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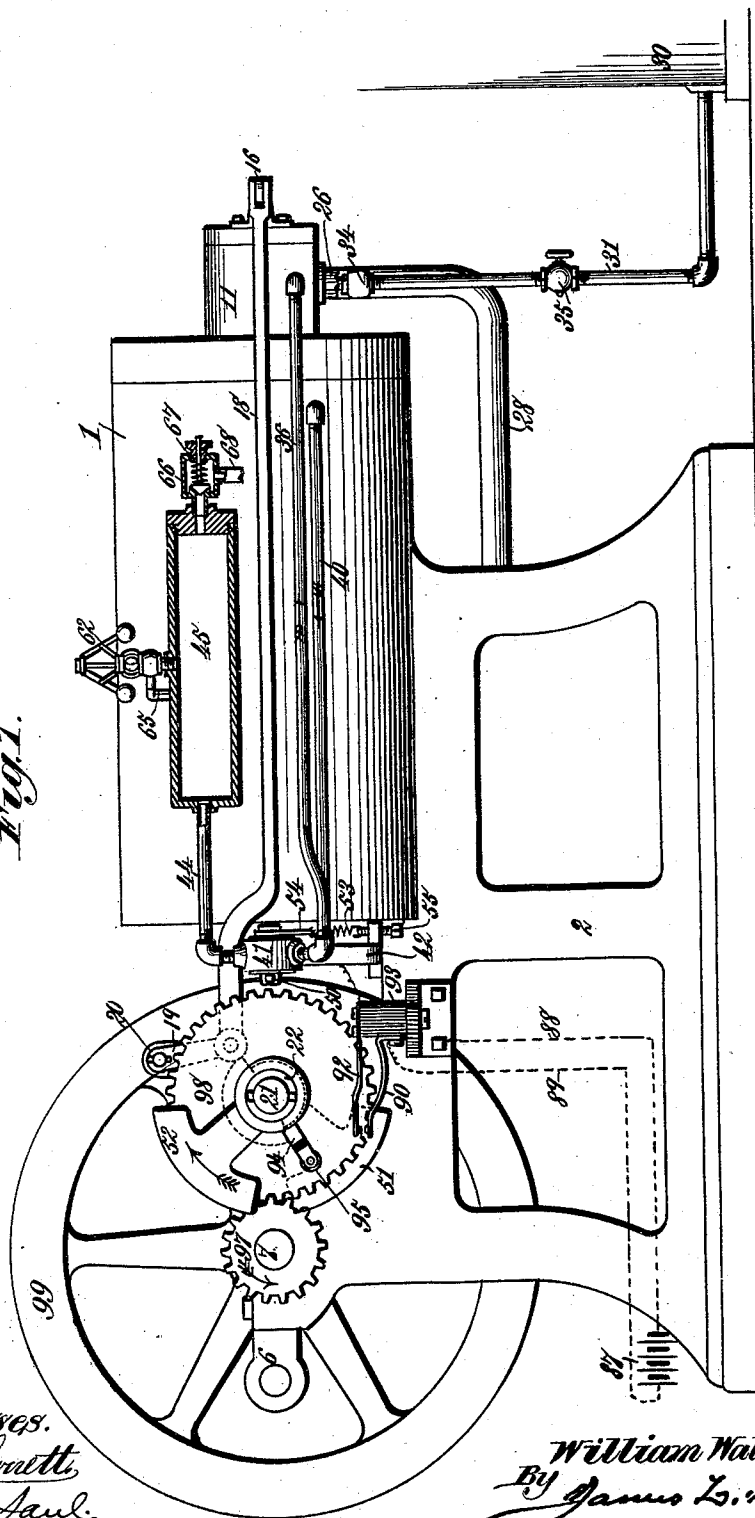
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W. W. GRANT.
GAS ENGINE.

No. 553,488.

Patented Jan. 21, 1896.

Fig. 1.



Witnesses.
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(No Model.)

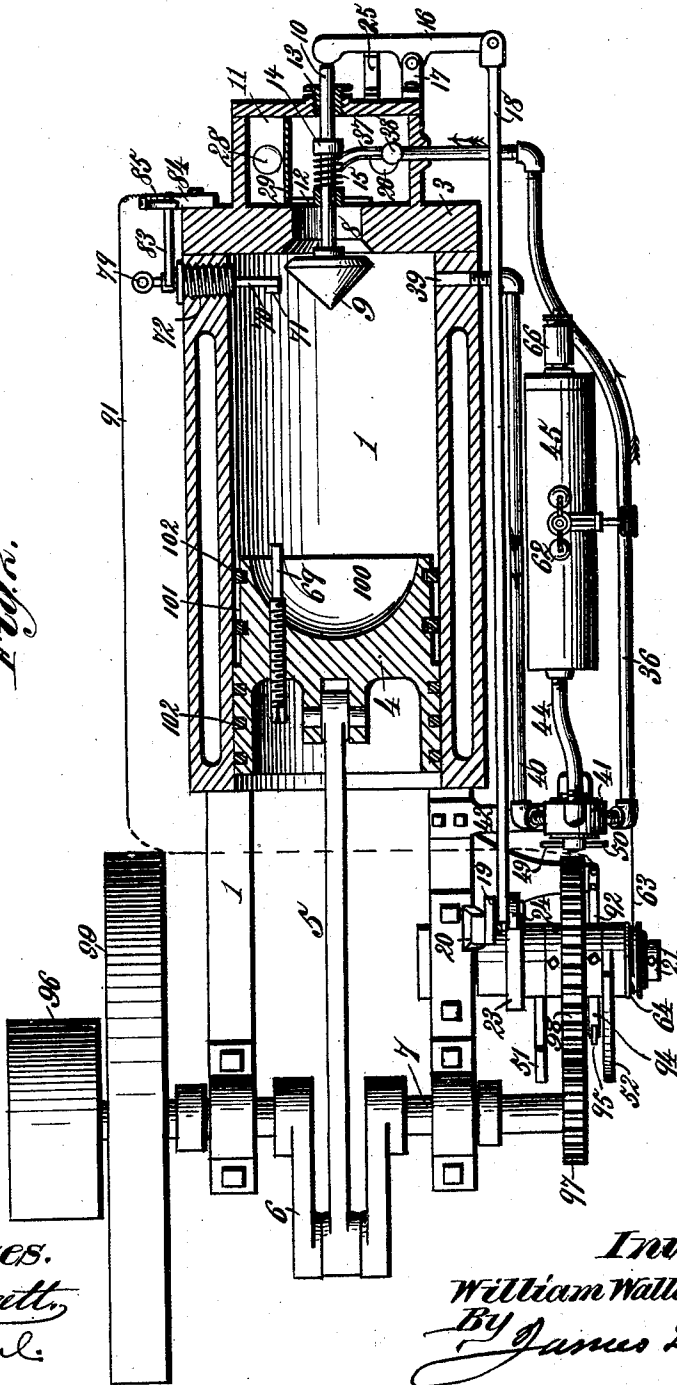
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Fig. 2.



