No. 612,756. Patented Oct. 18, 1898.

J. A. OSTENBERG.

GAS ENGINE.

(Application filed July 22, 1896.)

(No Model.) 2 Sheets—Sheet 1.

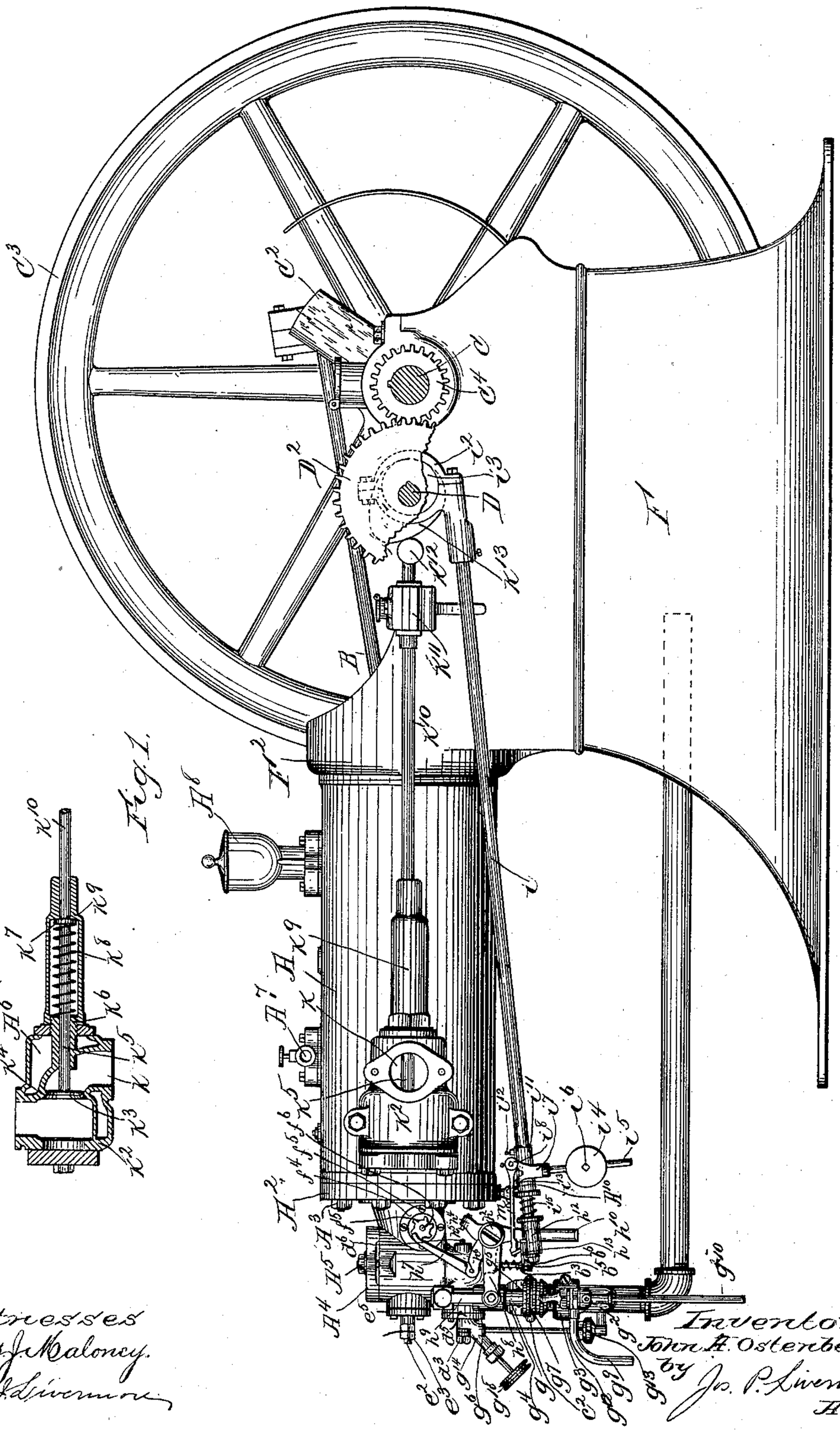

Fig. 1.

Fig. 5.

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2 Sheets—Sheet 2.

Fig. 3.

