No. 741,986. PATENTED OCT. 20, 1903.

R. P. THOMPSON.

OIL INJECTOR FOR GAS ENGINES.

APPLICATION FILED JAN. 31, 1902. RENEWED AUG. 10, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.

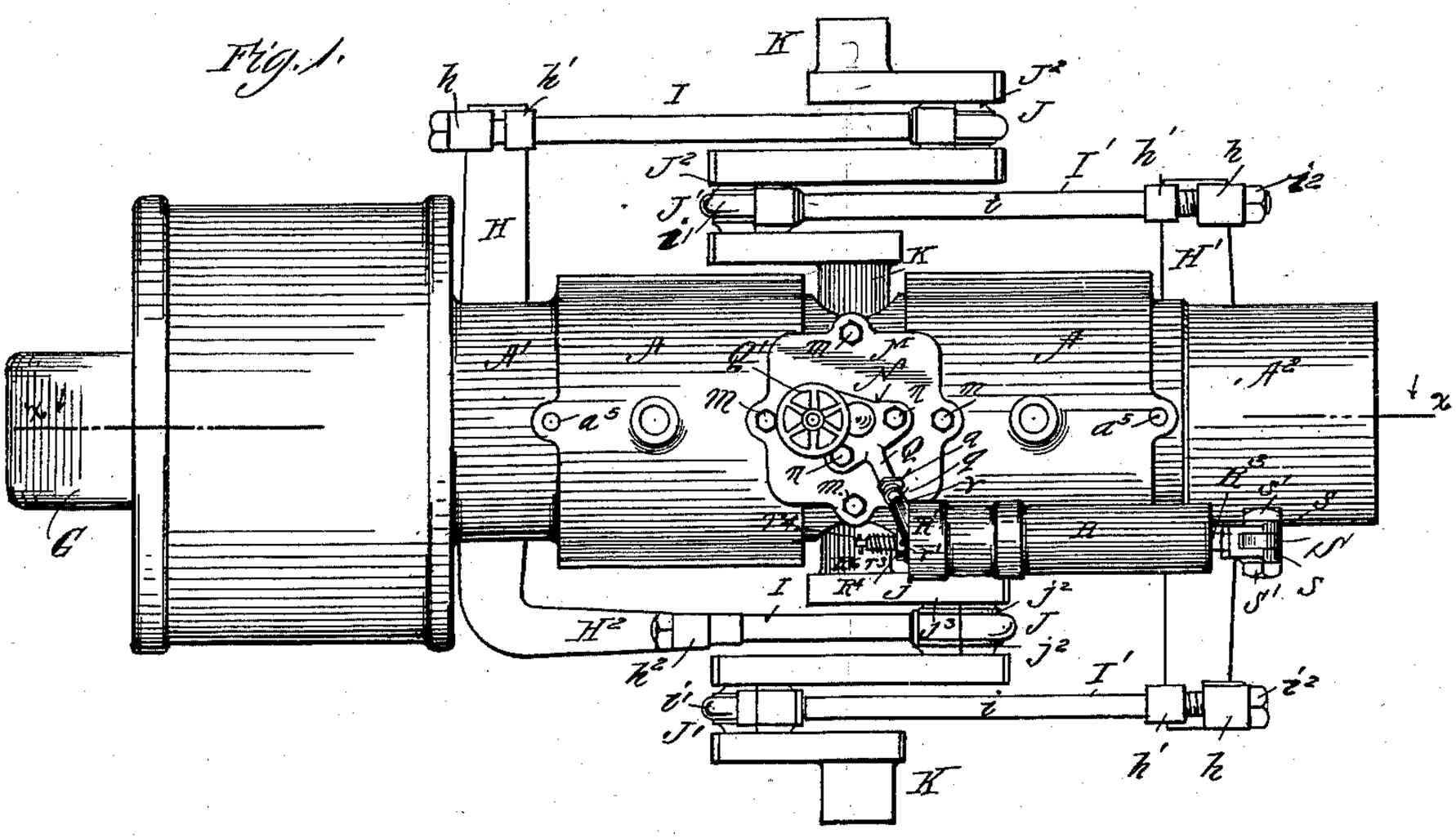
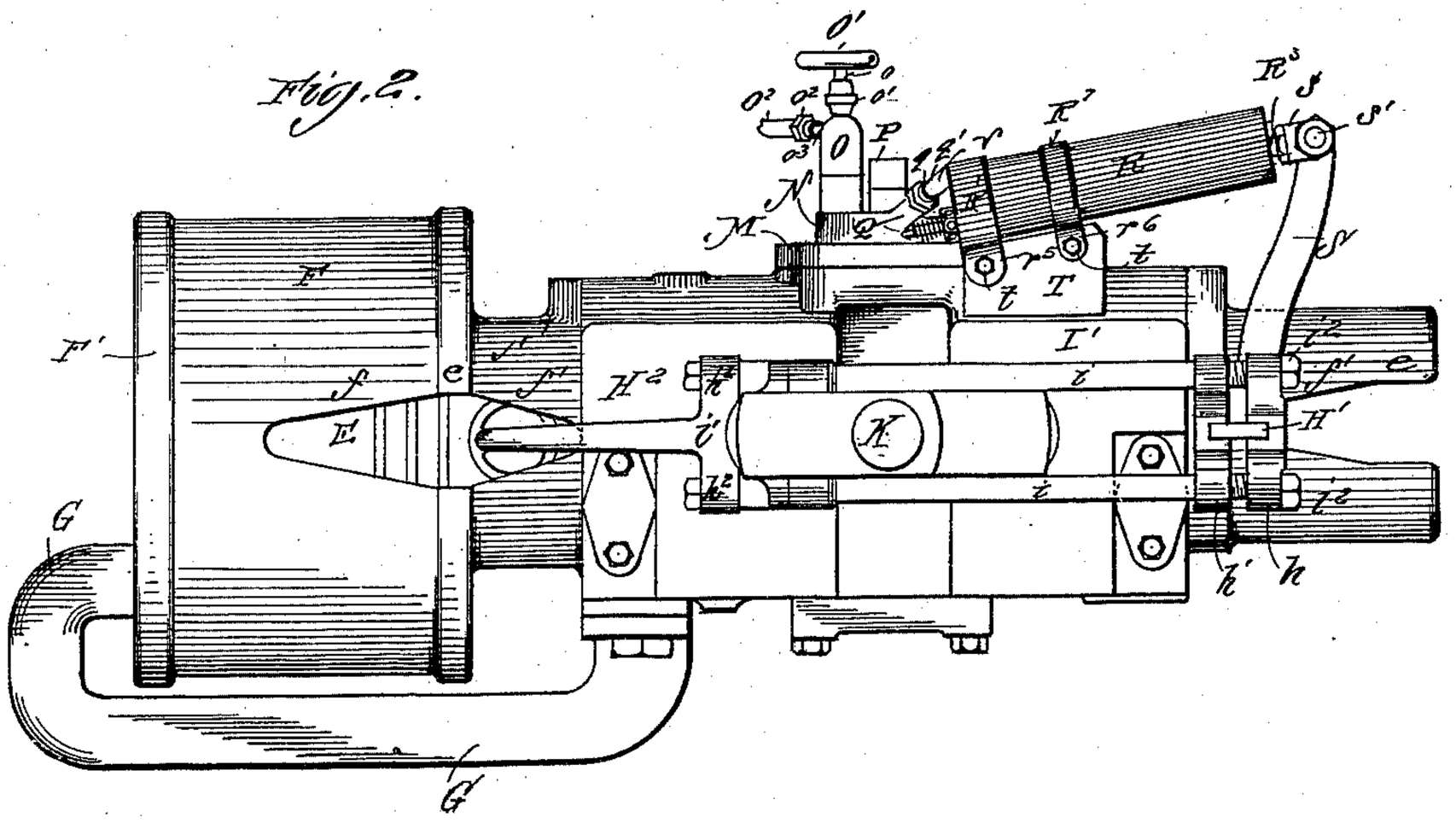


Fig. 2.