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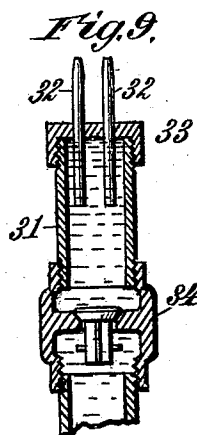
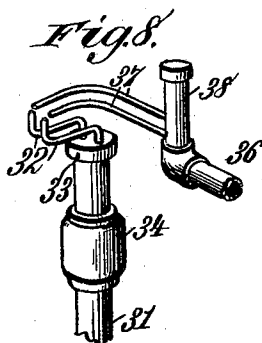
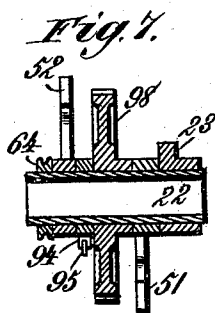
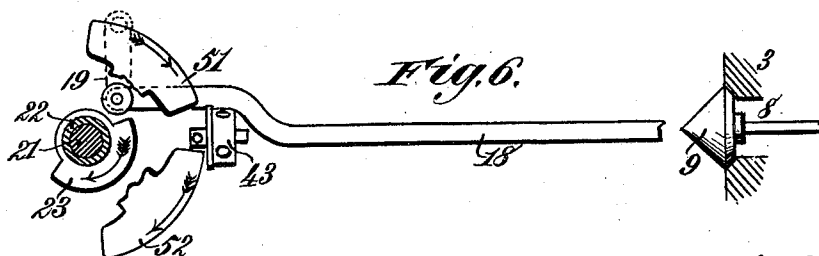
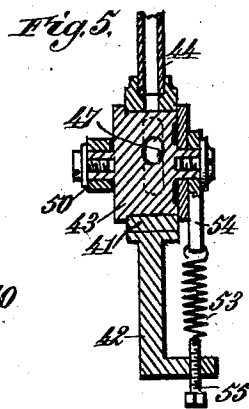
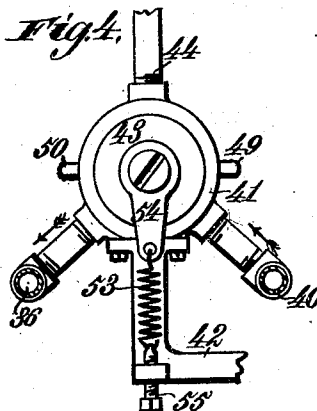
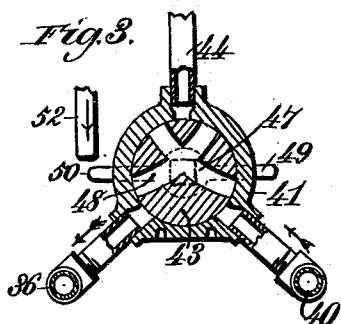
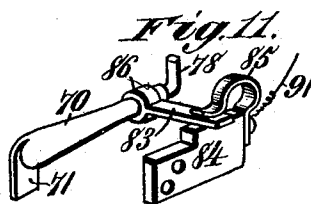
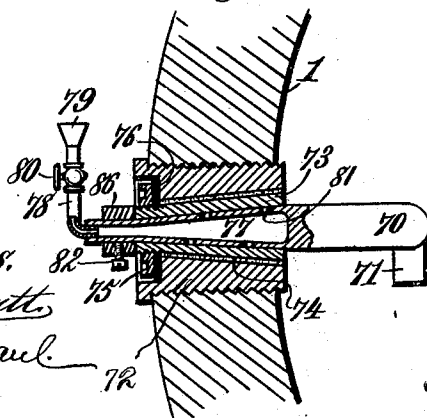


Fig. 10.



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Fig. 12.

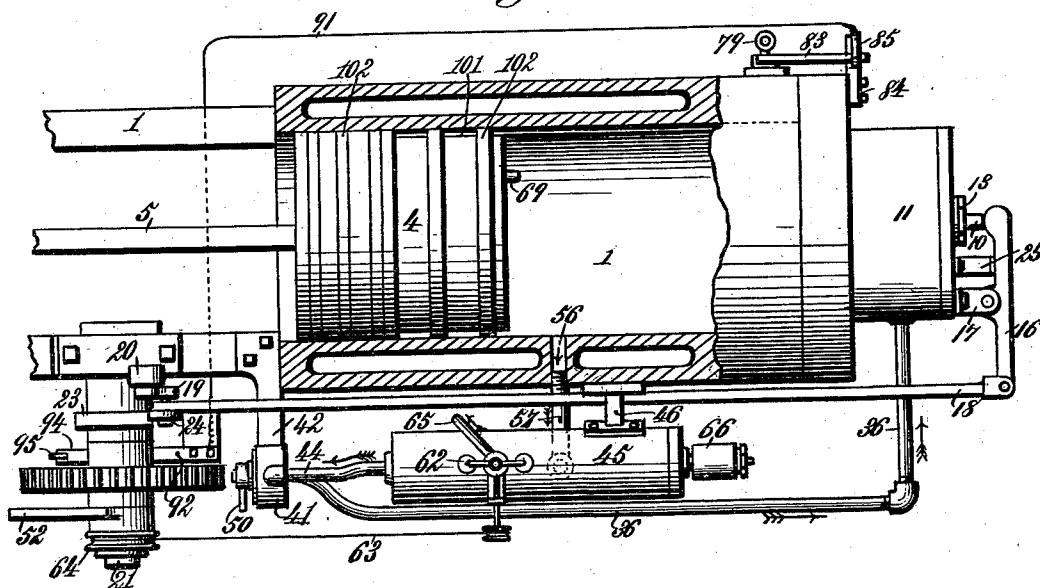


Fig. 13.

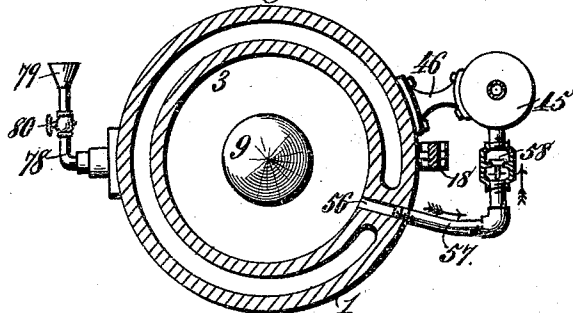


Fig. 14.

