

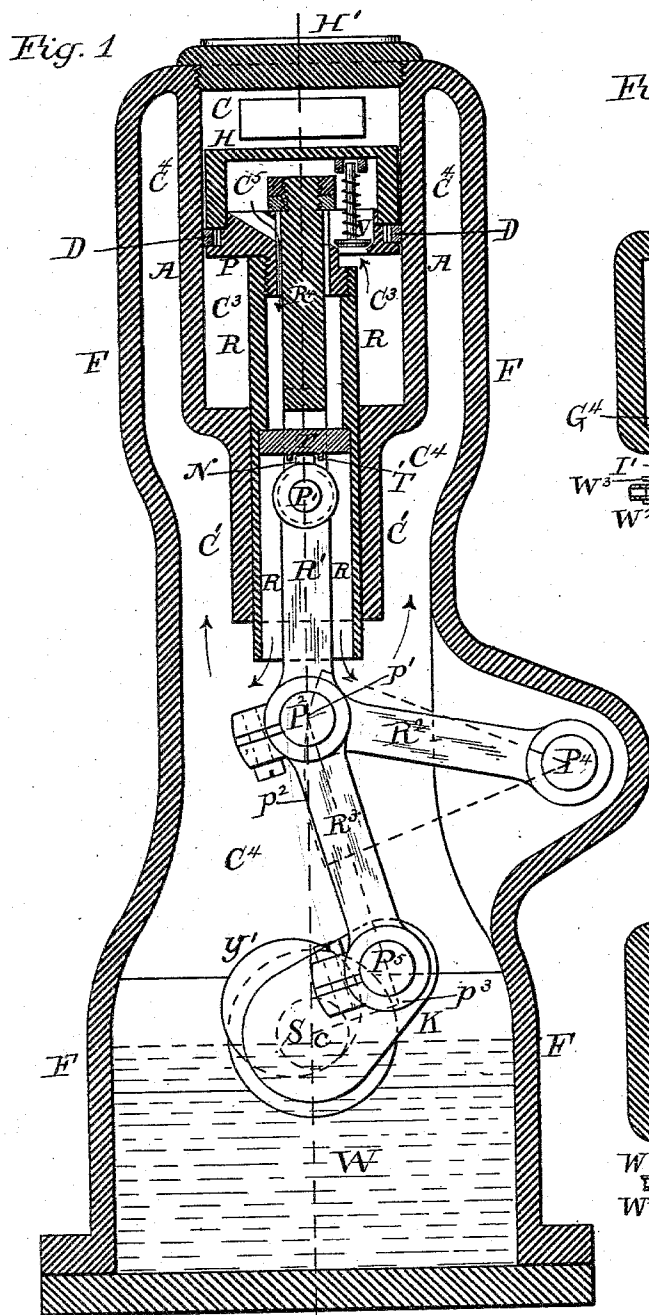
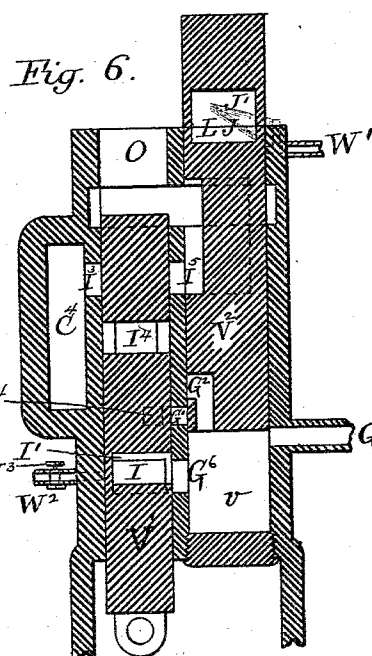
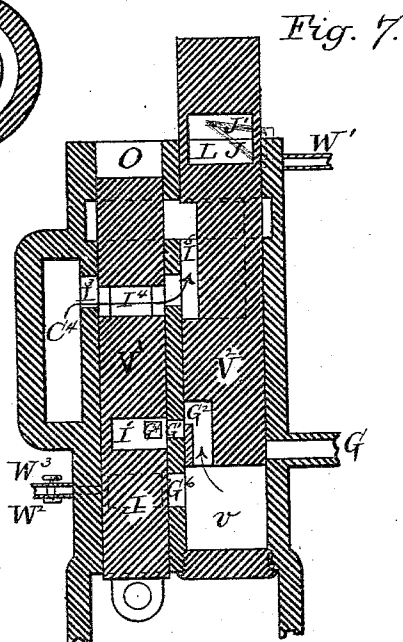
(No Model.)

4 Sheets—Sheet 1

L. H. NASH.
GAS ENGINE.

No. 289,019.

Patented Nov. 27, 1883.



