise of differential diameters to correspond with the differential diameters of the cylinder, separates said chambered casing or cylinder into a working compartment or chamber 4 and a compression compartment or chamber 5, in which the working piston 2 and the compression-piston 3, respectively, simultaneously reciprocate. This piston is connected by a piston-rod 6 with the usual crank-shaft 7, extending transversely through the cylinder, and which may be provided with the usual counterweights 8, if desired.

A suitable eduction or exhaust valve 9 is operatively connected with the cylinder adjacent to the working chamber or compartment 4, and in the preferred form thereof it is preferably disposed at the upper end there-

of and comprises a spring-actuated valve operatively connected by a swinging or pivotally-supported lever 11 and a suitable connecting-rod 12 to an eccentric 10, disposed on the crank-shaft 7, whereby at a certain predetermined period in the reciprocation of the piston the valve will be opened to permit the outflow of the products of combustion, as hereinbefore set forth. This valve comprises, in a general way, a valve member 13, a stem 14, extending through the upper wall of the casing, and a spring 15, intermediate said wall, and a collar or disk 16 on the upper end of the stem, whereby the valve member 13 is held tightly against its seat 17 in the working chamber 4. The swinging or pivotal lever 11 is bifurcated at its inner end and pivotally connected to an inverted-cup-shaped member or sleeve 18, inclosing the upper end of the valve-stem 14, whereby on the downward movement of the sleeve 18 the stem 14 will be depressed to actuate or depress the valve member 13.

A suitable packing 19 may be disposed intermediate the end of the stem and the upper end of the sleeve member, if desired.

The valve-seat 17 consitutes the end of a port or passage 20, opening into the working chamber 4 when the valve is open and which communicates with a main port or passage 21, adapted to convey the products of combustion away from the engine.

Leading from the lower end of the working chamber 4 is a second eduction port or passage 22, opening into said main port or passage 21, for assisting the outflow of the products of combustion from said working chamber. This working chamber 4 is also provided with an inlet or induction port or passage 23, disposed at any suitable place (herein shown opposite to the eduction or passage 22, but preferably slightly below the same) and in position to communicate with the chamber of the compound piston by means of a port or passage 24 of the working piston 2 when said compound piston has reached the completion of its downward stroke, for the purpose hereinafter specified. Instead of these ports or passages 23 and 24 a suitable valve might be disposed in the upper end of the working piston, such as a puppet-valve, and operative to permit the fresh air to rush into the working chamber in a manner hereinafter set forth in connection with said ports 23 and 24.

Suitably connected with the cylinder adjacent to the crank-chamber 5', which is preferably a part of the cylinder and a closed chamber, and below the compression-piston 3 is a suitable air-inlet or induction-valve 25, preferably constructed in the nature of a puppet-valve, comprising the valve member 26, a stem 27, and a relatively low-power compression-spring 28, carried thereby, said stem working in suitable guides 29, adjacent to the valve-seat 30 and the removable cap or closure 31 of the valve-chamber 32, and said valve being adapted to be actuated by suction caused by the piston on its reciprocation in a manner hereinafter set forth.

The guide 29, which is in the nature of a socket, of the closure 21 is adapted to limit the opening movement of the valve in a manner that will be obvious.

Connected with the cylinder in any suitable manner, preferably in position adjacent to both the working chamber 4 and the compression-chamber 5 of the engine, is a valve-chest 35, preferably embodying a compression-chamber 36. Operatively connected with this valve-chest 35, preferably adjacent to the under side thereof, by any suitable means, but herein shown connected thereto by means of the tubular member 38 of the evaporator (hereinafter described) and which is provided with a screw-threaded end 38', adapted to engage a screw-threaded opening in the valve-chest, is an evaporator or gas-producing device B, which may be of any suitable construction adapted for the purpose; but in the preferred form shown it comprises a chambered casing or cylinder 37, having a gas-conductor therein and shown herein in the nature of a tubular member 38, and which tubular member is preferably provided with a spiral channel or way 39, leading from its upper to its lower end, whereby the area of surface over which the gas-producing fluid, preferably gasolene, is distributed is increased and the liquid brought into more intimate contact with the air, and thus the rapid evaporation of the liquid promoted with a relatively small amount of air. The inner wall of the evaporator-casing may also be corrugated or provided with a spiral groove or channel, if desired, to increase the evaporating-surface. Opening into this chambered casing 37, adjacent to the upper end thereof, and preferably into an annular chamber 40 above the spiral way 39, is a liquid pipe or conductor 41, which is connected with a suitable liquid-reservoir 100, whereby the liquid is conducted into the upper end of said evaporator and permitted to flow around the tubular member 38 on the spiral way 39, and thereby spread to permit it to be evaporated and absorbed by the air admitted into the chamber, as above stated. That portion of the liquid which is not evaporated is collected in a suitable trough 42, adjacent to the bottom of the tubular member 38, from which an overflow-pipe 43 leads to a suitable overflow-tank 150, which is operatively connected to the reservoir 100 in any suitable manner, such as by means of a pump 200, for forcing the surplus liquid back into the main reservoir.