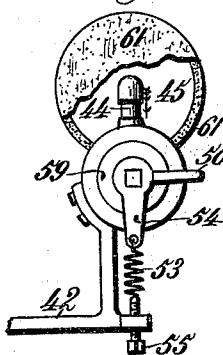
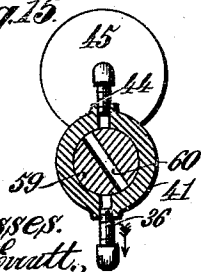


Fig. 15.

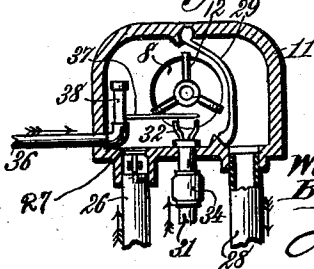


Witnesses.

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Fig. 16.



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UNITED STATES PATENT OFFICE.

WILLIAM WALLACE GRANT, OF BROOKLYN, NEW YORK.

GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 553,488, dated January 21, 1896.

Application filed September 22, 1894. Serial No. 523,815. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM WALLACE GRANT, 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.

My invention relates to gas-engines of that type in which an explosive charge, either of fixed gases or a mixture of atmospheric air and vaporized or atomized hydrocarbon, is employed within the power-cylinder for development of the energy required to drive a piston connected with the engine crank-shaft.

It is a special feature of my invention to provide a simple and automatically-controlled blast for operating one or more injectors or atomizers for producing or contributing to the production of required explosive properties in, for or to the working charge or charges for operation of the engine. According to my invention this said blast is to consist of gas or gases from within a power-cylinder, power-compartment or compression-chamber, or from any combination of these elements entering into a gas-engine, whether gas or gases of compression (before ignition) or gas or gases of expansion, (after ignition of a charge,) thereby in either case dispensing with a separate-piston pump to produce said blast.

Other objects of my invention are to provide improved mechanism for controlling the opening and closing of the valve at the single charging and exhaust port of the cylinder; to provide improved valve-operating mechanism for the blast; governor and safety-valve mechanism; an improved injector or atomizer, and an improved arrangement of electrodes in an electric circuit that is normally open or broken at two points so that only on the closing of the circuit at both these points the passage of a spark will be insured at the proper time to effect the required explosion of the charge.

The invention consists in the features of construction and novel combination of devices in an explosive gas or vapor engine, as hereinafter more particularly described and claimed.

In the annexed drawings, illustrating the invention, Figure 1 is a side elevation of my improved gas-engine in part section, and

shows the engine on dead-center as at conclusion of expansion-stroke. Fig. 2 is a plan of the same, partly in horizontal section. Fig. 3 is an enlarged vertical transverse section of a four-way valve and its connections for controlling the injector or atomizer-blast. Fig. 4 is an enlarged elevation of the four-way valve and its supporting-bracket. Fig. 5 is a vertical section of the four-way valve, taken at a right angle to the view shown in the preceding figure. Fig. 6 is a partly sectional detail view of portions of the mechanism for opening the cylinder-valve and the four-way valve for the atomizer-blast. Fig. 7 is a sectional view of a gear-actuated cam-carrying sleeve on which is also shown in section a pulley for the engine-governor. Fig. 8 is an enlarged perspective of one form of the injector or atomizer. Fig. 9 is an enlarged vertical section of the hydrocarbon-supply pipe and tubes for the atomizer. Fig. 10 is an enlarged sectional view of a portion of the engine-cylinder and oscillatory electrode mounted therein. Fig. 11 is a perspective of the oscillatory electrode. Fig. 12 is a part sectional plan of the engine as modified to permit utilization in the atomizer-blast of a portion of the gases of expansion from the power-cylinder. Fig. 13 is a part sectional detail and elevation of the same. Fig. 14 is an enlarged end elevation of the gas-receiver, partly broken away to show its non-conducting covering and illustrating also the connected one-way valve for the atomizer-blast. Fig. 15 shows the receiver in end elevation and the one-way valve in section. Fig. 16 is an end elevation of the inlet and exhaust chamber in section and inclosing the atomizer.

The engine-cylinder 1 is preferably mounted in a horizontal position on a base or frame 2, Fig. 1, of any suitable form and construction. As shown in Figs. 2 and 12, the cylinder may be water-jacketed throughout the greater part of its length, and is closed at one end by a head 3, the other end being open for the working of a close-fitting piston 4 connecting by a pitman 5 with a crank 6 of the engine-shaft 7, that is mounted in suitable bearings upon one end of the engine base or frame.

In the cylinder-head 3 is a single charging and exhaust port 8, controlled by a single valve

9, preferably of the puppet type. This valve 9 is inclosed in the engine-cylinder and may have a conical front face, while its rear face is preferably conoidal to correspond with a beveled seat at the inner edge of the cylinder-port. The stem 10 of the valve 9 is extended outward through the port 8 and through an inlet and exhaust chamber 11 on the outer face of the cylinder-head. A spider-frame 12 at the outer end of the cylinder-port 8 and a stuffing-box 13 in the rear wall of the chamber 11 serve to support and guide the valve-stem 10, so that the valve 9 may be moved steadily and in a straight line to and from its seat at the inner end of the single charging and exhaust port. On the valve-stem 10 is a collar 14, and surrounding the stem, between said collar and the spider-frame 12, is a spirally-coiled spring 15, that serves to act on the valve-stem in such manner as to close the valve 9 tightly into its seat after the valve-stem has been relieved from the pressure of the actuating mechanism through which the inward or opening movement of the valve is effected.

For the purpose of moving the valve-stem 10 inward to open the valve 9 a two-armed oscillatory lever 16 may be centrally pivoted to a lug 17 on the rear of the inlet and exhaust chamber. One end of this lever 16 is adapted to bear on the projecting end of the valve-stem 10 and the other end of said lever is pivotally connected with one end of a longitudinally-movable rod or bar 18, Figs. 1, 2, 6, 12 and 13, extended along one of the outer sides of the engine-cylinder. The other or forward end of the rod or bar 18 may be curved upward, as shown in Figs. 1 and 6, and is pivotally connected to the lower portion of a link or hanger 19, the upper end of which is secured to a standard or bearing 20 on the engine-frame.