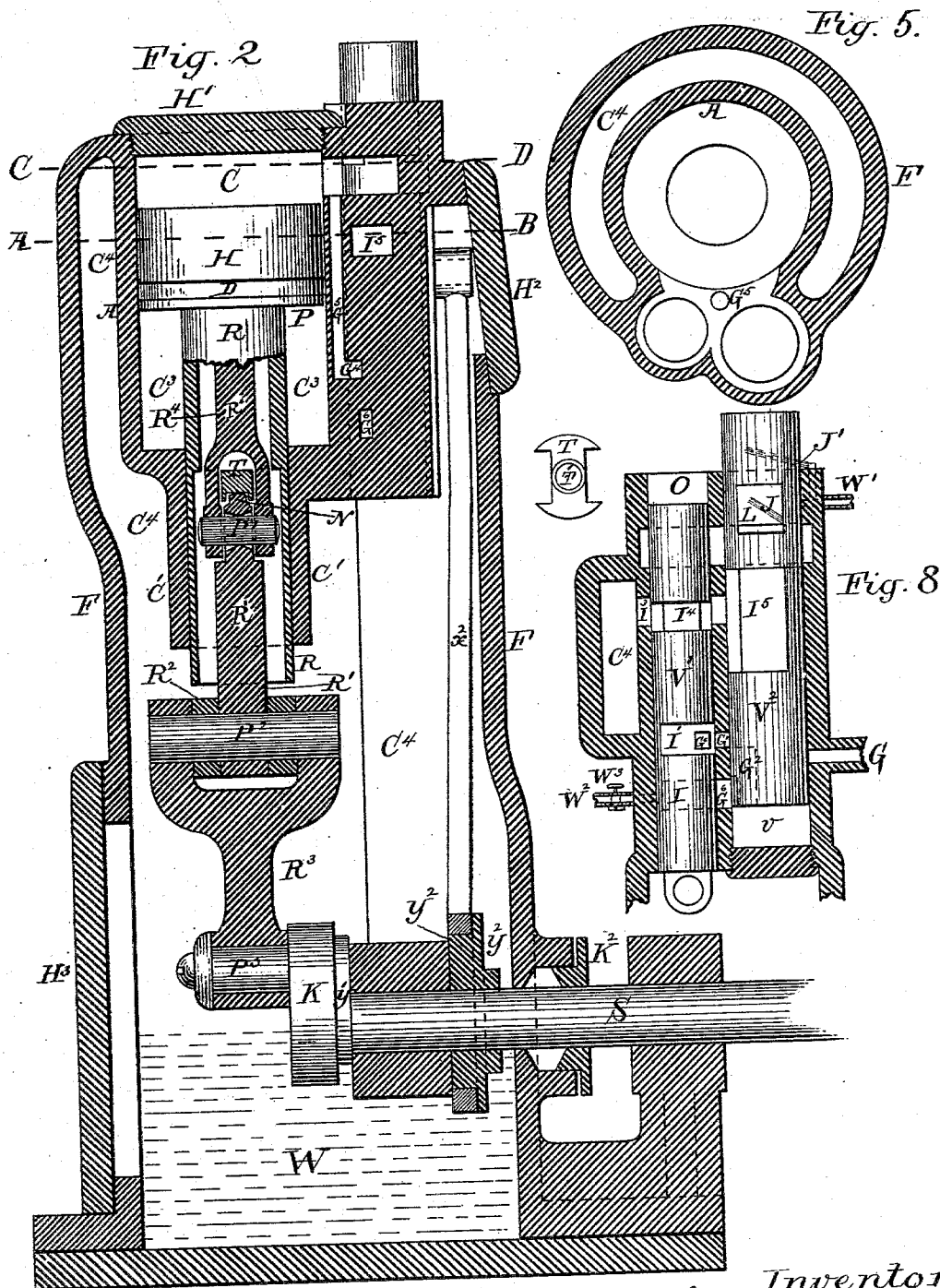
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(No Model.)

4 Sheets—Sheet 3.

L. H. NASH.
GAS ENGINE.

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Fig. 3.

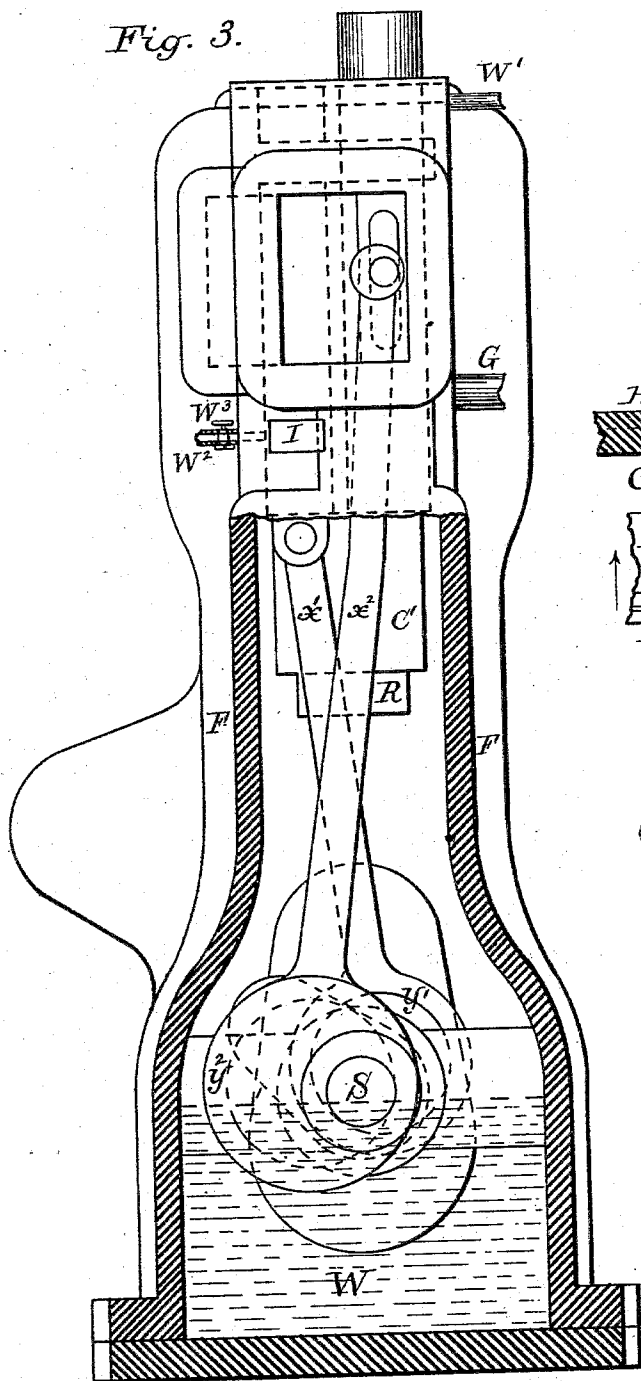
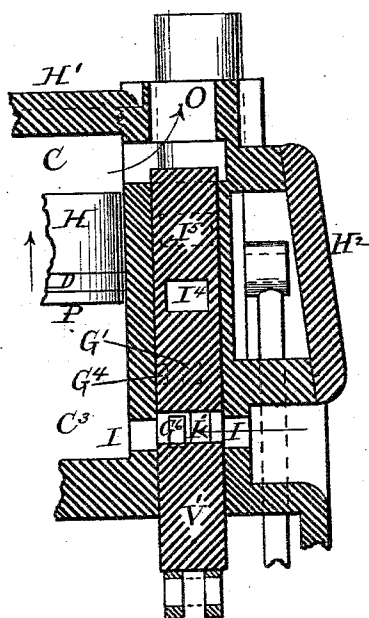


Fig. 9.