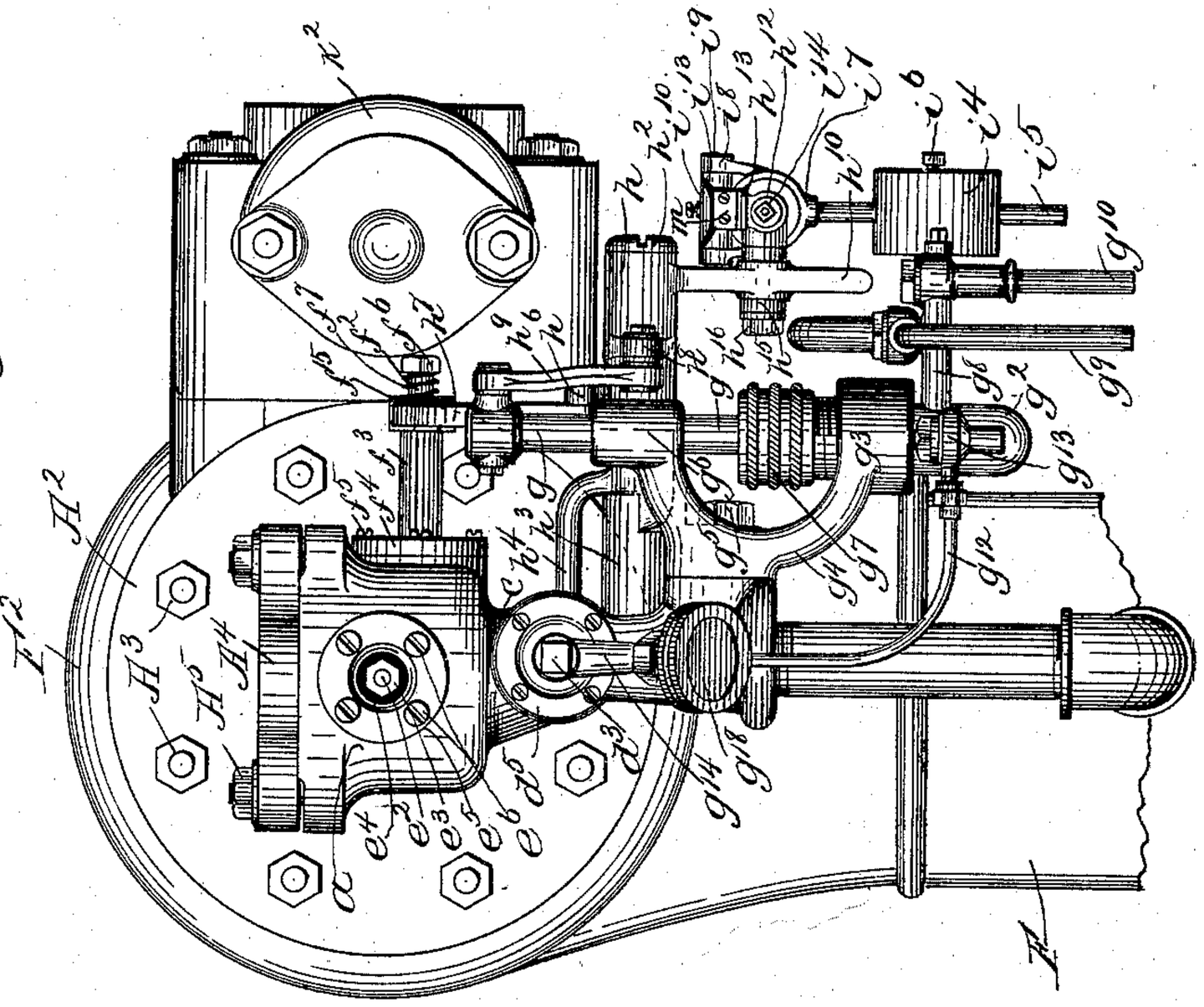

Fig. 2.

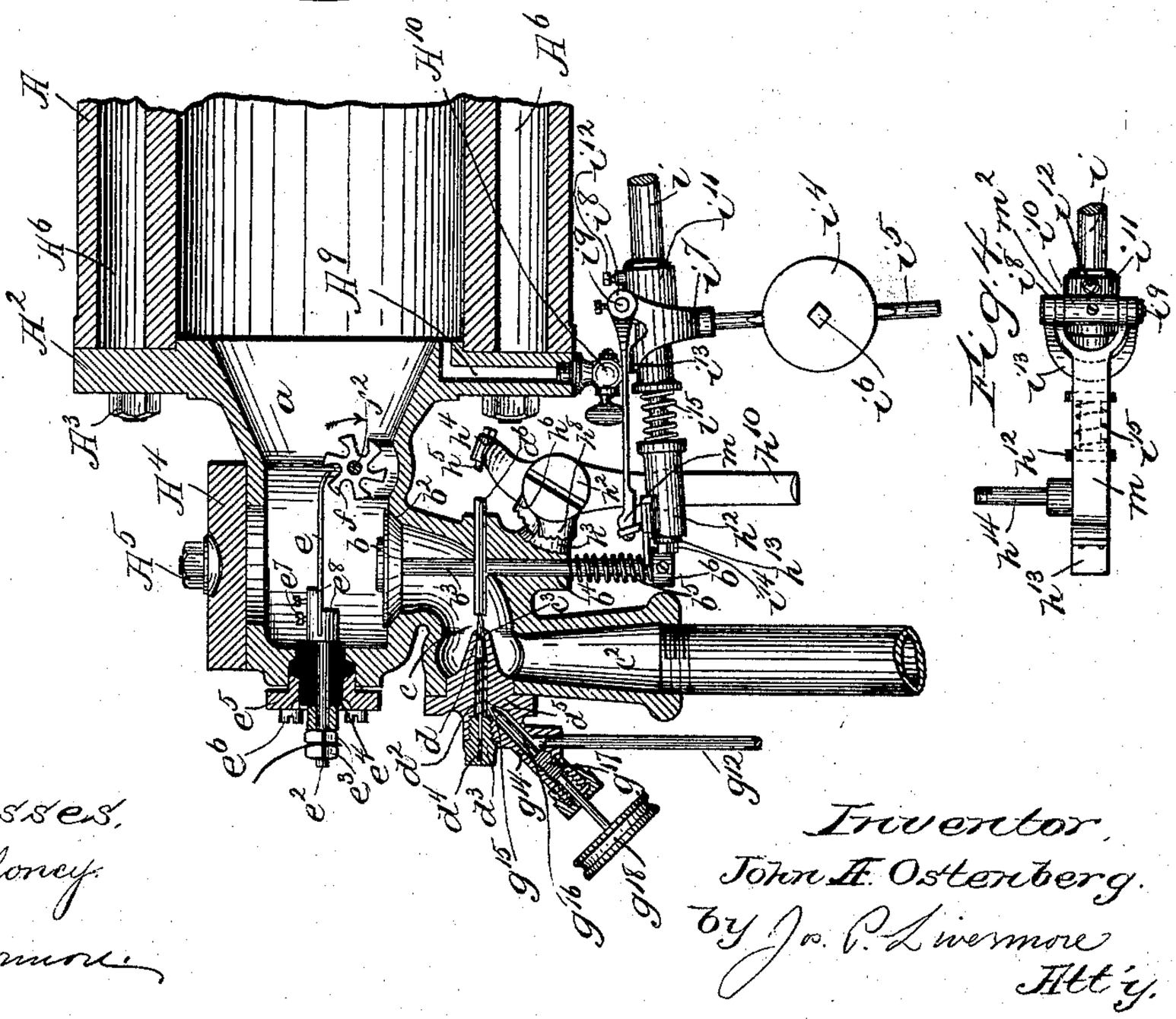

Fig. 4.