Adjacent to the standard 20, and also mounted on the engine-frame, is a fixed stud or spindle 21, Figs. 1 and 6, that projects in a horizontal or lateral direction. On this stud is loosely mounted a rotating sleeve 22, Figs. 1, 6 and 7, carrying a cam 23, arranged to come in contact at suitable intervals with a roller 24, Fig. 2, on the adjacent end of the longitudinally-movable rod 18; or the said roller may be omitted and the cam 23 be arranged to strike directly against the rod 18 or on the link or hanger 19 to which the said rod or bar 18 is connected. Through the pressure exerted by the cam 23 the rod 18 will receive a longitudinal movement in such direction as will cause one end of the connected oscillatory lever 16 to bear against and move the valve-stem 10 inward, so as to open the valve 9 controlling the cylinder-port. The cam 23 has such extent of surface and is so adjusted as to act on the longitudinally-movable rod 18 and cause the valve 9 to be opened just before the beginning of the exhaust-stroke of the piston 4, and will exert a continued action to hold the said valve 9 open during

the whole of the exhaust-stroke and the whole, or nearly the whole, of the charging-stroke. When the cam 23 has passed out of contact with the roller 24 or ceased to act on the rod 18, a spring 25, Figs. 2 and 12, will restore the lever 16 and rod 18, so as to relieve the pressure on the valve-stem 10 and permit its spring 15 to move the cylinder-valve 9 to its normally-closed position.

The inlet and exhaust chamber 11 is provided with an air-supply pipe 26, Figs. 2 and 16, through which the air to be carbureted for use in operating the engine may be drawn into the power-cylinder by the suction of the piston, either directly from the atmosphere or from an air-space inclosed by the engine-frame. A check-valve 27 or other device may be provided at the upper end of the air-supply pipe 26 to prevent the escape of exhaust-gases through said air-pipe. An exhaust-pipe 28 may lead from the chamber 11 to any required point, and in the chamber is arranged a flap-valve or shutter 29 for the purpose of preventing the suction of the engine from drawing back into the cylinder any exhaust-gases that have already passed into the said exhaust-pipe.

For carbureting the atmospheric charge gasoline or other liquid hydrocarbon may be supplied, as from a tank 30, Fig. 1, through a pipe 31 leading to the inlet and exhaust chamber. As shown in Figs. 9 and 16, the upper end of the hydrocarbon-supply pipe 31 is provided with one or more jet or discharge tubes 32 extended into the chamber 11 and having their lower ends, Fig. 9, dipped into or submerged in the hydrocarbon contained in the supply-pipe. Any desired number of injecting, spraying, or atomizing tubes 32 may be employed, and they are preferably fastened securely and with close joints into a screw-cap 33, Fig. 9, on the upper end of the supply-pipe 31, so that there can be no escape of hydrocarbon, except as it is drawn through the tubes 32 and atomized or vaporized and injected into or mingled with atmospheric air being drawn into the power-cylinder. In the hydrocarbon-supply pipe 31 is a check-valve 34, by which the level of gasoline in the pipe 31 will be sustained in readiness for promptly furnishing hydrocarbon for the required carbureting-spray. Unless some special provision is made to guard against an overflow, the level of the gasoline in the supply-tank 30 should never exceed in height and should be, preferably, lower than the top of the spraying-tubes. As shown in Fig. 1, a hand-valve 35 is arranged in the pipe 31 to prevent the column of gasoline from falling out of said pipe when the engine is not in use, and to serve, also, as a gage for controlling or regulating the volume of gasoline delivered to the injector or atomizer.

In order to lift the gasoline or other carbureting material and atomize or vaporize it, a blast-pipe 36 is arranged to enter one side of the chamber 11. As shown in Figs. 8 and 16,

the discharge end of the blast-pipe 36 is curved upward in the chamber 11 and extended beyond the point whereat is secured one or more horizontally-projecting atomizer blast-tubes 37, the discharge ends of which are in proximity to the exit ends of the tubes 32, with which the gasoline-supply pipe 31 is provided. The upper end of the blast-pipe 36 is closed above the point from which the tubes 37 project, and thus there is provided in said upper closed end of the pipe 36 an air-cushion 38 that will aid in equalizing the pressure in the blast-tubes 37 of the atomizer. There may be only one gasoline-tube 32 and only one blast-tube 37 comprised in the injector or atomizer, but I prefer to employ more than one tube of each kind.

Instead of providing an ordinary air-pump to supply a blast through the pipe 36 to the atomizer I have so designed this engine as to conveniently and economically utilize a portion of the gases from within the engine-cylinder to operate as a blast for injecting, atomizing, or vaporizing the hydrocarbon employed to carburet the succeeding charge or charges taken into the power-cylinder. The gases of compression consisting of the fresh charge of gas (before ignition) may be taken, in part, from the engine-cylinder or a communicating compression chamber or compartment to be used in the atomizing or injector blast or the gases of expansion—that is to say, after ignition and during expansion of the compressed charge—may be utilized for the blast.

If it is preferred to produce the injecting or atomizing blast with a portion of the gases for or of compression taken from the engine-cylinder 1 before explosion of the charge therein, the said cylinder will be provided on one side near its closed end or head 3 with an opening 39, Fig. 2, that connects with one end of a pipe 40, extended along the outside of the cylinder toward that end of the engine-frame on which the crank-shaft 7 is mounted. At its other end the pipe 40, as shown in Figs. 2, 3, and 4, connects with one side of a valve-casing 41, supported by a bracket 42 and inclosing an oscillatory four-way-valve plug 43, with which the blast-pipe 36 and the said pipe 40 are adapted to communicate. Although a four-way valve is shown, a three-way valve may be employed for the same purposes as the four-way valve.

A pipe 44, Figs. 1, 2, 3, 4, and 5, connects the four-way-valve casing with a preferably cylindrical gas or air receiver 45, Figs. 1, 2, 12, 13, 14, and 15, that may be supported in a horizontal position by a bracket 46, Figs. 12 and 13, on one side of the power-cylinder of the engine. The four-way-valve plug 43 is provided with intersecting passages 47 and 48, Fig. 3, the passage 47 being adapted to establish communication between the pipe 40 from the engine-cylinder and the pipe 44 of the gas-receiver 45 when the valve is in proper position for the purpose, while the passage 48 is designed to establish communi-

cation from the said receiver 45 and its pipe 44 to the blast-pipe 36 of the atomizer when the said four-way valve is suitably oscillated or shifted. On the valve-plug 43 are fixed two oppositely-projecting arms 49 and 50, Figs. 2, 3, and 4, through which the valve is oscillated. The four-way valve is actuated, through these arms, by means of cams 51 and 52, Figs. 1, 2, 3, 6, and 7, that may be adjustably fixed to and carried by the rotary sleeve 22, hereinbefore mentioned.

At or shortly after the beginning of the compression-stroke of the engine-piston 4 the cam 51 will come in contact with and depress the arm 49 of the four-way valve, and thereby oscillate said valve into such position that its passage 47 will establish communication between the pipes 40 and 44 and permit a portion of the compressing or compressed combustible charge to enter the receiver 45 from the engine-cylinder. Just before the compression-stroke of the piston 4 is completed the cam 51 passes from and releases the valve-arm 49, and the valve will then be restored to its normal closed position by means of any suitable spring 53, the compressed air or gas being thus confined in the receiver 45 until it is required for the atomizing-blast. The spring 53, Fig. 4, may be attached at one end to an arm 54 of the oscillatory valve-plug and at its other end to an adjusting-screw 55, supported in a projecting portion of the bracket 42, on which the valve-casing 41 is mounted.