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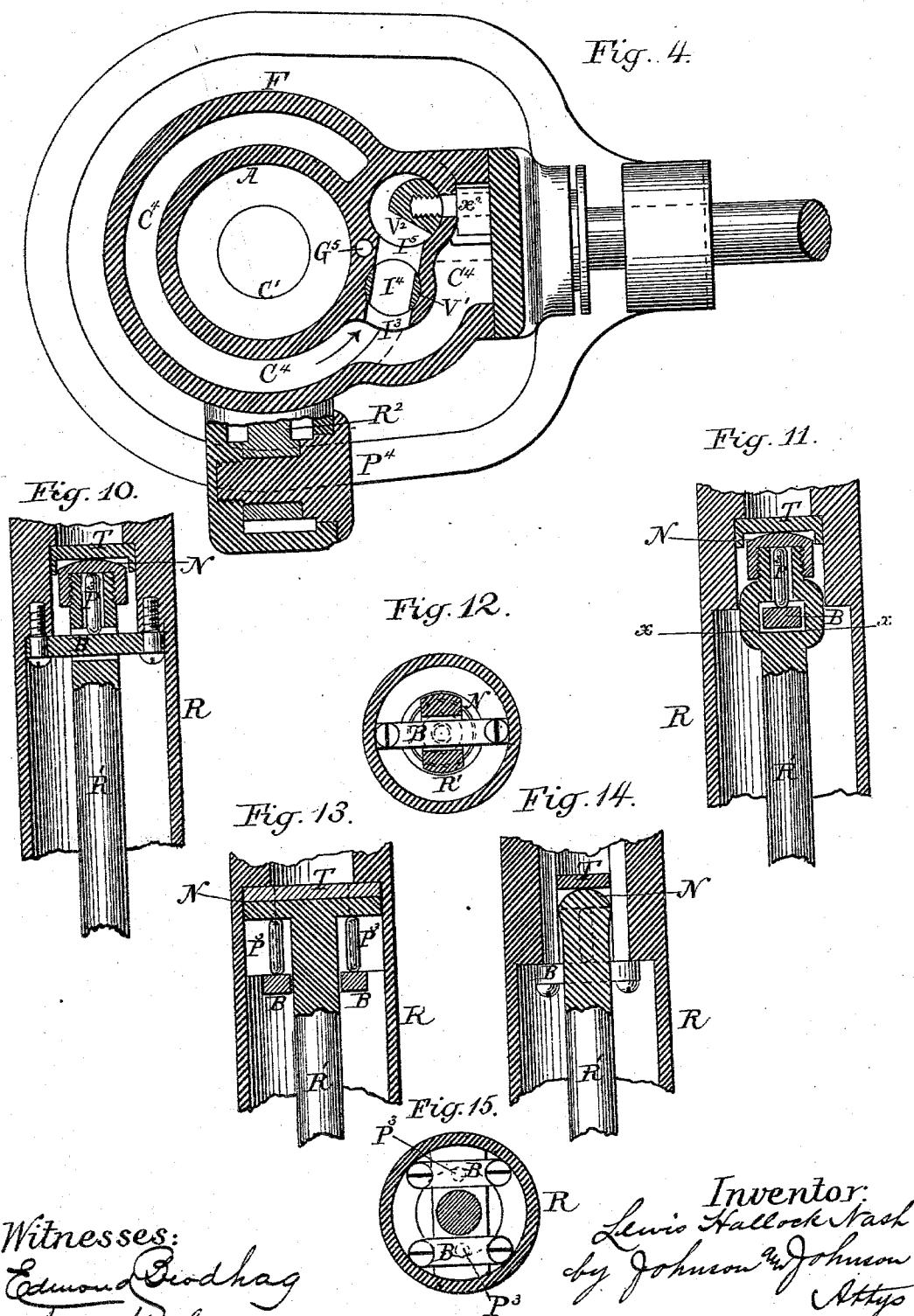
(No Model.)

4 Sheets—Sheet 4.

L. H. NASH.
GAS ENGINE.

No. 289,019.

Patented Nov. 27, 1883.



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UNITED STATES PATENT OFFICE.

LEWIS HALLOCK NASH, OF BROOKLYN, ASSIGNOR TO THE NATIONAL METER COMPANY, OF NEW YORK, N. Y.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 289,019, dated November 27, 1883.

Application filed March 19, 1883. (No model.)

To all whom it may concern:

Be it known that I, LEWIS HALLOCK NASH, a citizen of the United States, residing at Brooklyn, in the county of Kings and State of New York, have invented new and useful Improvements in Gas-Engines, of which the following is a specification.

The object of my invention is to produce a light, compact, durable, efficient, and powerful gas-engine, and to utilize the heat usually lost in a water-jacket, which I dispense with.

Authorities on the gas-engine state, in relation to the amount of heat utilized in gas-engines of the best type, that the amount of heat converted into useful work is about sixteen per cent.; heat abstracted by cooling-water, fifty-one per cent.; heat expelled with waste gases, thirty-one per cent.; loss by radiation, two per cent.