Connected with the evaporator-chamber is a hot-air conductor or pipe 44, leading to any suitable source of supply, whereby the liquid injected into the evaporator from the reservoir 100, which liquid may be of any suitable character, such as gasolene, will be vaporized and drawn into the interior of the tubular member 38 through a passage 45, where it unites with cold or fresh air conducted thereto

by a suitable cold-air conductor or pipe 46, and which diluted mixture is then in condition to be supplied to the valve-chest.

In order to regulate the supply of hot and cold or fresh air to the evaporator or gas-producing device B, the hot-air conductor 44 and the cold-air conductor 46 are each provided with a suitable valve 47, operated by any suitable means to regulate the supply thereof to the evaporator. These valves may be of any suitable construction, but in the form shown comprise suitable cocks connected by levers 48 with a rod 49, the end of which in turn is connected by a lever in the nature of a bell-crank lever 50, pivotally joined to any suitable support, such as the piston-cylinder 1. One of the arms or members, as 51, of this bell-crank lever 50 is provided with a bifurcated end 52, having transverse inwardly-extending studs 53, working in a way or groove 54 of a shiftable member 54', non-rotatively carried on the crank-shaft 7, adjacent to the power receiving or transmitting pulley-wheel 55, which is also shown carried on said crank-shaft 7 for rotation therewith. The hub of this pulley is shown carrying suitable governing mechanism for the valves 47, and thereby the engine, and which governing mechanism, in the preferred form thereof shown, comprises a pair of suitable weighted bell-crank levers or arms 56, pivotally supported by extending arms 57, carried by the hub 58 of the pulley. The weighted ends of these arms are connected by a suitable helical spring 59, and the inner ends of the arms extend into a suitable groove or way 60 of the shiftable member 54', whereby on the rotation of the pulley the governor will shift said shiftable member 54', and by means of the connecting mechanism thereby actuate the valves 47 to open and close the hot and cold air conductor or pipes, and thus regulate the inflow of air to the evaporator. It will be understood, however, that instead of having the hot and cold air valves 47 operatively connected with the governor mechanism such valves may be simply hand-valves and a valve be disposed in the tubular member 38 below the valve 61 and operatively connected with the governor, whereby the flow of the diluted mixture will be regulated rather than the flow of the hot and cold air. It will also be understood, however, that any suitable governing and connecting mechanism, as well as any suitable evaporator or other means, as before stated, adapted for the purpose specified, may be used, or instead of an evaporator an injector or pump might be used to inject fluid, such as gasolene or ordinary gas, if desired, into the tubular member 38.

Connected with the valve-chest, adjacent the upper end of the tubular member 38 of the evaporator, is a suitable valve 61, operative on the downward movement of the piston A by the suction created thereby to permit the flow of gaseous fluid from said evaporator through the chamber 36 of the valve-chest and by means of a suitable port or passage 62 to the compression-chamber 5 of the piston-cylinder. This valve 61 may be of any suitable construction; but in the preferred form thereof it is in the nature of a puppet-valve comprising the valve member 63 and its stem 64, having a suitable relatively low-power helical spring 65 carried thereon. The upper end of the stem 64 is guided in a suitable aperture or socket 66 of a removable closure or threaded plug 67, carried by the valve-chest, and the lower end of said stem is guided adjacent to the valve-seat 68. By means of this recessed or socketed closure or plug 67 the opening movement of the valve is limited in a manner that will be obvious.