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UNITED STATES PATENT OFFICE.

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GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 612,756, dated October 18, 1898.

Application filed July 22, 1896. Serial No. 600,109. (No model.)

To all whom it may concern:

Be it known that I, JOHN A. OSTENBERG, of Walpole, county of Cheshire, and State of New Hampshire, have invented an Improvement in Gas-Engines, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

The present invention relates to a gas-engine or an engine of that class in which gas or gasolene or other substance capable of exploding when mixed with air and ignited is utilized to drive a piston, the invention consisting mainly in a novel construction and arrangement of instrumentalities and in a novel form of the regulating device whereby the explosive substance is admitted to the cylinder and exploded only when the speed of the engine falls below a predetermined maximum, so that the substance employed to drive the engine is supplied only when required.

The engine embodying the invention is provided with a cylinder open at one end, such as is commonly employed in gas-engines in which the power is applied only to drive the piston outward, the return thereof being due to momentum, and an explosion-chamber is provided within the closed end of the cylinder, having an air and gas inlet controlled by a check-valve, so that air is forced in during the outward stroke of the piston by atmospheric pressure, there being also a gas-inlet in a supplemental chamber outside of the explosion-chamber, the said inlet being controlled by a valve adapted to be opened when gas-supply is needed as the piston is moving outward, the said supplemental chamber being in open communication with the air, so that when said gas-valve is opened gas and air are together drawn into the explosion-chamber through a check-valve and are compressed therein by the return stroke of the piston, means being also provided for igniting the mixture of gas and air thus compressed when the piston is near the inner end of the cylinder, the piston then being driven out by the expansion of the gas caused by the explosion thereof. The gas-valve and the igniting device, which is preferably a circuit-breaker having its terminals connected to opposite sides of an electric circuit, so that a spark is produced when the circuit is broken, are controlled by connecting mechanism coöperating with the main shaft of the engine, so as to be operated thereby when the piston is in the proper position, novel means being provided for automatically disconnecting the actuator for the gas-valve from its operating mechanism, which is controlled by the main shaft after the said shaft has reached a predetermined maximum speed, and for reconnecting these parts when the speed of the shaft falls below said maximum, thus practically regulating the speed of the engine.

In accordance with the present invention the actuating device for the gas-valve and circuit-breaker is controlled by a reciprocating rod suitably operated from the main shaft, and the said rod is connected with the actuating device aforesaid by a movable connecting-piece adapted to be thrown into and out of engagement with said actuating device by means of a weight or pendulum carried by and movably supported on said reciprocating rod. The said weight is arranged to move with the reciprocating rod, but is capable of movement independently thereof, it being obvious therefore that when the said rod reaches the end of its stroke the momentum of the weight will tend to cause said weight to continue its movement independently of that of the reciprocating rod, this tendency increasing as the speed of movement of the reciprocating rod increases and being resisted by a substantially constant yielding force, as that of gravity. The movable connecting-piece is so arranged as to be disconnected by the movement of said weight relative to the reciprocating rod, the result being that when the reciprocating rod is moving at a predetermined speed the weight at the end of each stroke thereof will operate to disconnect the same from the actuating device for the gas-valve and circuit-breaker, thus allowing the engine to run idle until the speed falls below the normal, when the weight will have less movement with relation to the reciprocating rod owing to the resisting force above mentioned, and will permit the movable connecting-piece to engage the actuating device and produce an explosion.

The invention is preferably embodied in what is known as a "four-cycle" engine in

which every other stroke is idle, the return of the piston serving to compress the air and gas before the explosion takes place, thus obviating the necessity of special means for compressing the air, which compression is practically essential for the proper operation of an engine operating on this principle. The engine therefore is so arranged that after the explosion takes place the piston is driven outward thereby, and when it reaches the end of its outward stroke an exhaust-port is opened by a device operated from the main shaft, so that the products of combustion are free to escape during the return movement of the piston, thus practically clearing out the entire contents of the cylinder. During the next outward stroke the device for operating the gas-valve when in normal condition—that is to say, not disconnected by the regulating device above described—operates to open the gas-valve admitting gas to the supplemental chamber, where it mixes with air therein and is forced therewith into the main explosion-chamber by the atmospheric pressure due to the outward movement of the piston, which produces a vacuum within the cylinder, the check-valve being opened by such atmospheric pressure. During the return movement of the piston due to momentum after the air and gas have thus been admitted the mixture of air and gas is compressed within the explosion-chamber, and at the end of such return movement the igniting device operates so that the explosion takes place. The igniting device and the gas-valve are provided, as has been above stated, with common actuating means, but are so arranged that the gas-valve is opened by a movement of said actuating means in one direction and the igniting device actuated by its movement in the opposite direction, so that the admission of the gas and air and the ignition thereof takes place at the periods described above. In order that the actuating device may coöperate, as thus described, with the main shaft of the engine, the latter is geared to a supplemental shaft or counter-shaft from which the actuating device and the exhaust are directly operated, the gear being so arranged that the speed of said supplemental shaft is half that of the main driving-shaft. Thus when the engine is running at normal speed effective pressure is exerted at one outward stroke of the piston, which then returns, forcing out the products of combustion, and again makes an outward stroke, allowing air and gas to be sucked in behind it and to become compressed during its inward stroke, after which the piston is again acted upon by the sudden expansion of gas due to the explosion, which takes place at the end of said inward stroke. Upon rising above maximum speed, however, the effective stroke is omitted because the gas-valve and igniting device are rendered inoperative by the regulating device, the exhaust however operating regularly at every other stroke to allow the air admitted unmixed with gas when the gas-valve is not operated to escape, so that at the next outward stroke of the piston a vacuum will be produced whereby the check-valve controlling the inlet to the closing-chamber may be lifted to admit the admixture of air and gas if the gas-valve should be operated at this stroke.