My invention is primarily directed to the saving of the heat abstracted by the use of a circulation of water, usually employed to cool the working-cylinder, and also to effect a partial saving of the heat expelled by the waste gases. This great saving is effected by utilizing the compressed working-fluid of the engine after compression to cool the heated portions of the engine on its way to the working-cylinder, while the saving of the heat lost in the waste gases is effected by provision which allows of a high degree of compression of the charge, and consequently of a greater expansion. This provision consists in injecting cold water into the gas-compression chamber with the gases before or during their compression, for the purpose of taking up heat produced by the compression of the gases, and thus reduce the power required for compression and deliver the compressed gases therefrom at a comparatively cool temperature, so as to render it a heat-absorbing element in its passage to the working-cylinder.

An important matter of my invention also consists of a novel construction whereby the parts subjected to wear are arranged so as not to be immediately affected by the heat developed in the power-cylinder, whereby the power-cylinder may be operated under a greater degree of heat than usual. There are other matters of improvement in construction and

in combinations which will be described preparatory to a designation of what is claimed as my invention.

The construction of my engine is such that the heat abstracted by the compressed working-fluid from the power-cylinder in cooling it is not lost; but this heat serves to increase the elastic force of the working-fluid, and is taken up both as the fluid is caused to pass over the working-cylinder and into it. The storing-chamber for the compressed working-fluid is made air-tight, surrounds the power-cylinder, and also the working parts of the engine, and this gives a very advantageous construction for effecting the lubrication of the working parts and of the power-cylinder.

In gas-engines the lubricating material becomes hard by reason of the dry heat used, and the working-cylinder has to be frequently cleaned out, and to prevent this I utilize the storage-chamber for the compressed working-fluid as a reservoir for water and for the lubricant, whereby the working-fluid is kept moist and the oil kept liquid upon the heated working parts, the construction of the piston being such as to work without lubrication other than it receives from the compressed working-fluid and the vapor of oil and water which may pass in with it. A vat of oil, without the moistening effect of hot water and the watery vapor, would not maintain the lubricant in a moist condition, nor allow the lubricated heated parts to be constantly washed by hot water, and thus kept clean. The return or back stroke of the piston is aided by the pressure of the compressed gas in the storage-chamber, which acts upon the enlarged piston-rod, thus rendering the engine partially double acting.

Having briefly stated the several matters of my invention, I will now proceed to describe more specifically my invention, reference being had to the accompanying drawings, which illustrate one form of engine adapted for carrying it into practical effect.

Figure 1 represents a vertical central section of an upright single-acting gas-engine, showing the piston at the point of ignition. Fig. 2 represents a similar view taken at right angles to Fig. 1, showing the valve-operating connections. Fig. 3 is a side view, the rear

part of the casing being removed to show the eccentric-valve connections and the air-inlet port. Fig. 4 represents a horizontal section taken on the line A B of Fig. 2, showing the valves in position to close the cylinder-ports. Fig. 5 represents a horizontal section taken on the line C D of Fig. 2, showing cylinder and valve inlet-ports, the valves being removed. Fig. 6, Sheet 1, represents a vertical section of the valves, showing their position during the return-stroke of the piston. Fig. 7, Sheet 1, represents a similar section, showing the valves in the position they occupy during the first part of the forward stroke as the charge is being admitted. Fig. 8, Sheet 2, represents the valve-chests in section and the valves in elevation in the position they occupy at the instant of the ignition of the charge. Fig. 9, Sheet 3, represents a section of the valve which governs the admission and discharge of the working-fluid. Fig. 10, Sheet 4, represents a section of a modified form of the rocking joint uniting the piston-rod with the connecting-rod; Fig. 11, a similar section taken at right angles to Fig. 10, and Fig. 12 a cross-section taken on the line *xx* of Fig. 11. Figs. 13, 14, and 15 are sectional details of another modification of the rocking joint.

I have shown my invention as applied to a single-acting engine in which the working-cylinder A is arranged in an upright position within an upright case or shell, F, which incloses it and the operating connections, the cylinder being arranged at the top of the case, and either cast or formed separately with it, and closed at its upper end by a removable head, H', which may be made hollow and communicate with the storage-space C', if desired. This shell or case forms the storage-chamber C' for the compressed working-fluid, and the latter therefore surrounds the cylinder as a heat-absorbing medium. It also forms a reservoir for water and oil, by which to keep the working-fluid moist and to lubricate the working parts. The valves are also partially, or may be entirely, inclosed by the case, and thus obtain the advantage of the cooling effect of the working-fluid upon the valve also. The forward end of the cylinder forms a compression-chamber wherein the gaseous mixture is supplied, compressed, and forced into said storage-chamber, where it is constantly maintained under compression for immediate use in the cylinder. The other end of the cylinder is the power end, into which the gases are admitted by the valves and ignited in any suitable way. The forward or lower end of the cylinder A terminates in an open cylinder, C', of less diameter than that within which the piston works, and forms a bearing for the trunk or hollow rod R, which supports the piston and acts as a slideway to it. This smaller cylinder has sufficient length to form a good bearing and tight joint for the hollow piston-rod, which opens into the storage-chamber, and thereby gives the advantage of

a force to drive the piston, on its back-stroke, from the pressure of the stored gases acting upon the enlarged piston-rod and the various surfaces exposed to said pressure. The enlarged diameter of the piston-rod takes up much of the compression-chamber C', and necessarily diminishes the volume of this chamber, and should be so proportioned as to compress the amount of gaseous mixture required by the engine. The piston P does not touch the working-cylinder, being supported by the rod R, and provided with a packing-ring, D, suited to stand a high temperature. A cap or cover, H, is suitably secured over the rear end of the piston to protect it from the direct contact of the ignited gases, and, in the construction shown, to form a communicating space, C'', Fig. 1, between the cylinder-space C', the hollow piston-rod, and the storage-chamber. The greatest heat will be developed in the end of the cylinder where the gases ignite, and this part of the cylinder will become very hot, and the cap H, working within this hottest part of the cylinder, nearly fills it on the return-stroke of the piston, and by making the cap H of sufficient length the ring D will be caused to work in a comparatively cool part of the cylinder. If found necessary, the capped end of the piston may be supported by a rod passing through the cylinder-head. In this construction I arrange a stop-valve, V, within the piston, as shown in Fig. 1, by which the gases are caused to pass at each compressing action of the piston from the cylinder-space C' into the piston-space C'', and from thence down through the hollow piston-rod R into the storage-chamber. The valve V for this purpose is arranged to open upward into the cap-space C'', and is closed by a spring of suitable strength. The valve, however, may be placed at the bottom of the compression-chamber, and the communication of the latter thereby made direct with the storage-chamber, in which case the cap would serve only to protect the piston, as stated. In either case the hollow piston-rod is exposed to the cooling effect of the gases in the working of the engine.