One means or mechanism for regulating or controlling the supply of gaseous fluid from the compression-chamber 5 of the piston-cylinder to the working chamber 4 thereof comprises a suitable valve mechanism C, operative at certain predetermined periods in the cycle of movements of the apparatus to permit said working chamber 4 to be supplied with the gaseous fluid drawn by the action of the piston from the evaporator B to said compression-chamber 5 of the engine, and in the preferred form of one construction thereof this valve mechanism, which is disposed in the valve-chest 35, comprises a suitable valve 70 in position intermediate a passage or port leading to the working chamber 4 and the chamber 36 of the valve-chest, through which chamber the gaseous fluid passes from the evaporator to the compression-chamber 5 of the piston-cylinder, and which valve in its preferred form comprises a suitable valve member 72, adapted to engage the valve-seat 72'; a valve-stem 73, the upper end of which is guided by a suitable socket 74 in a removable closure or cap 75, secured to the valve-chest, and by means of which the opening movement of the valve is limited, and the lower end of which stem is guided in a similar socket 76, carried by the lower wall of said valve-chest 35. This stem 73 is provided with a collar or bearing 77, upon which an arm 79 bears for normally holding the valve closed. This arm is shown fixedly secured to a shaft 80, journaled in the valve-chest 35, and which carries, adjacent to its outer end, a valve-closing lever 81, which is normally operated in one direction during one part of the cycle of movements by a relatively low-power spring 82. (Shown connected at one end to the lever 81 and at its opposite end to a suitable pin or holding device 83 on the valve-casing.) This low-power spring 82 normally holds the valve closed with a relatively light pressure, not sufficient, however, to materially oppose the passage of the gaseous fluid from the compression-chamber 5 to the working chamber 4 of the cylinder when it has reached a certain degree of compression. Hence in order to prevent the passage of such gaseous fluid when under compression, at im-

proper times in the cycle of movements, suitable means or mechanism operative at certain periods in the movements of the piston is provided to secure the valve closed with an increased power—such, for instance, as during the explosion in the working chamber 4—so as to prevent the return of gases and the entrance of the flame to the passages below the valve, and which means or mechanism, in one form thereof, comprises a lever-actuator 84, in the nature of a stem or rod 85, having its upper end guided by an apertured extension 86 of the valve-chest 35 and having its lower end projecting through a perforation 87 of the lever 81. This stem has a collar 88, adapted to bear on said lever 81, and carries a compression-spring 89 of relatively high power acting between said collar and the extension 86 of the valve-chest, whereby the valve will be held closed against the passage of the gaseous fluid. As a means for operating this lever-actuator 84 to permit the gaseous fluid to open the valve and flow into the working chamber 4 at certain periods in the operation of the device, said lever-actuator is connected by suitable mechanism with the crank-shaft 7, and which mechanism is herein shown comprising an eccentric 90, carried upon said shaft, and a suitable rod 91, having a strap 92 encircling said eccentric 90 and having its upper end provided with means, such as a socket 93, adapted to receive the lower end of said lever-actuator, whereby during one period of the cycle of movements the connecting-rod 91 will be thrown upward by the eccentric 90, to thereby move the lever-actuator 84 upward against the pressure of its spring 89, and thus release the bearing of said actuator upon the lever 81, whereby the gaseous fluid under pressure will open the valve 70 against the relatively light power of its spring 82 and permit said fluid to rush into the port or passage 71, and from thence and by means of a suitable passage 95 into the working chamber 4 of the piston-cylinder to charge the same, said fluid being then ignited by any suitable means to thereby explode the same in the working chamber 4. The means herein shown for this purpose consists of a suitable tubular exploder 96, opening into said passage 95, although it will be obvious that it might be located at any other suitable place, and which in practice will be kept sufficiently hot to ignite the gaseous fluid by means of a flame applied to the outside thereof. It will be understood, however, that any other suitable means might be used for this purpose, such as an electric spark.