When the piston 4 begins its charging-stroke the cam 52 will have been moved into position to depress the valve-arm 50 and thus oscillate the four-way valve in such direction that its passage 48 will establish communication between the pipe 44 of the receiver 45 and the blast-pipe 36 to the atomizer. All or a portion of the compressed aeriform or gaseous contents of the receiver 45 will thereupon be permitted to forcibly discharge into and through the pipe 36 to supply the blast for furnishing a hydrocarbon spray or vapor to the charge of atmospheric air which at this time is being drawn into the engine-cylinder. Thus it will be seen that the receiver 45 is charged—at each period of compression in the power-cylinder 1, and delivers a blast for the injector or atomizer—at each period when the power-cylinder is being charged.

The above description relates to utilizing a portion of the fresh charge (before ignition and explosion thereof in the power-cylinder) to serve as a blast for operating the atomizer, or for purposes of vaporizing, carbureting, or procuring a combustible; but it may at times be desirable to produce the blast from some portion of the power-cylinder charge after ignition and explosion, instead of before ignition, or while the charge is in a state of expansion consequent upon ignition and explosion.

In order to take a portion of the gases of expansion from the power-cylinder 1 at a desired period of expansion, an opening 56,

Figs. 12 and 13, may be provided in one side of the power-cylinder at a greater or less distance from its head, according to the pressure at which it is required to charge the receiver. The cylinder-opening 56 communicates with preferably the under side of the receiver 45 through pipe connections 57, Figs. 12 and 13, in the upper vertical portion of which is located a check-valve 58, arranged to permit the inlet of gas to the receiver and prevent its escape therefrom through the pipe 57 to the cylinder. In its outward movement the piston 4 will uncover the opening 56, whereupon a portion of the hot expanding gas in the cylinder 1 will rush through the pipe connections 57, lift the valve 58 and pass thence into the receiver. The check-valve 58 closes when the pressure against its under side is relieved or when the pressure within the receiver 45 is greater than in the pipe 57, and thus by the closing of said valve escape of gas is prevented and it remains confined, under pressure, in the receiver. With this mode of connecting the cylinder 1 and receiver 45 the four-way-valve plug 43 may be replaced by a one-way-valve plug 59, having a single straight passage 60, as shown in Fig. 15. The one-way-valve plug 59 will require only one operating-arm 50, as shown in Fig. 14, and only one actuating-cam 52, as shown in Fig. 12, and may be provided with a spring 53, Fig. 14, similar to that employed with the four-way valve. It also has a casing 41 connecting with the blast-pipe 36 and with the outlet-pipe 44 of the receiver 45. (Shown in Figs. 12, 14 and 15.) The spring 53 normally holds the one-way valve 59 and its single passage 60, Fig. 15, in such position that communication will be cut off between the receiver 45 and the blast-pipe 36 of the atomizer. When, however, the cam 52 comes in contact with and depresses the arm 50 of the one-way valve, the passage 60 will be brought into alignment with the pipes 36 and 44, and a blast from the receiver 45 will thus be furnished to the atomizer to inject and spray the gasoline or other hydrocarbon for carbureting the charge then being drawn into the power-cylinder. On release of the valve-arm 50 from the cam 52, the valve will be closed or restored to normal position by its spring.

It will be obvious that the four-way valve hereinbefore described could be used for controlling the charging and discharging of the receiver 45 when the gases of expansion are utilized for the blast, somewhat as it is used for controlling the production of a blast from the compressed or unignited charge; but by the substitution of a one-way valve and its use in conjunction with the check-valve 58 in the pipe connection 57, one of the valve-actuating cams can be dispensed with and all necessity avoided for adjustment to a proper time for charging the receiver 45 with hot expansion-gases, since the power-piston by uncovering the cylinder-opening 56 will set the time for charging the receiver, while the

check-valve 58 will act automatically to render the receiver self-charging and retain or secure the charge therein. The opening 56 may be placed at any point in the power-cylinder space between the cylinder-head and the farthest outward throw of the piston, according to the required period and degree of pressure for charging the receiver. For the purpose of preventing the pressure of gas in the receiver 45 from sinking by a too rapid radiation of heat the receiver may be provided with a packing or covering 61, Fig. 14, of any suitable insulating or non-conducting material. In some cases it may be desirable to provide the receiver 45 with a water-jacket—as, for instance, when the receiver is to be charged at or about the moment of initial pressure, consequent upon ignition of the explosive charge within the power-cylinder.

There may be placed on the receiver 45, or at some suitable point connected therewith, a governor 62, Figs. 1 and 2, of any appropriate or preferred construction that will be adapted to properly regulate the speed of the engine. The governor may be driven by sprocket-chain or belting 63, Figs. 2 and 12, from a pulley 64 on a rotary sleeve 22, Fig. 7. A pipe 65 is provided to carry off any gas released by the governor.

Obviously the governor may be placed upon either of the pipes 36, 40, or 44, instead of upon the receiver 45, and, in the event whereof, the pipe 65 may be dispensed with, as the governor will not, when placed upon either of the pipes named, operate to permit escape of the blast into the atmosphere. The governor when placed upon the pipe 36 will operate to permit or prevent passage of the injector-blast to the atomizer, according to the speed of the engine.

On the receiver 45 or on either of the pipes 36, 40 or 44, may be placed a safety-valve 66, Figs. 1, 2 and 12, preferably seated by a spring 67, Fig. 1, and having a pipe 68 for escape of gas at a pressure beyond that for which the valve is set.

Explosion of the charge in the power-cylinder 1 is effected electrically through a spark produced by make-and-break contact of suitable electrodes in an electric circuit that is automatically controlled by the engine.