It will be understood that, in using the compressed gases as a cooling medium for the working parts of the engine, while in the compression of the gaseous mixture it will necessarily be heated to a certain extent, yet it will be very much colder than the power-cylinder, and therefore will abstract heat from it. The hotter the power-cylinder is maintained the less will be the heat given up to it by the gases therein, and therefore the less heat will need to be abstracted by the cooling-gases in keeping it at a given temperature. The interior wall of the hollow piston-rod is formed with a shoulder about the middle of its length, upon which rests a step, T, which is made of hardened steel, and has a ring-seat, T', on its under side, inclosing a flat surface, upon which bears the convex end N of a con-

necting-rod, R' , which latter is held up against its seat by a tie-rod, R^4 , supported centrally within the hollow piston-rod by being passed through the piston and secured by lock-nuts resting thereon, and connected at its lower end to the said connecting-rod R' by a loosely-fitting horizontal joint-pin, P' , the said tie-rod being forked to pass over the end of the said connecting-rod, and a rocking bearing is also provided between the pin P' and the eye in the rod R' , said eye forming an edge convex or ridge-bearing, as shown in Fig. 2. As the bearing and the pin-joint at P' are loose, the rod R' is free to rock in any direction within certain limits upon its convex end N , and upon the working-bearing in the joint-pin, and provides for lateral alignment of the parts. By making the curve of the end of rod R' of proper form there will be practically no friction to this form of connection within the limits of the motion required by it, and there will be no possibility of any binding or clamping action upon the piston-rod R to cause friction in case the parts should get out of line. As the bearing T can give no sliding motion, there will be no wear, and no lubrication or adjustment will be needed, while the bearing forms a kind of socket-joint which serves to take up the thrust of the piston upon its forward stroke. This rocking socket-joint bearing may be variously constructed, and I shall hereinafter describe modifications of this rocking bearing. The power-transmitting crank-shaft S enters the lower end of the case through a stuffing-box, K^2 , and its crank K is connected by the rod R^3 to the rod R' by a joint-pin, P^2 , to which a guide-rod, R^2 , is also jointed and sweeps from a pivot, P^4 , secured to one side of the case, as shown in Figs. 1, 2, and 4. I prefer to secure the joint-pin P^2 rigidly to the connecting-rod R' . The guide-rod takes a swinging movement (shown by the dotted lines) which intersects at two points the center line of the cylinder. The extent of the divergence of this arc from the center line of the cylinder is the measure of all the side strain of the bearing of the piston-rod upon the cylinder C , and the longer the connecting-rod R^2 is made more nearly will the arc of the sweep coincide with the center line of the cylinder. It will be seen that the arc crosses the center line at two points, p' p^2 , Fig. 1. I prefer to so adjust the length of the guide-rod R^2 that the crossing-point p' shall occur at the instant of the stroke when the ignition of the gaseous charge takes place, for this is the instant when the greatest pressure is upon the piston. Since the rod R' is at such instant in line with the axis of the cylinder, (see Fig. 1,) there will be no side-pressure of the bearing of the piston-rod R upon the cylinder C . This curve $p' p^2$ follows along near the center line through that portion of the stroke wherein the most work is being done by the gases in the cylinder; hence the wear upon the sliding part R and friction will be

very little, the angular strain upon the connecting-rod R^3 being taken up on the guide-rod R^2 , where its friction can be easiest borne.

Figures 1, 2, and 3 show the position of the parts when the ignition takes place; and it will be seen that the position of the connecting-rod R^3 is such as to exert its greatest power in producing rotation of the crank K . In Fig. 1, $p' c$ show that the effective arm of the leverage of the rod R^3 is nearly that which it would be in an engine using a long connecting-rod at half-stroke, while by the use of the short connections shown this point occurs in the early part of the stroke of the piston. The piston also at this point has its greatest speed, which is greater than that of the crank-pin P^3 . This is a feature of importance in a gas-engine, since the high initial pressure of the gases at ignition only lasts for an instant, and it is important that the piston should travel fast at this time to utilize the power so developed.

By the combination of the three coacting rods R' R^2 R^3 , jointed at P^2 , which forms the connection between the piston and the crank, I obtain the important beneficial results stated, while such combination makes it possible to use very short connecting-rods, thus giving great compactness to the engine and greatly reducing its weight. The operation of the engine is not, however, dependent upon this combination of connecting-rods.