In the operation of this improved explosive gas-engine, the liquid having been conveyed to the evaporator and there vaporized by the hot air and then united with the cold air leading to said evaporator, and the action of the compound piston A on its downward movement having caused sufficient suction to raise the valve 61—which is also somewhat assisted in its opening movement by the gaseous fluid beneath the valve in the evaporator—the gaseous fluid is drawn from the evaporator through the chamber 36 of the valve-chest 35 to the compression-chamber 5 of the cylinder 1 until the piston has reached the end of its downward stroke, Fig. 5. At the same time said piston compresses the air in the crank-chamber 5', and thus causes the same to rush into the chamber of the compound piston and through the port 24 of the working piston, and into the working chamber by means of the port or passage 23, opening into said chamber and communicating with the working piston-port 24 when said piston has reached the limit of its downward stroke, Fig. 5, and thus replace to a great extent the burned gases, said piston having previously uncovered the exhaust or eduction port or passage 22, leading to the main exhaust port or passage 21, and permitted a portion of the products of combustion, resultant from the previous explosion in the working chamber 4, to pass out through said port, thereby assisting to clear the chamber and also to reduce the pressure on the exhaust-valve 9, in order to permit the same to be readily opened at the proper time.

The working piston is provided with a deflector 101, adapted to direct the fresh air upward. On the inauguration of the return or upward stroke of the piston, Fig. 6, the exhaust-valve 9 is opened by means of the connecting mechanism, comprising the eccentric 10, rod 12, and lever 11, whereby the fresh air, admitted into the working chamber through the ports 24 and 23 from the crank-chamber, forces out the remaining burned gases during the greater portion of the upward movement of the piston, to thereby permit the clearing of the chamber preparatory to the next explosion. This upward stroke of the piston A creates a vacuum and a suction in the crank-chamber 5' sufficient to open the fresh-air-inlet valve 25 to fill said crank-chamber with fresh air preparatory to compressing the same and forcing it into the working chamber 4 by means of the ports or passages 24 and 23, as described in connection with Fig. 5. At the same time the piston during the major portion of its upward stroke greatly compresses the gaseous fluid previously conveyed from the evaporator through the valve-chest chamber 36 to the compression-chamber 5 of the cylinder—and which substantially filled both the cylinder-compression-chamber 5 and valve-chest chamber 36 when the piston was at the end of its downward stroke—back into the valve-chest chamber 36 alone, thereby bringing it under great compression, the valve 61 having been closed by its spring 65 when the piston practically reached the end of its downstroke, and when said piston reaches a predetermined point in said upward movement and adjacent to the top of the cylinder and also practically simultaneously with the closing of the exhaust-valve the eccentric 90 on the crank-shaft is rotated into position and actuates the rod 91, which operates the

valve-actuator 84 to release the valve 70, whereby the pressure of the gaseous fluid opens said valve 70 against the pressure of its low-power spring 82, and thereby permits such fluid to flow into the passages 71 and 95, Fig. 7, where it is ignited and exploded in the working chamber to force the piston downward to again draw a fresh supply of gaseous fluid, whereby the operations just stated are continued, to thereby permit an explosion at each rotation of the crank-shaft and at the completion or termination of each upward stroke of the piston, and thus obtain a continuous operation of the apparatus without requiring a multiplicity of pistons.

According to another form of means for regulating or controlling the flow of gaseous fluid from the compression-chamber 5 of the cylinder to the working chamber 4 thereof. Figs. 8, 9, and 10, the valve-chest 35 communicates with the cylinder 1 of the engine, preferably adjacent to the compression-chamber 5 thereof, by a port or passage 62′, which leads from a compression-chamber 36′ in the valve-chest, substantially similar to the compression-chamber 36, Fig. 3. Disposed above this passage 62′ is a second port or passage 97, having its inner end walls preferably flush with the piston, and which passage ends beneath the valve 70′, whereby, when the valve is open, said passage 97 communicates with the port or passage 71′, leading to the passage 95′, which opens into the working chamber 4 of the cylinder.