Figure 1 is a side elevation of an engine embodying the present invention with a portion of the framework broken away to show the main and supplemental shafts and the gear connection between them. Fig. 2 is a longitudinal section of the explosion-chamber and a portion of the cylinder, a portion of the actuating device for the gas-valve and circuit-breaker being shown in elevation and the remainder broken away. Fig. 3 is an end elevation of the engine, looking toward the closed end of the cylinder; Fig. 4, a plan view of the regulating device, and Fig. 5 a sectional detail of the exhaust-valve.

The cylinder A is herein shown as mounted in the frame F, which forms a standard or base for the shafts, the open end of said cylinder being set in a collar or annular support F^2, the opposite end of said cylinder being closed by the head A^2, which is preferably cast integral with the part which forms the explosion-chamber *a* and the inlet passage or chamber *c*, which will be hereinafter described. The said cylinder contains a piston of ordinary construction, as will be readily apparent from the drawings, although the piston itself is not herein shown, said piston being connected by a pitman B to the crank C^2 to insure the momentum necessary for engines of this kind, in which the force is exerted on one side only of the piston.

The cylinder, piston, and pitman, together with the main shaft C and the fly-wheels, are all of usual construction, as will be readily understood from Fig. 1 without further description.

The gas and air which form the explosive mixture are admitted to the explosion-chamber *a* (best shown in Fig. 2) through a check-valve *b*, herein shown as coöperating with an annular beveled valve-seat b^2 in the lower portion of the explosion-chamber *a*, and provided with a guiding-stem b^3, extending downward through a guide-opening b^4 in a wall of the casing which contains the chamber and inlet-passage, the said valve being normally maintained seated by means of a spring b^5, interposed between the exterior of the casing and a head or flange b^6 at the end of the stem b^3. The inlet to the explosion-chamber *a*, controlled by the said valve *b*, is through an inlet-passage or chamber *c*, having an air-inlet c^2 and a gas-inlet c^3, controlled by a valve *d*, herein shown as a tapering valve or needle-valve coöperating with the inlet c^3, which is in the nature of a nozzle having tapering inner walls against which the tapering valve *d* is normally seated by means of a spring d^2, bearing against a block d^3, which has a

guide-opening d^4 for the stem of the valve d, said block d^3 being screwed into an opening at the rear of a cap or bonnet, secured in an opening in the wall of the supplemental chamber c. Gas or gasolene is admitted to the inlet c^3 through a suitable pipe, as will be hereinafter described. During the outward stroke of the piston, therefore, a vacuum is produced in the cylinder and explosion-chamber, so that the pressure of the air entering the supplemental chamber c through the air-inlet c^2 will lift the check-valve b; and it is obvious that if the valve d is simultaneously opened or opened at any time during the inflow of air the gas admitted to the supplemental chamber c will be drawn with the air into the cylinder during the outward stroke of the piston and will be compressed therein during the inward stroke of the piston, its escape being prevented by the check-valve b, which will obviously seat automatically. The gas and air thus admitted and compressed may be exploded at the proper time by any suitable igniting device, a circuit-breaker being preferably employed, adapted to alternately make and break an electric circuit, so as to draw an arc between the switch-terminals at each break. The igniting device is herein shown as a circuit-breaker comprising a spring-contact e and a rotating contact-piece f, comprising a star-wheel or similar device the projections of which are adapted to come in contact with the stationary contact or spring e and, as the wheel rotates, to make and break contact therewith, the arrangement being such, as indicated in Fig. 2, as to produce a sudden break and considerable separation of the contact portions, so as to draw an arc and produce a spark which will ignite the explosive mixture.

The rotating contact f is arranged to be moved by steps at the proper time, each step advancing the star-wheel the distance between two of its spokes or projections, so that a movement of the said wheel in the direction of the arrow will carry it from the position in which it is shown to a similar position with the wheel one step farther in advance, thus causing the contact to be made and broken and a spark to be produced.

The electric circuit may be completed in any suitable way, and, as herein shown, one wire is connected to the rod e^2 as between the nuts e^3, the said rod extending through an insulating collar or sleeve e^4, which is secured in an opening in the explosion-chamber by means of an annular clamping-piece e^5, fastened as by cap-screws e^6.

The contact-piece e is herein shown as secured by set-screws e^7 between two clamping-jaws e^8 at the end of the said rod e^2 within the explosion-chamber a, the other wire of the said circuit being connected to any portion of the cylinder or engine, the rotating member for the circuit-breaker being mounted on a spindle f^2, provided with a tubular bearing f^3, preferably having a flange f^4, secured, as by set screws f^5, to the edge of an opening in the explosion-chamber, so that the contact-piece may be readily removed for inspection or repairs. There being no insulation between the spindle f^2 and its bearing it is obvious that if a circuit-wire is connected to any portion of the cylinder the spindle f^2 and break-wheel f will be in circuit, while the contact e, which is connected to the opposite wire, will be insulated therefrom by the insulating-block e^4, so that the two members of the circuit-breaker are electrically disconnected, except when said members are in contact, as above described.