As shown, the valves are arranged within chambers formed in the casing, so as to communicate with each other—the compression-chamber, the storage-chamber, and the cylinder, as shown in Figs. 4 and 5. These valves are shown as being cylindrical, provided with suitable ports corresponding with ports in the valve-chambers, and operated by rods $x' x^2$, connecting with eccentrics $y' y^2$ on the crank-shaft, as shown in Figs. 2 and 3. The valve V' is operated by the eccentric y' , set quartering to the crank, and controls the exhaust, the admission of the gaseous products to the compression-chamber C^3 , and the admission of the compressed gases to the cut-off valve V^2 , arranged in communication with it. The cut-off valve V^2 operates to cut off the admission of the charge at any desired instant of the stroke to light the charge, and as a pump to compress charges of gas for the lighter. The valve V' has a port, I' , which communicates with ports $G^6 I$ and pipe W^2 , to admit the charge of air, gas, and water in one part of its stroke, and in another part of its stroke it opens communication with passages $G' G^4$, to allow the gas compressed by the valve V^2 to pass through the ports and passages $G^2 G' G^4 G^5$ into the cylinder-space C to ignite the charge. The passage G^5 heats from the port G^4 , and opens into the cylinder C in such close proximity to the lighter-valve space L as to conduct a stream of gas, so as to be instantly lighted, and to communicate the flame to the cylinder-charge, as shown in Figs. 2 and 5, whereby a simple jet of gas is used to effect

the lighting of the charge, instead of admitting a denser charge of gaseous mixture at the latter part of the period of admission of the gases. The valve V' also has a port, I^4 , which opens communication through the port I^3 with the storage-chamber C^1 , and through the port I^5 in the valve V^2 , whereby, in connection with said valve V^2 , the admission of the charge to the cylinder is controlled. The chamber of the valve V' is open at its end at O , Figs. 6 and 9, and the valve V' operates to discharge the waste gases at the proper time through said opening. The valve V^2 has a port, I^5 , which opens communication between the port I^4 in the valve B' and the cylinder-space C and a port, G^2 , which opens communication through G' between the two valves with the port I' in valve V' , while the lower end of said valve V^2 operates to admit gas through the supply-pipe G into the space v , and through the port G^6 into the port I' of valve V' at the proper time. The valve V^2 has also a lighter-chamber, L , within which an internal gas-jet, J , burns, and is supplied by the pipe W' , an external jet, J' , being arranged to relight the internal jet J at each stroke from the same supply. The lighting of the charge by means of these jets is the same as is usually practiced in gas-engines; but I may use any suitable means for ignition, as by the electric spark.

Referring to the cooling effect of the gases before described upon the working parts of the engine, such cooling action will be sufficient, in engines developing a comparatively small amount of power and using a moderate degree of compression, to preserve the working parts at a proper degree of temperature.

In engines developing greater power and using a higher degree of compression my invention embraces the novel use of water as a medium for assisting the cooling operation of the gases, and by the same means saving the heat absorbed by the water in developing power in the engine. In small engines developing a moderate power with a small degree of compression I provide a simple way of effecting this result, while for engines using higher compression and developing greater power I provide means adapted to produce the effect required. For light engines it will be sufficient to fill the lower part of the storage-chamber with water, W , which will be heated by the heat conducted down the engine-case, and thus generate vapor, so that the compressed gases in the storage-chamber will be mixed with the vapor, and thus increase the cooling effect of the working-fluid. As shown, the crank-shaft and its connections are arranged to work in the storage-chamber, and their rapid motion will cause the water to be thrown up in spray upon the connections and the lower portion of the cylinder, and thus assist in keeping these parts cool, and serve to prevent the accumulation of oily matter in the cylinder and upon the working parts. As the mixed gases, steam, and spray forming

the working-fluid passes over the hot surface of the power-cylinder A on its passage to the inlet-valves, the spray will be converted into steam, and further assist in keeping the cylinder cool. The water to supply the waste by evaporation may be supplied in any suitable way; but it is best to allow it to enter with the air and gas into the compression-chamber of the cylinder.

For low-pressure engines the water may be admitted in a stream through pipe W^2 , and the quantity can be regulated by a cock, W^3 , as required to keep the engine at the proper temperature. The oil for lubrication is best supplied into the storage-chamber, so that it will be carried by the spray to lubricate all the working parts.

In engines developing a great amount of power, where it is required to compress the charge to a very high degree in order to secure such power, the gases undergoing such compression would be greatly heated by the work of compression, and therefore the working-fluid would not be in condition to be used in developing power. I provide for preventing this undue heating of the gaseous mixture while undergoing compression by injecting a sufficient quantity of cold water with the air and gas directly into the compression-chamber through the pipe W^2 . The best effect is produced when the water is injected in spray, so as to mix thoroughly with the gases, so that the water will take up the heat generated by the compression of the gases, thus keeping the temperature of the compressed gases at a low degree. By thus injecting water with the air into the compression-chamber it is possible to compress the gases to a very high degree, without causing a high temperature in the compression-chamber while undergoing compression. In this comparatively cooled condition the gases and water pass out of the compression-chamber into the storage-chamber, where, by reason of their contact with the heated parts of the engine, they will take up the heat from these parts, and this heat will be utilized in heating the gases and evaporating a portion of the water carried with them, the surplus water falling into the storage-chamber for the gas and water. This heating of the gases is by heat abstracted from the cylinder by their contact with its outer walls, and thus instead of losing the heat abstracted from the power-cylinder I am using it to heat the working-gases previously to their admission into the power-cylinder; hence by my invention heat is only lost by two sources, instead of three—viz., that conducted and radiated from the engine-casing and that rejected with the waste gases. The loss from the first cause can be saved to a great extent by covering the engine with a non-conducting material, so that the only loss of heat will be that carried off or rejected with the waste gases, while a further saving of heat is effected by reason of being able to use a high degree of compression of the

charge, and consequently to expand the working-gases in the power-cylinder to such an extent as to diminish the temperature of the waste gases.

5 Referring to the rocking joint which I have described, I have illustrated modifications thereof in Figs. 10, 11, 12, 13, 14, and 15.

In the modification shown in Figs. 10, 11, and 12 the tie-rod R^4 is dispensed with, and 10 the connecting-rod R' is held up against its seat T by a centrally-placed pin, P^2 , supported at its lower end upon a bar, B , screwed to the hollow piston-rod, and bearing at its upper end upon a hardened-steel nut, N^3 , screwed upon 15 the end of the rod R' , and forming a convex bearing, N , upon the seat T . By making the curve of the nut N of proper proportion to the length of the pin P^2 a perfectly easy rock may be obtained. In some cases the bearing-sur- 20 face of the seat T may be made convex, and the end of the nut N may be flat or slightly concave, the curves having such relation to each other that the rocking upon such surface is without friction.