The compression-piston 3 is shown provided with a port 98, whereby, when the compound piston A has reached a predetermined point in its upward stroke, said port is in position to connect the passages 62′ and 97, whereby the gaseous fluid drawn from the evaporator B through the compression-chamber 36′ of the valve-chest 35 into the compression-chamber 5 of the cylinder, and which practically filled said chambers 5 and 36′ during the downward stroke of the piston and has been compressed back during the major portion of the upward stroke of said piston into said valve-chest compression-chamber 36′ alone, rushes by means of the piston-port 98 into the passage or port 97, Fig. 9, below the valve 70′ and opens the same, and thence rushes through the passages 62′ and 95′ to change the working chamber 4 of the cylinder in a similar way to that shown and described in connection with Figs. 1 to 7. Suitable packing-rings (not shown) may be disposed on the piston in any suitable way to prevent leakage from one passage to the other. In this construction of apparatus the valve-spring 83′ of the valve 70′, which is of relatively low power, is carried by the stem 72‴ thereof and is preferably disposed below the valve-seat 72″ and intermediate a socket or recess 99 in the valve-chest and a collar 99′ on said stem. The opposite end of this valve-stem 72‴ is guided in a socket 74′ of a removable plug or closure 75 and is adapted to limit the opening movement of said valve. The valve 61′ in the valve-chest 35, operative to admit the inflow of the gaseous fluid from the evaporator, is substantially similar to the valve 61 heretofore described. In this construction, however, the port 24′ of the working piston 2 opens into the passage 71′ instead of into a separate passage or port 23, as in the previously-described construction. The other parts in this construction of the improved engine being substantially similar to that heretofore described, the operation thereof will be obvious from the foregoing description, and it will also be obvious that the necessity of having the valve 70′ operated from the crank-shaft is unnecessary in this particular construction, as said valve 70′ is held in position by its relatively low-power spring 83′ until that predetermined period in the cycle of movements when the compression-piston 3 in its upward stroke has its port 98 in position to connect the ports or passages 62′ and 97, Fig. 9, when the compressed fluid will rush from the compression-chamber 36′ of the valve-chest 35 into said passage or port 97 and open said valve and rush into the working chamber 4 by means of the passages 71′ and 95′, where it will be ignited and then explode to depress the piston, which will act to draw an additional supply of gaseous material from the evaporator, and thus continue in operation.

In the claims and specification it will be understood that the words "downward" and "upward," or their equivalents, will be understood to mean the "to-and-fro" stroke of the piston in whichever position it may operate, whether in an upright, horizontal, or other character of engine.

While I have described air as the diluent preferably employed, yet, as is obvious, any other suitable agent may be substituted therefor and conveyed through the pipe 46, if deemed desirable.

Having described my invention, I claim—

1. The combination of a casing having a working chamber and a compression-chamber; a piston working in said casing; a valve-chest connected with said casing; an evaporator provided with a spiral way connected with said valve-chest; means for conducting the gaseous fluid from the evaporator through the valve-chest to the compression-chamber and from thence back through the valve-chest to the working chamber; and means for controlling the flow of the gaseous fluid from the compression-chamber to the working chamber during a predetermined period in the cycle of movements of the apparatus.

2. The combination of a casing having a working chamber and a compression-chamber; a piston working in said casing; an evaporator or gas-producing device provided with a spiral way in which the gaseous fluid is completely formed; means for conducting the completely-formed gaseous fluid from the evaporator to the compression-chamber and

from thence to the working chamber; and means for controlling the flow of gaseous fluid from the compression-chamber to the working chamber during a predetermined period in the cycle of movements of the apparatus.

3. The combination of a casing having a compression-chamber and a working chamber; a piston working therein; means for conducting gaseous fluid to the compression-chamber of the casing and from thence to the working chamber thereof; means in position for restricting or controlling the flow of such gaseous fluid to the working chamber during a certain predetermined period in the cycle of movements of the apparatus; and means adapted to permit the induction of fresh air into the casing below the compression-chamber and from thence through the casing into the working chamber after the explosion of the gaseous fluid therein.

4. The combination of a casing having a compression-chamber and a working chamber; a piston working therein; means for conducting gaseous fluid to the compression-chamber on the downward stroke of the piston and from thence to the working chamber during a part of the upward stroke of the piston; means in position for restricting or controlling the flow of such gaseous fluid to the working chamber throughout the entire downward stroke and the major portion of the upward stroke of said piston; means for permitting the induction of fresh air to the casing below the compression-chamber at the inauguration of the upward stroke of the piston; and means for permitting the flow thereof from said compression-chamber through the casing and the piston and into the working chamber at the completion of the downward stroke of said piston.