In order to control the admission of the gas to the explosion-chamber and to actuate the circuit-breaker for the purpose of igniting the said gas, these parts are provided with a common actuating device coöperating with the main shaft, as will be hereinafter described. The said actuating device may also be arranged, if necessary, to operate a pump for gasolene or other liquid from which the explosive gas may be produced, such a construction being herein shown. The said actuating device, as herein shown, consists of a rock-shaft h, mounted on a spindle h^2, secured in a portion h^3 of the casing, in which are the explosion-chamber and inlet-chamber, the said rock-shaft being provided with an arm or projection h^4, adapted to coöperate with the valve d, as by means of a longitudinally-movable pin d^6, bearing in an opening in the wall of the inlet-chamber c, so as to engage in its longitudinal movement with the point of the valve d to open the same, the said projection h^4 or an adjustable pin, as h^5, connected therewith, being adapted when the shaft h is rocked to come in contact with the end of the pin d^6, and thereby open the valve d, as indicated in Fig. 2.

The circuit-breaker is actuated by means of a projection h^6 from the rock-shaft h, having a pawl h^7 pivoted thereto, the said pawl coöperating with a ratchet-wheel f^{15}, mounted on the spindle f^2, so that a movement of the rock-shaft in one direction will cause the pawl to engage a tooth of the said ratchet-wheel, while the movement in the opposite direction will turn said ratchet-wheel the distance between two consecutive teeth, which is a sufficient distance to secure a closure and break of the circuit and a spark within the explosion-chamber, as above described. The ratchet-wheel f^{15} is preferably connected with the spindle f^2 by means of a spline, and the said spindle f^2 is provided with a head f^6, between which and the ratchet-wheel f^{15} is interposed a spring f^7, whereby the contact-piece on the wheel is held snugly against the inner surface of the bearing, so as to insure good electrical contact.

To operate the pump when gasolene is to be used, an arm or projection h^8 from the said rock-shaft is provided and connected, by means of a link h^9, to the plunger g of a pump of any suitable construction, the pump herein

shown comprising a chamber g^2, within which the plunger g reciprocates, the said chamber being secured in a split collar g^3 at the end of the arm or bracket g^4, secured by the bolt g^5 to the casing which contains the explosion-chamber, said bracket being also provided with a guide-collar g^6 for the plunger g. The plunger g passes into the chamber g^2 through a head g^7, consisting, as shown, of a coupling-piece screwed onto the outside of the upper end of said chamber and provided with a flange on its upper side between which and the upper end of the chamber packing material may be contained, so as to provide a stuffing-box for the plunger, and the liquid is admitted to the chamber g^2 through an inlet-pipe g^8, preferably provided, as shown, with two branches g^9 and g^{10}, adapted to lead to a reservoir or tank of gasolene, the pipe g^{10} being provided with a check-valve which will allow the gasolene to flow therefrom into the pipe g^8, but will not allow its return to the pipe g^{10}, and the pipe g^9 being provided with a check-valve which will permit the gasolene from a pipe g^8 to enter said pipe g^9, but not the reverse. The check-valves are not shown, as their operation is obvious, the object of this arrangement being to permit the gasolene which when forced from the chamber by the plunger cannot flow out of the outlet g^{12}, which will be hereinafter described and which is adapted to be regulated so as to control the amount of gasolene supplied to the engine, to return to the reservoir through the pipe g^9.

The outlet-pipe g^{12} is connected to the chamber g^2 through a check-valve contained in a coupling-piece g^{13}, so that as the plunger descends the gasolene which has flowed into said chamber owing to atmospheric pressure as the plunger rises will be forced out through the check-valve in the head g^{13} through the pipe g^{12} to the tube g^{14}, which communicates through a tapering nozzle g^{15} with the nozzle controlled by the valve d.

In order to regulate the supply of gasolene which will be admitted at each stroke of the pump to the nozzle c, a valve g^{16} is provided, having a tapering end coöperating with the tapering valve-seat g^{15} and provided with a screw-thread g^{17}, coöperating with an internal thread in a projection in which the inlet-pipe g^{14} is formed, so that the said valve can be regulated by turning the same, as by the actuating-knob g^{18}. Assuming, therefore, that the engine is to be operated by means of gasolene and that the actuating device or rock-shaft h is connected with the shaft of the engine in such manner as to be properly operated thereby, it will be seen that a movement of said shaft in one direction will produce a downstroke of the pump, thus forcing a certain amount of gasolene up into the inlet controlled by the valve d, and the same movement will cause the arm h^4 to engage the pin d^6 and open the said valve d, so that the gasolene can escape into the chamber c, the nozzle being, as shown, of such character that the liquid will issue in fine spray, these operations taking place during the outstroke of the piston-rod, so that the valve b is lifted by atmospheric pressure and the sprayed liquid and air admitted to the explosion-chamber, while the same movement of the rock-shaft causes the pawl h^7 to travel back over the ratchet-wheel f^{15} until it falls behind and engages a tooth thereof, so that in the return movement of the rock-shaft h the rotating switch member will be advanced one step, so as to produce an explosion and consequent exertion of power within the cylinder.

To produce the proper movement of the rock-shaft h, so that the pump will operate and the valve be opened and the explosion take place at the proper times, the said rock-shaft is operated from the main shaft C, the direct connection being preferably with the supplemental shaft D, which is geared thereto, as will be hereinafter described.