25 In the modification shown in Figs. 13, 14, and 15 the bearing is adapted to rock in one direction only, as differing from those described, which are adapted to rock in any direction. In this latter modification the bearing end of 30 the connecting-rod R' is formed of a section of a cylinder.

In the operation of the engine the air enters the compressing-cylinder chamber C^3 through the port I , as it is opened and closed 35 by the valve-port I' in the valve V' , said port I opening at the wall of the shell, as in Figs. 3 and 9. Gas is admitted through the pipe G into the space v under the valve V^2 , so that the valve-space v is filled with pure gas, while 40 the excess of gas more than can be contained in the space v passes through the ports G^2 and I' into the compression-cylinder chamber C^3 with the air. At the same time water may be admitted through the pipe W^2 into the port I' 45 with the air and gas. The piston, on its back-stroke, draws the mixture of gas, air, and water into the chamber C^3 , and at the same time expelling the waste gases of previous charge through the port O as it is opened by the valve 50 V' . (See Figs. 6 and 9.) When the piston has completed its back-stroke, the valves are in the position shown in Fig. 7, the outlet-port O being closed and the ports I , G , and W^2 also closed by the valve V' , so that the forward 55 stroke of the piston compresses the gases contained in the chamber C^3 , forcing them out through the stop-valve V and through the hollow piston-rod into the storage-chamber C^4 , which surrounds the working-cylinder and 60 communicates with it in the operation of the valves, as in Fig. 4. At the beginning of the forward motion of the piston the port I^4 of the valve V' opens communication through the port I' with the storage-space C^4 , and with the 65 port I^4 of the valve V^2 , so that the compressed charge enters the cylinder-space C^3 through

the ports and passages I^3 I^4 I^5 until the valve V^2 closes communication with the cylinder by closing the port I^5 , as in Fig. 8. At the same time the gas contained in the space v is forced, 70 by the returning movement of the valve V^2 , through the ports and passages G^2 G' G^4 G^5 , from which last passage it issues in a jet into the cylinder-space C , where it serves to communicate the flame from the lighter to the 75 charge. At this instant the valve V^2 also opens communication between the lighter-space L and the cylinder-space C , so that the flame from the lighter-jet J is communicated to the gas-jet issuing from G^5 , and hence to the charge. 80

Referring to the lighter, it is important to notice that the passage G^5 serves to carry the flame of the lighter to the gases in the cylinder, and the operation of lighting is as follows, viz: The space v receives the gas through 85 the pipe G , and upon the return-stroke of the valve V^2 the gas is compressed in the said chamber v . In the movement of the valve V^2 , (the valve V' being in the position shown in Fig. 7,) it opens communication between its 90 ports G^2 and G' , so that the gases pass direct to the passage G^5 , opening into the cylinder-space C , so that the gas issuing from the said passage G^5 is lighted by the lighter-jets at the instant communication is made by the valve 95 V^2 between the lighter-space L and the cylinder-space C .

As shown in Fig. 2, the shell or air-tight casing is provided with removable covers for access to the working parts of the engine. 100

Referring to the action of the stored gases in returning the piston upon the return-stroke, it will be understood that the reservoir-space C^4 is full of gases under pressure, which pressure acts continuously upon the sectional areas of 105 the enlarged piston-rod R , causing an upward pressure upon it at all times. In the forward stroke of the piston there is an excess of pressure behind the piston over that exerted by the gases in the reservoir C^4 , which drives the piston forward; but on the return-stroke the waste 110 gases are discharged from behind the piston from the space C , so that the pressure is relieved from the cylinder-space C , and the pressure of the gases upon the hollow piston-rod 115 R drives the piston back through the return-stroke, the effective area of the surface upon which the pressure of the stored gases in the reservoir C^4 acts being equal to the area of the cross-section of the hollow rod R . 120

Referring to the rocking bearing of the piston connecting-rod, the motion is not one of sliding friction, but of rocking, the same as that of a rocking-chair upon the floor, or of the rolling of a sphere upon a plane surface, 125 and the contact of the convex surface upon the seat T takes up the strain upon the forward stroke. In order to keep these parts in contact, the pin P is held up against the bearing end of the rod R' , which forces the convex rolling bearing N upon its seat T , and thus prevents the parts from getting out of con- 130

tact. The bearing of the pin P is not the usual eye-bearing; but the eye is formed with a ridge or convex bearing, as shown in Fig. 2, which co-operates with the rolling end spherical bearing to prevent all tendency of the parts to bind, and provides for a perfect alignment of the connections. The head H' of the cylinder is made removable for access to the power-chamber C to clear the walls of carbon deposit, while the casing of the fluid-chamber C', at its upper vertical wall, is provided with an opening closed by an air-tight removable cover, H², for access to the valves, and an opening in said casing at its lower opposite vertical wall is closed with an air-tight removable cover, H³, for access in fitting the crank-operating connections.

I claim—

1. The method, substantially herein described, of operating gas-engines, which consists in passing the compressed air and gases around and over the hot surfaces of the power-cylinder, for the purpose of cooling the power-cylinder and heating the gases before admission thereto, substantially as described, for the purpose specified.

2. The method, substantially herein described, of operating gas-engines, which consists in compressing the air and gases, storing them, under pressure, for use, and then passing them around and over the outer heated surfaces of the power-cylinder on their way for admission thereto, substantially as described, for the purpose specified.

3. The method, substantially herein described, of operating gas-engines, which consists in compressing air and gas, in connection with cold water injected within the chamber wherein the compression of the air and gas is effected, and then conducting said compressed gases into the power-cylinder in suitable charges for operating the engine.

4. In a gas-engine, the combination, with the power-cylinder, of an air-tight storage-chamber containing water and oil, into which the compressed gases pass on their way to, around, and over the power-cylinder, substantially as described, for the purpose specified.