5. The combination of a casing having a compression-chamber and a working chamber; a piston working therein; means for conducting gaseous fluid to the compression-chamber on the downward stroke of the piston and from thence to the working chamber during a part of the upward stroke of said piston; means in position for restricting or controlling the flow of such gaseous fluid to the working chamber throughout the entire downward stroke and during the major portion of the upward stroke of such piston; means for permitting the induction of fresh air into the casing below the compression-chamber during the upward stroke of the piston; means for conducting the products of combustion from the working chamber and embodying valve mechanism operative on the upward stroke of the piston; and means for permitting the flow of fresh air from said compression-chamber through the casing and into the working chamber at the completion of the downward stroke of said piston.

6. The combination of a casing having a working chamber and a compression-chamber; a compound piston working therein and comprising a working piston and a compression-piston; a valve-chest connected with said casing; means for conducting gaseous fluid into the valve-chest and from thence to the compression-chamber of the casing on the downward stroke of the piston, whereby it will be compressed back into said valve-chest on the upward stroke of said piston; means for conducting the compressed fluid from the valve-chest chamber to the working chamber; means disposed in said valve-chest and operative during one part of the cycle of movements to prevent the flow of such gaseous fluid to the working chamber and operative during another part of the cycle of movements to permit the flow of such gaseous fluid to the working chamber to actuate the piston; and means for permitting the induction of fresh air into the casing below the compression-chamber and from thence into the working chamber at certain periods in the cycle of movements of the apparatus.

7. In a gas-engine, the combination of a casing having a working and a compression chamber; a crank-shaft; a compound piston therein comprising a working and a compression piston and operatively connected with the crank-shaft; a valve-chest connected to said casing; means for conducting the gaseous fluid to the valve-chest; a passage connecting said valve-chest with the compression-chamber; a valve operative by the action of the piston to permit the inflow of the gaseous fluid into said valve-chest and from thence to the compression-chamber of the casing; a passage connecting said valve-chest with the working chamber of the casing; and valve mechanism operatively connected with the crank-shaft and operative during a certain period in the rotation thereof to permit the compressed gaseous fluid to flow from the valve-chest into the working chamber of the cylinder to actuate the piston.

8. In a gas-engine, the combination of a casing having a working and a compression chamber; a crank-shaft; a compound piston therein comprising a working and a compression piston; a valve-chest connected to said casing; means for conducting the gaseous fluid to the valve-chest; a passage connecting said valve-chest with the compression-chamber; a passage connecting the valve-chest with the working chamber; a valve in said chest; spring-actuated mechanism for holding said valve closed during a part of the cycle of movements of the apparatus; and an eccentrically-actuated lever connected with the crank-shaft and operative to actuate said valve-closing mechanism to release the valve and permit the flow of the gaseous fluid to the working chamber.

9. In a gas-engine, the combination of a casing having a working and a compression chamber; a crank-shaft; a compound piston therein comprising a working and a compression piston; a valve-chest connected to said casing means for conducting the gaseous fluid to the valve-chest; a passage connect-

ing said valve-chest with the compression-chamber; a passage connecting the valve-chest with the working chamber; a valve in said chest; spring-actuated mechanism for normally holding said valve closed and comprising a shaft journaled in said valve-chest having an arm operatively engaging the valve and spring-actuated lever also connected to said shaft; means for holding said valve closed with increased pressure during a part of the cycle of movements of the apparatus and comprising a spring-actuated rod engaging said spring-actuated lever; and means for operating said spring-actuated rod at a certain predetermined period in the cycle of movements of the apparatus and comprising an eccentrically-actuated lever or rod connected to the crank-shaft.

10. In a gas-engine, the combination of a casing having a working and a compression chamber; a crank-shaft; a piston therein comprising a working and a compression piston; a valve-chest connected to said casing; an evaporator or gas-generator connected with said valve-chest and provided with a spiral way; a valve operative by the action of the piston to permit the inflow of the gaseous fluid from the evaporator or gas-generator; a passage connecting the valve-chest with the compression-chamber; a passage connecting the valve-chest with the working chamber; and valve mechanism operatively connected with the crank-shaft to permit the opening thereof at a predetermined period in the cycle of movements of the apparatus, to thereby permit the compressed fluid to flow from the valve-chest to the working chamber of the casing to actuate the piston.

11. An evaporator comprising a chambered casing having a liquid-conductor connected therewith; a tubular member therein having a spiral way; an overflow-conductor connected to said evaporator; a hot-air conductor connected with said casing; and a cold-air conductor connected with said tubular member.