As shown in Fig. 2, one electrode, 69, is carried by and adjustably secured to the piston 4 in the power-cylinder and has a longitudinal movement with said piston. For a portion of its length this electrode is externally screw-threaded for tapping it into and through the piston, and one end is adapted for attachment of a wrench to adjust it forward or back, as may be required, to suit the stroke of the piston. The other electrode, 70, is provided at one end with a lateral or downward projection 71, Figs. 2 and 11, for contact with the electrode 69 and is so mounted as to be capable of rocking or oscillating on its axis in a suitable bearing provided in one side of the power-cylinder. The manner of mount-

ing the oscillatory electrode 70, so as to insulate it from contact with the engine, is shown in Fig. 10. An externally-threaded screw-plug 72, Figs. 2 and 10, is tapped into one side of the engine-cylinder 1 near its closed end or head. This screw-plug 72 has a central tapered perforation within which is placed a conical sleeve or bearing 73 tapered both inside and outside and having exterior screw-threads upon its smaller outer end. Between the interior of the plug 72 and the exterior of the inclosed conical sleeve or bearing 73 is a thickness of insulation 74, such as asbestos or other suitable material. A nut 75 is placed on the outer threaded end of the sleeve 73 within the outer recessed end of the plug 72 and is suitably formed or recessed for attachment of a wrench or spanner to permit the nut being tightened, so as to draw up the sleeve 73 tightly and firmly within its insulated covering. An insulating-washer 76 separates the nut 75 from the screw-plug 72, in which the sleeve or bearing 73 is supported. The oscillatory electrode 70 is mounted within the conical sleeve or bearing 73 and is tapered throughout a portion of its length to form a close-fitting joint therewith. The interior of the oscillatory electrode 70 is hollowed to form an oil or lubricant chamber 77, which may be supplied or recharged, as required, through a pipe 78, that may have an upper funnel-shaped end 79 and be provided with a cock 80, if desired. Lubricant escapes to the bearing 73 through openings 81 leading from the oil-chamber in the electrode.

To the outer end of the electrode 70 is secured, by means of a set-screw 82, Fig. 10, an adjustable arm 83, Figs. 2 and 11, that normally rests on an insulating-block 84 of wood or other suitable material secured to the engine-cylinder. A spring 85 is attached to this block or support 84 and presses the arm 83 down thereon, so as to hold the oscillatory electrode 70 in normal position and restore it after make-and-break contact with the electrode 69 carried by the piston 4 of the power-cylinder. By reference to Fig. 10 it will be observed that the attaching-collar 86 of the electrode-arm 83 serves, in conjunction with the tapered sleeve or bearing 73, to prevent any endwise movement of the oscillatory electrode. As will be seen by Figs. 2, 10 and 11, the electrode 70 is capable of oscillation under impact of the longitudinally-moving electrode 69 carried by the piston 4, and under the return pressure of the spring 85 bearing on the electrode-arm 83 a rubbing between the contact-points of the electrodes is effected as they enter upon their make and break of contact.

The electric circuit may comprise a battery 87, Fig. 1, or other source of electric energy. A wire 88 connects one pole of the battery with the engine-frame, (or other part of the engine, as desired.) A wire 89 connects the other pole of the battery with an insulated contact-spring 90, and a wire 91, Figs. 1, 2,

and 11, connects an adjoining insulated contact-spring 92, Fig. 1, with the insulated spring 85, Fig. 11, that bears on and makes contact with the arm 83 of the oscillatory electrode. There are normally two breaks in this circuit—namely, one between the separated electrodes 69 and 70, and the other between the separated contact-springs 90 and 92 that are mounted on an insulating block or support 93, Fig. 1, secured to the engine-frame. On the rotary sleeve 22, hereinbefore referred to, is carried an insulated cam-arm 94, Fig. 1, that may have a roller 95 on its outer end. This arm 94 is so arranged that at the proper time its roller 95 will press on one of the normally-separated contact-springs 90 and 92 and thereby cause said springs to be in contact with each other, thus closing one break in the circuit for exploding the compressed charge in the power-cylinder.

The object of having two breaks in the electric circuit is to provide a means for securing a spark but once in each two revolutions of the engine, for with each revolution of the engine there is a make-and-break contact between the electrodes 69 and 70; but as no current can pass while the circuit is broken by the normal separation of the two springs 90 and 92, as these springs are only closed together, or in contact once in two revolutions of the engine, (owing to the rate of movement imparted to the cam-arm 94, as presently explained,) it is only at this time that the contact of the electrodes will entirely close the circuit. Then, at their separation, to break the circuit the spark will pass which is to ignite the compressed charge and produce the explosion that gives increased momentum to the piston of the engine. The arrangement of the springs 90 and 92 and cam-arm 94 is such as to permit contact between said springs a little before the electrodes 69 and 70 come together at the end of the compressing-stroke of the engine, and also enables them to remain closed or in contact for a little while after separation of the electrodes, thus insuring ignition of the charge in the cylinder.

Upon one end of the engine crank-shaft 7 may be secured a band wheel or pulley 96, Fig. 2, for attachment of belting to take power from the engine. The other end of the engine crank-shaft 7 carries a spur-pinion 97, Figs. 1 and 2, meshing with and driving a spur-gear 98, Figs. 1, 2, 7, and 12, that is fast on the rotary sleeve 22, to which are also secured the cam 23 for actuating the levers through which the cylinder-valve 9 is opened, the cam or cams 51 and 52 for opening the valve that controls the atomizer-blast, the pulley 64 for driving the governor, and the cam-arm 94 for making contact between the insulated and normally-separated springs 90 and 92 in the electric circuit. The gear 98 is twice the diameter of the pinion 97, so that by proper adjustment of the cams on the rotary sleeve 22, that is practically a part of said gear, the requisite time movements may

be readily obtained throughout the moving parts of the engine. A fly-wheel 99, Figs. 1 and 2, is preferably carried on the engine crank-shaft.

5 As shown in Fig. 2, the power-piston 4 has its working face provided with a concaved recess 100 to avoid striking the cylinder-valve 9 and oscillatory electrode 70 and to form a compression and explosion chamber in the
10 closed end of the cylinder. In order to provide for a free working of the piston and prevent any tendency to binding within the cylinder the inner end portion of the piston 4 may have its periphery provided with an annular rabbet 101, whereby the external diameter of this portion of the piston is sufficiently
15 reduced to permit an easy longitudinal movement. The piston may be provided with expansible packing-rings 102, as usual.

20 The engine, as shown in Figs. 1 and 2, may be assumed to have just completed the explosion and expansion stroke. The crank 6 is, therefore, upon the outward dead-center and the cam 23 has acted to open the cylinder-
25 valve 9, and will now hold it full open for the exhaust. The cylinder-valve 9 is opened a little before the outward dead-center is reached, so that exhaust may be actually entered upon before the piston 4 begins to make
30 its exhaust-stroke. In Fig. 2 the cylinder-valve 9 is shown full open, and the next inward stroke of the piston will exhaust the cylinder. Just as the crank 6 passes the inward dead-center upon the next or outward
35 stroke of the piston to charge the cylinder the cam 52, acting on the arm 50 of the four-way valve, will open said valve to permit discharge of the receiver 45 and produce a blast through the pipe 36 to the injector or atomizer
40 to furnish a hydrocarbon spray or vapor to the ingoing charge of atmospheric air that is now entering the engine-cylinder through its still open port. The cam 52 will slip by and release the valve-arm 50 before the charging-
45 stroke of the engine is completed, and the four-way valve (or the one-way valve, as the case may be) will then be restored by its spring 53 to normal closed position. When the outward dead-center is passed for the following return or compression stroke of the
50 piston 4, the cam 51 will act on the valve-arm 49 of the four-way valve and turn or oscillate said valve to such position that a portion of the compressing or compressed charge or gases of compression in the engine-cylinder 1 will find entrance through pipes 40 and 44 into the receiver 45, and just as the compression-
55 stroke is completed (or a very little before) the cam 51 becomes disengaged from the arm 49 of the four-way valve. The said valve thereupon closes through the action of the spring 53, and the compressed charge within the receiver 45 is thus confined until later released to operate the atomizer upon the next
60 charging-stroke of the engine. Just before the conclusion of the compression-stroke the insulated cam-arm 94, Figs. 1, 2, 7, and 12,