To oscillate the rock-shaft h, the latter is provided with an arm h^{10}, connected to a reciprocating rod i, adapted to be reciprocated by the rotation of the supplemental shaft D, the said rod i being preferably provided, as shown, with an eccentric-strap i^2, coöperating with an eccentric i^3 on the said supplemental shaft D, so that a complete rotation of said shaft produces a back-and-forward movement of the said rod i. Assuming, therefore, that the said rod i is permanently connected to the arm h^{10}, it will be seen that the rock-shaft h will oscillate between its extremes at each rotation of the shaft D and will therefore open the valve to admit gas once during such revolution of the shaft D and will produce an explosion once during such revolution, one of these operations taking place at the end of one half-revolution of the shaft D and the other at the end of the other half-revolution.

As has been stated, the invention is preferably applied to an engine of the four-cycle type or one in which the operation of the piston itself is utilized to compress the gas and air previous to the explosion thereof, and in order that such may be the operation the shaft D is connected by a spur-gear D^2 to a spur-gear C^4 of half the diameter of the gear D^2, so that the shaft D makes but one complete revolution at each two complete revolutions of the shaft C, or, what is the same thing, at each two complete strokes of the piston. Assuming, then, that an explosion has just taken place and that the rod i is in its extreme right-hand position, reference being had to Fig. 1, it is obvious that a complete stroke will be made—that is to say, that the piston will have gone once outward and inward with relation to the cylinder before the rod i has reached its extreme right-hand position, at which time the gas-valve will be opened and the pawl h^7 engaged with a new tooth of the ratchet-wheel f^{15} preparatory to producing an explosion at the next movement of the rod i in the opposite direction or

from right to left. Such being the case it is obvious that during the next outward movement of the piston air and gas will be drawn into the explosion-chamber and compressed at the next inward movement of the piston, at the end of which time the rod *i* will have again reached its extreme left-hand position and produced an explosion, so that the same cycle of operations is repeated. At the end of each explosion it is obviously necessary that the cylinder should be cleared of the products of combustion, and to this end the exhaust-port *k* is provided, herein shown as an opening in a supplemental chamber k^2, secured to the side of the cylinder A, the said exhaust-opening *k* being controlled by a valve k^3, (shown in Fig. 5,) coöperating with an annular seat k^4 within the chamber k^2, and provided with a stem k^5, guided and supported in a coupling-piece k^6, said stem having a flange k^7 at its outer end between which and the outside of the coupling is interposed the spring k^8, tending to maintain the said valve seated. Screwed onto the outside of the said coupling k^6 is a collar or guide-piece k^9, into which is longitudinally movable a rod k^{10}, for which the said piece k^9 forms a bearing and support, the said rod k^{10} also having a bearing k^{11} at its opposite end and terminating in a cam-roll k^{12}, coöperating with the cam k^{13}, mounted on the shaft D. It is obvious, therefore, that the exhaust-valve k^3 will be opened at every other stroke of the piston, and the cam k^{13} is so placed with relation to the eccentric i^3 that the said cam will engage the rod k^{10} to open the exhaust-valve just long enough after the rod *i* is operated to produce the explosion to allow the main shaft C to make about half a revolution, or, in other words, to allow the piston to substantially reach the end of its outward stroke, so that when it begins its inward stroke the exhaust-port will be open and the products of combustion driven out. As it reaches the end of its inner stroke the exhaust-port becomes closed, the gas-valve at the same time being opened, so that gas and air are drawn into the air-cylinder as the piston moves outward and said gas and air being compressed on the next inward stroke at the end of which the explosion again takes place, the exhaust-port being again opened immediately after.

The operation thus far described is exactly what would take place if the connection between the rod *i* and the rock-shaft *h* were a permanent connection. In order to regulate a gas-engine, however, it is practically essential that the explosion should be omitted for one or more strokes if the engine reaches abnormal speed, owing to a drop in the load or for other reasons. The regulation is accomplished by novel means in accordance with the present invention, said means consisting in a device whereby the rod *i* will be automatically disconnected from the projection h^{10} of the rock-shaft *h* if the said rod *i* moves at more than a predetermined speed. This is accomplished by providing a weight loosely connected to the rod *i* and adapted to be moved thereby during the reciprocation of said rod, but also free to move independently of said rod owing to the momentum acquired thereby during the movement of said rod, the said momentum, upon which depends the tendency of said weight to move independently, obviously increasing with the speed of movement of said rod. The said weight is so arranged as to coöperate with a movable connecting-piece to throw the same out of engagement with the arm h^{10} if the movement of the weight is sufficient to produce the corresponding movement of the connecting-piece, and its independent movement is resisted by a practically constant force, as that of gravity or a spring, so adjusted that a material movement of the weight independent of that of the rod will occur only after the rod reaches a predetermined speed.

As herein shown, the weight i^4 is in the form of a pendulum suspended from the reciprocating rod *i*, the said weight being preferably secured to a stem i^5, along which it is longitudinally adjustable, being secured in any desired position, as by a nut or set-screw i^6, the said stem being pivotally connected to the rod *i*, so that the momentum of the said weight acquired during the movement of the reciprocating rod will tend to cause said weight to continue its movement in the direction of movement of the said rod when the said rod stops and is moved again in the opposite direction, it being obvious, however, that such movement of the weight is resisted by the force of gravity, which tends to keep the weight at its lowest point. Coöperating with the said weight is the movable connecting-piece *m*, comprising a hook also pivotally connected to the rod *i* and normally adapted to engage a portion of the actuator *h* when the rod *i* is in its extreme left-hand position, so that in the return movement of said rod from left to right the actuator *h*, being connected therewith, will be operated as hereinbefore described. The said hook *m*, however, is arranged to coöperate with the weight i^4, so that when the movement of the reciprocating rod *i* has reached a speed sufficient to produce the independent movement of said weight the said hook will be lifted so as not to engage with the actuator *h*, the operation of the parts actuated thereby thus being omitted as is necessary.