12. The combination of a casing; a crank-shaft; a piston in said casing; a valve-chest connected with said casing and having valve mechanism therein; an evaporator connected with said valve-chest and comprising a chambered casing having a tubular member therein having a spiral way; a liquid-conductor connected to said chambered casing; a hot and a cold air conductor connected with the casing and the tubular member, respectively; and valve mechanism in said hot and cold air conductors and operatively connected with the crank-shaft, whereby the supply of air to the evaporator is regulated.

13. The combination of a casing; a crank-shaft; a piston in said casing and operatively connected with the crank-shaft; a valve-chest connected to said casing and having valve mechanism therein; a gas-producing device connected to said valve-chest and having hot and cold air conductors connected therewith; a liquid-conductor also connected therewith; and valve mechanism in said hot and cold air conductors and operatively connected to the crank-shaft, whereby the supply of air to the gas-producing device is regulated.

14. The combination of a casing; a crank-shaft; a piston in said casing and operatively connected with the crank-shaft; a gas-producing device operatively connected with said piston-casing and comprising a chambered casing; a liquid-conductor connected thereto; a hot and a cold-air conductor also connected thereto; valve mechanism in said hot and cold air conductors; a governor operatively connected with the crank-shaft; and mechanism connecting said valves and governor for regulating the supply of air to the gas-producing device.

15. The combination of a casing; a crank-shaft; a piston operatively connected to said crank-shaft; a valve-chest connected to said casing and having valve mechanism therein; a gas-producing device connected to said valve-chest and operatively connected with a liquid-reservoir; an overflow-conductor also connected with said gas-producing device and with an overflow-tank; a pump operatively connecting the overflow-tank and liquid-reservoir; a hot and cold air conductor connected with said gas-producing device; and valve mechanism in the hot and cold air conductors and operatively connected with the crank-shaft, whereby the supply of air to the gas-producing device is regulated.

16. The combination of a casing having a working chamber and a compression-chamber; a crank-shaft; a compound piston working in said casing and comprising a compression-piston and a working piston and operatively connected with the crank-shaft, said working piston and working chamber having ports communicating with each other at the end of the downward stroke of the piston; an air-inlet valve operative on the upward movement of the piston to admit fresh air into the casing, whereby on the next downward movement of said piston the same will, by means of the communicating ports, flow into the working chamber; an exhaust-valve operatively connected with the crank-shaft, whereby on the inauguration of the upward stroke of the piston said valve will be opened to permit the fresh air to force the products of combustion from said working chamber; a valve-chest connected with said casing and having a passage communicating with the compression-chamber thereof and a passage communicating with the working chamber thereof; a fluid-controlling valve in said chest; a valve-actuator operative throughout the entire downward movement of the piston and the major portion of the upward movement thereof to hold said valve closed; means operatively connected with the crank-shaft and operable at a predetermined period in each rotation thereof to release the valve-actuator and thereby permit the gaseous fluid to open said valve and rush into the working cham-

ber to charge the same when the piston has reached a predetermined period in its upward movement; a gas-producing device connected with the valve-chest; a valve operative on the downward stroke of the piston to permit the gaseous fluid from the evaporator to be drawn therefrom through the valve chest to the compression-chamber of the cylinder; a liquid-supply conductor connected with said gas-producing device; a hot and a cold air conductor also connected with said gas-producing device; valve mechanism in said hot and cold air conductors; a governor operatively connected with the crank-shaft; and mechanism connecting said governor and hot and cold air valve mechanisms, whereby the valves thereof will regulate the supply of air to the gas-producing device, and all combined and operative to obtain an explosion of the gaseous fluid in the working chamber at each rotation of the crank-shaft and at the completion of each upward stroke of the compound piston, to thereby drive said piston downward.

17. The combination with a casing having a working chamber and a compression-chamber; a piston working in said casing; a valve-chest connected to said casing; an evaporator or gas producing device connected to said valve-chest; means for conducting the gaseous fluid from the evaporator through the valve-chest to the compression-chamber and from thence back through the valve-chest to the working chamber; and a spring-pressed valve disposed in the valve-chest for controlling the flow of the gaseous fluid from the compression-chamber to the working chamber during a predetermined period of the cycle of movements of the apparatus.

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Witnesses:
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