will have pressed the contact-springs 90 and 92 together and closed the electric circuit at that point. At the conclusion of the compression-stroke the two electrodes 69 and 70
70 will have rubbed together and be in contact within the power-cylinder, thus completing the electric circuit, and just as the inward center is passed the electrodes have again
75 rubbed, contact is broken between the electrodes, the spark passes, explosion and expansion of the charge follows, and an increased momentum is thereby given to the piston. At the end of this outward piston-stroke two revolutions of the engine will have transpired and
80 the engine will again be, as in Figs. 1 and 2, ready to enter upon the exhaust-stroke.

When a portion of the expanding-gases in the engine-cylinder are to be utilized for the
85 atomizer-blast instead of the fresh compressing or compressed charge, the receiver 45 becomes self-charging as soon as the piston 4, upon its outward stroke, due to explosion and expansion of the compressed charge, un-
90 covers the port or opening 56, Fig. 12, and the gravity-valve 58, Fig. 13, then secures the charge within the receiver until its release by action of the cam 52, Fig. 12, on the one-way
95 valve, Fig. 15, at the charging of the engine-cylinder. Thus, with but slight modification of the engine, the gases from within the power-cylinder, whether gases of compression before
100 ignition or gases of expansion due to or after ignition and explosion of the charge may be safely, conveniently, and economically utilized for producing the blast to inject and vaporize or spray the hydrocarbon employed in
carbureting the cylinder-charge.

When the hot gases of expansion are used, the tendency of the heat thereof to assist in
105 the vaporization of a liquid hydrocarbon will be understood. When a gas, such as illuminating-gas or other form or order of a fixed gas, is desired to be employed instead of a
110 liquid hydrocarbon for the carbureting of a charge to render the charge explosive, the tubes of the atomizer, as used for liquid hydrocarbon, may be substituted, if so desired, by larger atomizer-tubes. The hydrocarbon-
115 pipe 31 with valve 34 and key 35, Fig. 1, may be connected with the gas main or pipe conducting such fixed gas, and any pressure within said gas-main may be approximately balanced by weighting the valve 34 for the purpose thereof and the engine thereupon made
120 to operate with a fixed gas instead of a liquid hydrocarbon.

I do not propose to apply the blast as I have here described it to the shown form of atomizer only, but propose employing said blast
125 in connection with any form of device with which a blast (produced by gas or gases from within the power-generating compartment or cylinder of the engine) may be made applicable for delivering or procuring hydrocarbon
130 to a body of gas or gases for the purpose of rendering such gas or gases explosive.

Various modifications of devices may be

employed for utilizing gas or gases from within the power-generating compartment or cylinder of the engine or from the interior of a compression chamber or compartment communicating with said cylinder as a means toward the admixture of hydrocarbon with another body whereby to secure a required combustible or inflammable compound for the development upon ignition of energy which may be converted into work. I employ the term "hydrocarbon" for convenience and do not restrict myself to the employment of hydrocarbon only, but embrace within the scope of employment any form of body which can be and which it may be preferably desired to employ in connection with the hereinbefore-described blast for the purpose or that is capable of imparting or securing the required property of inflammability upon admixture with another body.

Employment of the words "engine charge" embodied in the claims forming part of this specification refer to and are meant and intended to embrace any gaseous, aeriform, vaporized, sprayed, atomized, or liquid body, charged or passed into the engine or parts of the engine, without the intervention or employment therefor of any mechanically-constructed piston, other than the power-piston of the engine's power-cylinder, with the exception, however, of hot expanding vapor, gas or gases, (due to combustion of a charge,) which, while being likewise embraced within the intent and meaning of "engine charge," are so embraced irrespective of the circumstances or conditions under which the original vapor, gas, or gases (subsequently entered into the hot expanding state) were charged or passed into the engine.

What I claim as my invention is—

1. In a gas or vapor engine, the combination with an atomizer, or injector, wherewith to effect a combustible charge for the engine, of a pipe or passage to lead or convey part of the engine charge from the cylinder or combustion chamber of the engine, to operate as a blast for the said atomizer or injector.

2. In a gas or vapor engine, the combination with an atomizer, or injector, wherewith to promote the effecting of a combustible charge for the engine, of a pipe or passage to lead or convey a part of the ignited expanding engine charge to the atomizer, to operate as a blast therefor; said blast constituting the gaseous medium by which the operation of atomizing, spraying, or injecting is effected.

3. In a gas engine, the combination with a power cylinder and its piston, adapted to compress a charge for the operation of the engine, and an injector, or atomizer, of means for causing a portion of the engine charge to operate automatically as a blast for the said injector, or atomizer, another portion of said charge being employed in driving the piston of the power cylinder.

4. In a gas engine, the combination of a power cylinder, an injector, or atomizer, to

contribute to the charging of the engine, a pipe or passage for conducting gas, gases or vapor, from the engine charge to the injector, or atomizer, to operate as a blast, and a valve for controlling said blast.

5. In a gas engine, the combination with a power cylinder, and an injector, or atomizer, of a receiver adapted to take in a portion of the gas, gases or vapor, from the engine charge and hold the same under pressure, and means for periodically releasing gas, gases or vapor, from said receiver to operate as a blast for the injector or atomizer.

6. In a gas engine, the combination with a power cylinder, and an injector, or atomizer, for assisting to charge the engine, of a pipe or passage for taking or conveying gas, gases or vapor, from the engine charge to operate as a blast for the injector, or atomizer, a valve for controlling the said blast, and cam mechanism actuated from the engine, to operate said valve.

7. In a gas engine, the combination of a power cylinder having a single charging and exhaust port controlled by a valve, an atomizer or injector, located in a chamber adjacent to said port, a gas receiver adapted to receive and hold under pressure a portion of the gases from the engine charge, a valve operating to permit of a charging into and discharging from said receiver, and mechanism for operating said valve to periodically release the gas from the receiver to serve as a blast for the atomizer, substantially as described.