As herein shown, the stem i^5, which carries the weight i^4, is secured to the head-piece i^7, which is forked and provided with lugs i^8 and pivoted upon the ends of the pin i^9, which extends transversely through a head i^{10}, formed upon the upper surface of an adjustable collar i^{11}, fitting the rod *i* and longitudinally movable with relation thereto, said collar being secured in any desired position by a set-screw i^{12}. The said forked head i^7 is also provided with a projection i^{13} in the form of a loop extending over the collar i^{11}, the lower

portion of said loop normally resting upon the surface of said collar, the weight, as shown, being hung somewhat forward of its pivot i^9, so that it will normally hang in the position shown in Figs. 1 and 2, it being obvious, however, that the momentum acquired by the said weight when carried toward the left by the rod i will tend to continue the movement thereof in that direction and produce an upward movement of the looped extension i^{13} with relation to the rod i.

The hook m is preferably forked at its pivoted end and provided with lugs m^2, which are also mounted on the pin i^9, and said hook extends from said pivot toward the arm h^{10} of the rock-shaft h. Secured to the arm h^{10} is a collar h^{12}, having a flat upper surface h^{13}, upon which the end of the hook m normally rests, as shown, the stem of the hook thus being somewhat raised above the surface of the projection i^{13}, so that when the weight i^4 is in its normal position and the rod i has moved to its extreme left-hand position the hook m will drop over the edge of the surface h^{13} and engage therewith, so that in the movement of the rod i in the opposite direction the arm h^{10} will be carried to the right, rocking the shaft h and producing the desired operation of the parts actuated thereby.

The rod i, as shown, extends through the collar h^{12}, so that it is free to move independently thereof except when the hook m is engaged with the edge of the surface h^{13}. The nut i^{14} is preferably secured to the end of the rod i beyond the collar h^{12}, as shown.

In order to maintain the actuator h in its normal position when the arm h^{10} is engaged with the hook m, a spring i^{15} is interposed between the collar i^{11} and the collar h^{12}, so that the arm h^{10} is prevented from following the rod i in its movement from left to right unless the hook m is engaged therewith, in which case the parts move together with the spring compressed between them. As soon, however, as the speed of the engine reaches a predetermined maximum the momentum acquired by the weight i^4 when moved toward the left by the rod i will be sufficient to cause the said weight to continue its movement after the rod i is stopped, so that the head i^7 is swung on its pivot and the hook m is lifted by the projection i^{13}, thus taking place at the time when the hook would normally drop over the edge of the surface h^{13}, the said hook thus being prevented from engaging the said edge as the rod i moves back, so that the movement of said rod produces no corresponding movement of the actuator h.

The collar h^{12} may be secured in any suitable way to the arm h^{10}, it being herein shown as provided with a spindle h^{14}, extending through a transverse opening in a hub or enlargement h^{15} of the arm h^{10} and secured therein by a nut h^{16}, as shown in Fig. 3.

The cylinder, explosion-chamber, &c., may be constructed in any suitable or usual way, the explosion-chamber and inlet-chamber c being preferably formed in a single casting integral with the head A^2 of the cylinder A, the said head being secured thereto by nuts A^3, secured to the ends of bolts passing through openings in the said head A^2 and secured in the body of the cylinder A. Thus the valves and the igniting device and the actuating device are all mounted and supported in a single piece, openings being provided whereby all the parts are readily removed and assembled.

The interior of the explosion-chamber may be reached by removing the bonnet A^4, which forms, as clearly shown, a cover for the said chamber which is provided with an opening at the top, the said bonnet being secured by nuts A^5 in the usual way, the opening being sufficiently large to admit of the insertion of the check-valve b, the stem of which is simply passed down through the guideway therefor in the lower portion of the casting, as shown in Fig. 2, and secured in position by means of the spring b^5 and head b^6, afterward secured thereto.

The opening for the switch-terminal e is at the rear of the explosion-chamber, its construction having been already described, as well as that of the gas-inlet nozzle c, which is also removable for the repair or inspection of the gas-valve.

The air-inlet c^2 is, as shown, a downward extension from the said casting, to which is preferably secured a pipe, as shown, which is carried forward and terminates below the frame F, which supports the machine.

The cylinder is preferably provided with a water jacket or space A^6, into which water is admitted through an inlet A^7, there being also provided an outlet, (not herein shown,) so that a circulation of cold water may be maintained around the cylinder to prevent undue heating thereof during the operation of the engine.

As shown in Fig. 5, the water-space A^6 also extends around the exhaust-chamber k^2. The cylinder is also provided with a lubricator A^8, of any suitable or usual construction, through which oil is admitted to lubricate the piston. As shown in Fig. 2, a port A^9 is provided, preferably formed, as shown, in the cylinder-head and adapted to be closed and opened by a petcock A^{10}, the object of this being to place the interior of the cylinder in communication with the air while the engine is being started, the starting operation being necessarily accomplished by manually or otherwise starting the shaft to produce sufficient momentum to operate the valves and igniting device, considerable difficulty being experienced owing to the fact that a large amount of power is required to compress the air in a cylinder during the inward stroke, which takes place when the exhaust is closed, this being obviated by opening the cock A^{10}, so that the air behind the piston can escape instead of being

compressed, the cock then being closed as soon as sufficient momentum is given to the shaft to start the operation of the engine.