5. In a gas-engine, the combination of the power-cylinder with the piston, forming therein the power-space C and the compression-space C' for the gases, and an outer shell or case forming a storage-chamber for the compressed gases surrounding the cylinder, communicating by suitable valves with the compression-chamber and with the power-space of the cylinder, and suitable valves and connections for the engine, substantially as described.

6. The combination of the working-cylinder of a gas-engine, operating to compress the gases in its forward end, with an air-tight inclosing case or shell, forming a reservoir for the compressed gases surrounding said working-cylinder, a hollow piston-rod opening into said reservoir, and a suitable valved communication with the said compression-space of

the cylinder with the gas-storing chamber, whereby the pressure of the stored gases is utilized to drive the piston back on its return-stroke.

7. The combination, in a gas-engine, of the power-cylinder having a trunk-bearing, C', a hollow piston-rod, R, and the piston P, forming the chambers C C' in said cylinder, and a hollow cap for said piston communicating with the hollow piston-rod, with an inclosing case or shell for the power-cylinder communicating with said hollow piston-rod, and a suitable valved opening in the piston, adapted to open communication with the cylinder-space C', through the hollow piston-cover, and the hollow piston-rod with said gas-storage chamber, substantially as described.

8. The combination, with a piston, of a rod-connection having a rolling or spherical end bearing upon a seat formed in the hollow piston rod or trunk, and a pin by which the parts are secured, substantially as set forth.

9. The combination, with a piston, of a rod-connection having a rolling or convex bearing upon the pin, to provide for lateral alignment, as shown and described.

10. In a gas-engine, the combination of the air-tight upright shell or case F with the power-cylinder, depending therein at the top, the piston, a hollow piston-rod, the valve V in the piston, and suitable valves and crank-connections for the engine, the said upright shell forming a chamber for the compressed gases, for water, and for oil.

11. The combination, with a piston-rod connection having an end bearing free to move in any direction, of a pin-connection having a convex bearing adapted to hold the said end bearing of the rod-connection against its seat, substantially as described.

12. The combination, in a gas-engine, of a hollow piston-rod with the crank-connecting rods R' and R², a pivoted guide-rod, R³, and means, substantially such as described, whereby said hollow piston-rod is connected with the crank-connecting rod R' by a bearing adapted to rock or roll with the motion of the connections.

13. The combination, in a gas-engine, of the power-cylinder and the piston or piston-rod, with the crank-connecting rods R' and R², jointed to each other and to a guide-rod, R³, pivoted to the engine-frame, operating substantially as described.

14. The combination, in a gas-engine, of a cylinder having a trunk-bearing, C', a hollow piston-rod, R, and the tie-rod R', with the crank-connecting rods R' and R², the said rod R' terminating in a convex bearing, the pivoted rod R², and the bearing-step T, seated upon a shoulder in the hollow piston-rod, substantially as described.

15. The combination, in a gas-engine, of the piston P with a hollow cap or cover, H, therefor, forming a chamber for compressed air and gas, as specified.

16. The combination, in a gas-engine, of the

cylinder and the piston with the two coacting valves V' V^2 , the valve V' being constructed and adapted to open and to close its ports corresponding with the full period of the stroke of the piston, and the valve V^2 operating as a cut-off, a compressor for the gas which supplies the lighter, and a carrier for the lighter, substantially as described.

17. The combination, in a gas-engine, of the valves V' V^2 , constructed and arranged to operate substantially as described, with the external lighter-jet, J' , the internal lighter-jet, J , and the passage G^5 , opening into the cylinder-space C , substantially as described.

18. The combination, in a gas-engine, of the valve V' , having the ports I' I^1 and corresponding ports in the valve-chamber, with the valve V^2 , having the ports and passages, substantially as described, whereby the valve V' operates to admit the air and gas to the compression-chamber C^3 to discharge the waste gases from the power-cylinder, and to co-operate with the valve V^2 to admit the charge into the power-chamber, as set forth.

19. A gas-engine in which the cylinder is suspended within a reservoir containing a fluid under compression, in combination with the controlling-valves of the engine, and the piston-operating connections, also arranged within said reservoir, substantially as herein set forth.

20. A gas-engine having all of its operating parts contained within a surrounding chamber which serves as a reservoir for a fluid-motor.

21. The method of operating gas-engines, which consists in introducing a fluid to the cylinder upon one side of the piston, where it is compressed and transferred through the piston to a storage-chamber, from which it is admitted to the power side of the piston, substantially as set forth.

22. A gas-engine in which the piston is provided with a valved chamber into which a fluid under compression is admitted, and ports

or passages for conducting the same to a storage-chamber, substantially as set forth.

23. A gas-engine in which the piston is provided with a valved chamber, and a trunk-extension containing ports or passages for conducting a fluid under compression to a storage-chamber surrounding the cylinder, as and for the purpose set forth.

24. The method of operating gas-engines, which consists in conducting a fluid under pressure into a reservoir containing water which is sprayed and mingled therewith, heating the same and then conducting the mixed gases and steam to the engine-cylinder, substantially as set forth.

25. The method of cooling the connections of a gas-engine, which consists in spraying water contained in a surrounding chamber upon the said connections, substantially as set forth.

26. A gas-engine provided with a surrounding chamber containing a liquid, and having its crank adapted, in the path of its revolution, to be immersed in said liquid, for spraying the same, in combination with a storage-chamber for compressed air and gas within said surrounding chamber, substantially as described, for the purpose specified.

27. In an engine, the combination of a cylinder and a fluid-pressure chamber cast integrally, the former being contained within the latter, substantially as described.

28. The combination of a fluid-pressure chamber and an engine-cylinder cast integrally, the latter being contained within the former, and each provided with a removable head or cover, substantially as set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

LEWIS HALLOCK NASH.

Witnesses:

A. E. H. JOHNSON,

J. W. HAMILTON JOHNSON.