8. In a gas engine, the combination of a power cylinder, an atomizer, a receiver communicating with the power cylinder and adapted to receive and hold under pressure a portion of the gases from within the power cylinder, a valve for permitting a discharge from said receiver, a pipe connecting said receiver with said valve, a blast pipe connecting said valve with the atomizer, and cam-mechanism to periodically open said valve and release the confined gas to operate as a blast for the atomizer, substantially as described.

9. In a gas engine, the combination of a power cylinder, an atomizer, a receiver adapted to communicate with the power cylinder to receive and hold under pressure a portion of the gases from within said cylinder, a valve for controlling admission to and discharge from said receiver, a blast-pipe connecting said valve with the atomizer, cam mechanism to periodically open the said valve alternately in opposite directions to establish communication between the power cylinder and receiver and between said receiver and the blast pipe, and a spring to restore said valve to its normal closed position, substantially as described.

10. In a gas engine, the combination of a power cylinder, an atomizer, a receiver adapted to receive and hold under pressure a portion of the gases derived from the engine

charge, a valve for controlling discharge from said receiver, a blast-pipe connecting said valve with the atomizer, cam mechanism for periodically opening said valve, and a governor and safety valve in communication with the receiver, substantially as described.

11. In a gas engine, the combination of a power cylinder, an atomizer, a receiver having a non-conducting covering or packing and adapted to communicate with the power cylinder to receive and hold a portion of the gases from within said cylinder, a valve to permit admission to and discharge from said receiver, a blast-pipe connecting said valve with the atomizer, cam mechanism actuated from the engine crank shaft to periodically open said valve for releasing gas to produce the atomizer blast, and a spring for normally closing said valve to hold the contents of the receiver under pressure, substantially as described.

12. In a gas engine, the combination of a power cylinder, an atomizer comprising a hydro-carbon supply pipe provided with a check valve and having in the upper closed end of said pipe an exit tube or tubes the lower ends of which are submerged in the hydro-carbon contained in said supply pipe, a blast pipe having a closed cushioning end, with exit tubes secured into said blast pipe, in proximity to the cushioning end of the blast pipe, the outer ends of which tubes are in proximity to the outer ends of the exit tubes of the hydro-carbon supply pipe, and means for automatically controlling a blast through said blast pipe and tubes to lift hydro-carbon from its supply pipe and effect an atomizing or diffusion of the same, substantially as described.

13. In a gas engine, the combination of a power cylinder, an atomizer comprising a hydro-carbon supply pipe having in its upper closed end an exit tube or tubes the lower ends of which are submerged in the liquid hydro-carbon contained in said supply pipe, a blast pipe having an exit tube or tubes adjacent to the exit tube or tubes of the hydro-carbon supply pipe and provided with a projecting and closed end beyond its exit tubes, to provide an air cushion for equalizing the pressure, and means for automatically controlling a blast through said blast pipe, substantially as described.

14. In a gas engine, the combination of a power cylinder, an oscillatory electrode mounted in the power cylinder and insulated therefrom, a piston provided with an adjustable electrode in electrical connection with the piston and engine, an electric circuit including said electrodes, insulated make and break contact springs located in the circuit, a rotary part actuated from the engine crank shaft, and an insulated roller carried by an arm on said rotary part and adapted to periodically close the circuit through said contact springs, substantially as described.

15. In a gas engine, the combination of a

power cylinder having a piston provided with an adjustable electrode, an oscillatory electrode mounted in one end of the cylinder and insulated therefrom, the said oscillatory electrode having an arm resting normally on an insulating support, a spring for pressing said arm onto its said support, insulated make and break contact springs, a wire connecting one of said springs with the spring that presses on the arm of the oscillatory electrode, a battery having a wire connecting with the other, insulated contact spring and a wire connecting with the engine, and an adjustably mounted cam arm actuated from the engine crank shaft and adapted to periodically close the circuit through said insulated make and break contact springs, substantially as described.

16. In a gas engine, the combination of a power cylinder having a piston provided with an electrode, an insulated electrode mounted in the power cylinder and insulated therefrom and provided in its interior with an oil chamber having exits for passage of lubricant to the bearing for said oscillatory electrode, means for supplying lubricant to said oil chamber, an electric circuit including the electrodes, insulated make and break contact springs, and an insulated cam arm actuated from the engine crank shaft to periodically close the circuit through said insulated contact springs, substantially as described.

17. In a gas engine, the combination of a power cylinder having a piston provided with an electrode, a screw plug tapped into said cylinder and provided with a central tapering perforation, a conical sleeve or bearing inserted in said screw plug and insulated therefrom, a nut on the small outer screw threaded end of said conical sleeve and insulated from the surrounding screw plug, a tapered oscillatory electrode mounted in said conical sleeve or bearing and provided on its outer end with an arm, an insulated support or stop for said arm, a spring attached to said support and adapted to press the arm of the oscillatory electrode down thereon, an electric circuit including said spring and electrodes, insulated make and break contact springs, and an insulated cam actuated from the engine crank shaft to periodically and relatively close the circuit through said insulated contact springs that the electric circuit may be completed when the electrodes are also in contact, substantially as described.

18. In a gas engine, the combination of a power cylinder having a single charging and exhaust port closed by a valve located within the cylinder, an oscillatory electrode mounted in the power cylinder and insulated therefrom, a piston having a recessed working face to form an explosion chamber and avoid contact with the cylinder valve and oscillatory electrode, a portion of the exterior diameter of said piston being reduced to afford it a free movement in the cylinder, an electrode carried by the piston, an electric circuit, in

ulated make and break contact springs in said circuit, and means for periodically closing the circuit through said contact springs, substantially as described.

5 19. In a gas engine, the combination of a power cylinder having a single charging and exhaust port, a valve adapted to control said port and having a stem extended through the
10 chamber at the outside, a lever adapted to bear on said valve-stem to open the said valve, a longitudinally moving rod connected with said lever, a link suspending the other end of said rod, a cam actuated from the engine
15 crank shaft to cause said rod and lever to open the said cylinder valve, and a spring to close said valve on disengagement of said rod from its actuating cam, substantially as described.

20 20. In a gas engine, the combination of a power cylinder, an atomizer, a receiver for

utilizing gases derived from the engine charge, to produce a blast for the atomizer, a valve to control said receiver, a blast pipe from said valve to the atomizer, a piston carrying an
25 electrode, an oscillatory electrode mounted in the power cylinder and insulated therefrom, an electric circuit comprising insulated make and break contact springs, a governor, and safety valve, and mechanism actuated from
30 the engine crank shaft for controlling the cylinder valve, the electric circuit, the atomizer blast and the governor, substantially as described.

In testimony whereof I have hereunto set
35 my hand and affixed my seal in presence of two subscribing witnesses.

WILLIAM WALLACE GRANT. [L. S.]

Witnesses:

S. S. SHAFER,
W. B. EILENBERGER.