While the specific construction which has been hereinbefore described is believed to possess many advantages, it may be obviously modified without departing from the invention, and it is not, therefore, intended to limit the invention to such specific construction.

I claim—

1. In a gas-engine, the combination with the explosion-chamber provided with an inlet controlled by a check-valve, of an air-passage leading to said inlet; an inlet to said air-passage for the explosive gas or liquid and a valve controlling said inlet; a mechanically-operated igniting device within the combustion-chamber, and common means for controlling said valve and igniting device comprising a movable member coöperating with a shaft of the engine; a weight carried by said member but capable of movement independently thereof, and means for disconnecting said member from the parts operated thereby by the independent movement of said weight, substantially as described.

2. In a gas-engine provided with an explosion-chamber, the combination with a valve controlling the admission of an explosive gas or liquid to said chamber, and a mechanically-operated igniting device within said chamber; of a common actuator for said valve and igniting device, operating mechanism for said actuator comprising a reciprocating rod adapted to be reciprocated by the rotation of the main shaft, a movable connecting member adapted to connect said reciprocating rod and actuating device together, a weight carried by said rod but movable independently thereof, and an engaging portion movable with said weight and adapted to engage said connecting device when such independent movement of said weight takes place, substantially as described.

3. In a gas-engine, the combination with the explosion-chamber, of a valve controlling the admission of an explosive gas or liquid to said chamber; an igniting device consisting of a circuit-breaker within said chamber provided with a rotating contact-piece, a common actuating device for said valve and said circuit-breaker comprising a rock-shaft having an arm or projection adapted to operate the valve, and a pawl coöperating with a pinion mounted on the spindle of said rotating switch-contact, a reciprocating operating-rod for said actuating device, and means for disconnecting said rod from said actuating device in response to an increase in speed, substantially as described.

4. In a gas-engine, the combination with the explosion-chamber, of a mechanically-operated igniting device within said chamber, a valve controlling the admission of a common explosive gas or liquid to said chamber, an actuating device for said valve and igniting device comprising a rock-shaft adapted by its movement in one direction to open said valve and by its movement in the opposite direction to actuate said igniting device; a reciprocating rod provided with a movable connecting member adapted to connect the same with said actuating device when said rod is at or near one extremity of its reciprocating movement, a weight carried by said rod but capable of independent movement with relation thereto, and an engaging portion carried by said weight adapted to engage said connecting device, substantially as described.

5. In a gas-engine, the combination with the valve controlling the admission of the explosive, and the igniting device, of an actuator common to both, a reciprocating rod connected with the main shaft of the engine; a collar on said rod connected with said actuating device; a hook pivotally connected to said rod normally resting upon the surface of said collar but movable beyond the edge thereof during the movement of the said rod; and a weight pivotally suspended from said rod and provided with an engaging projection underlying said hook, substantially as described.

6. In a gas-engine, the combination with a valve controlling the inlet for the explosive, and a mechanically-operated igniting device for said explosive, of an actuator common to said valve and igniting device, a reciprocating rod, means for automatically connecting said rod to, and disconnecting it from said actuator in response to variation in the speed of said main shaft, the main shaft provided with a gear, a supplemental shaft provided with a gear double the diameter of that on the main shaft and meshing therewith, and means for producing the reciprocating movement of said rod from the rotation of said supplemental shaft, substantially as described.

7. The combination with the explosion-chamber provided with an air-inlet controlled by a check-valve, of a valve controlling the admission of a liquid or gaseous explosive to a chamber or a passage leading to said inlet, a mechanically-operated igniting device within the explosion-chamber, a common actuator for said valve and igniting device, an exhaust-valve, and means for operating said exhaust-valve and actuator by the rotation of a supplemental shaft geared to the main shaft and adapted to make two revolutions for each single revolution thereof, substantially as described.

8. In a gas-engine, the combination with a pump for an explosive liquid, of a valve controlling the admission of such liquid to the explosion-chamber, and a common actuating device for said valve and pump comprising a rock-shaft coöperating therewith respectively, and adapted each time it operates to open said valve and operate the pump, a reciprocating rod suitably operated by the main driving-shaft of the engine, and means for automatically connecting and disconnecting said

rod and said rock-shaft in response to variations in the speed of the main shaft, whereby said valve is caused to remain closed, and the pump to remain stationary in response to an increase of speed, substantially as described.

9. In a gas-engine, the combination with the valve controlling the admission of the explosive, and the igniting device, of an actuator common to both, a reciprocating rod operated by the main shaft of the engine, a hook pivotally connected with said rod and adapted to engage said actuating device, and a weight pivotally connected with said rod and adapted by a movement on its pivot to disengage said hook from said actuating device, substantially as described.

10. In a gas-engine, the combination with the explosion-chamber, of a spring-seated valve controlling the admission of an explosive thereto; an unseating device for said valve; a pump for said explosive; an igniting device comprising a circuit-breaker having stationary and rotatable members within the explosion-chamber, the rotatable member being provided with a ratchet outside of the explosion-chamber; a common actuating device for said valve-unseating device, pump and igniting device consisting of a rock-shaft having an arm adapted to engage the said unseating device, a connection with the pump and a pawl adapted to coöperate with the ratchet aforesaid to operate the igniting device; an operating device for said rock-shaft consisting of a rod adapted to be continuously reciprocated while the engine is running; and means for disconnecting said rod from said actuating device in response to an increase of speed in the running of the engine, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN A. OSTENBERG.

Witnesses:

H. J. LIVERMORE,

N. P. FORD.