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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 3.

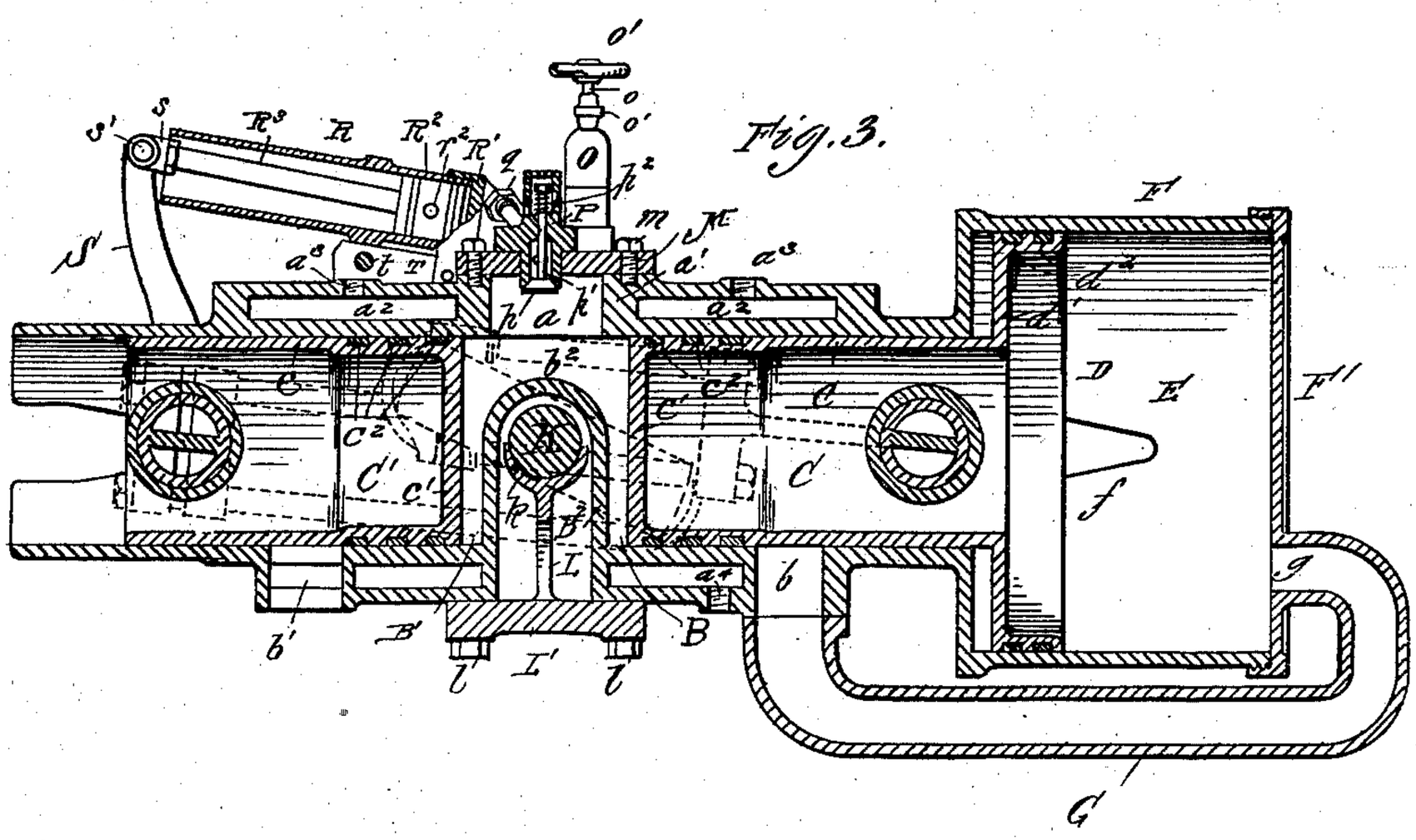
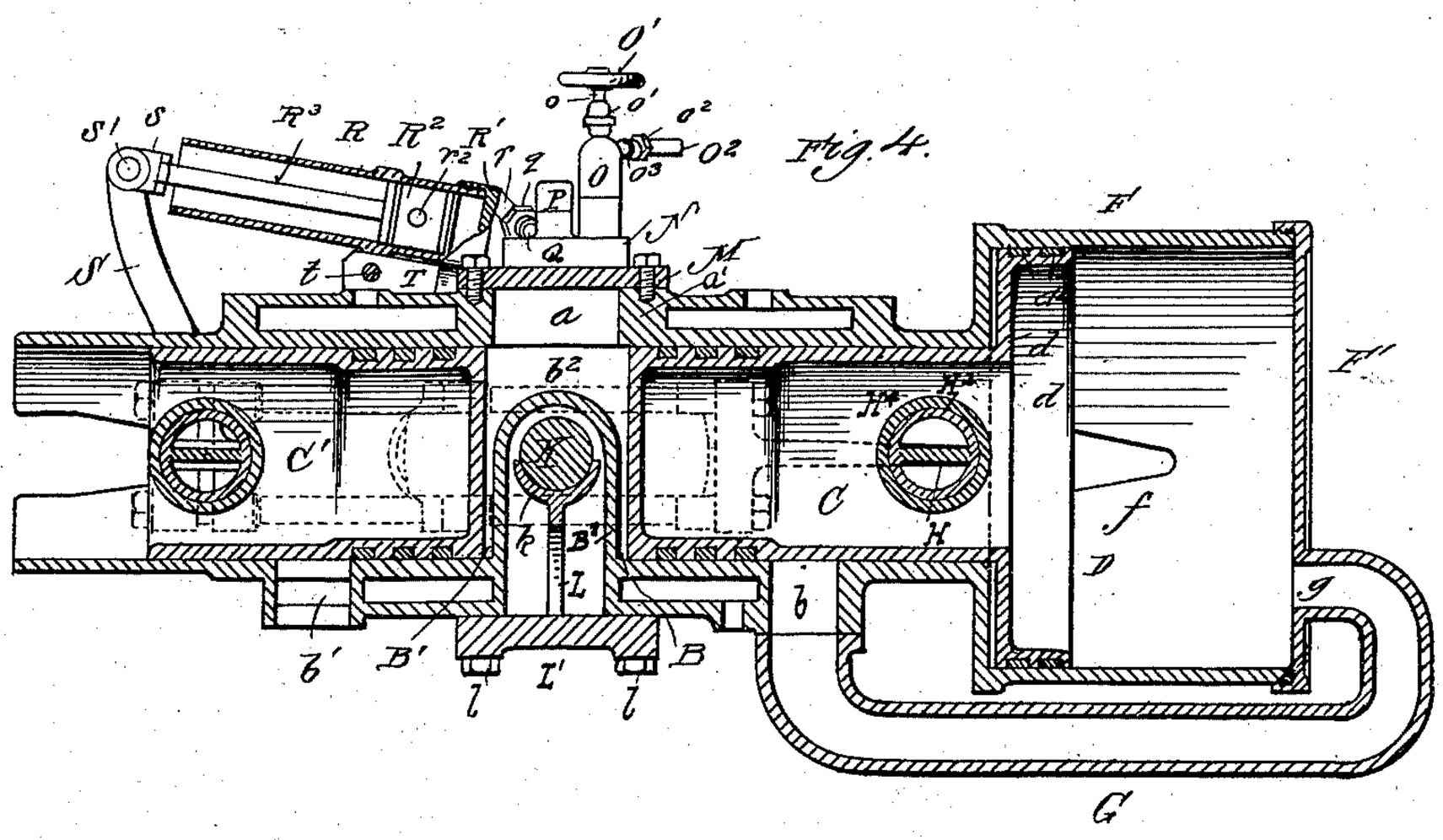


Fig. 4.



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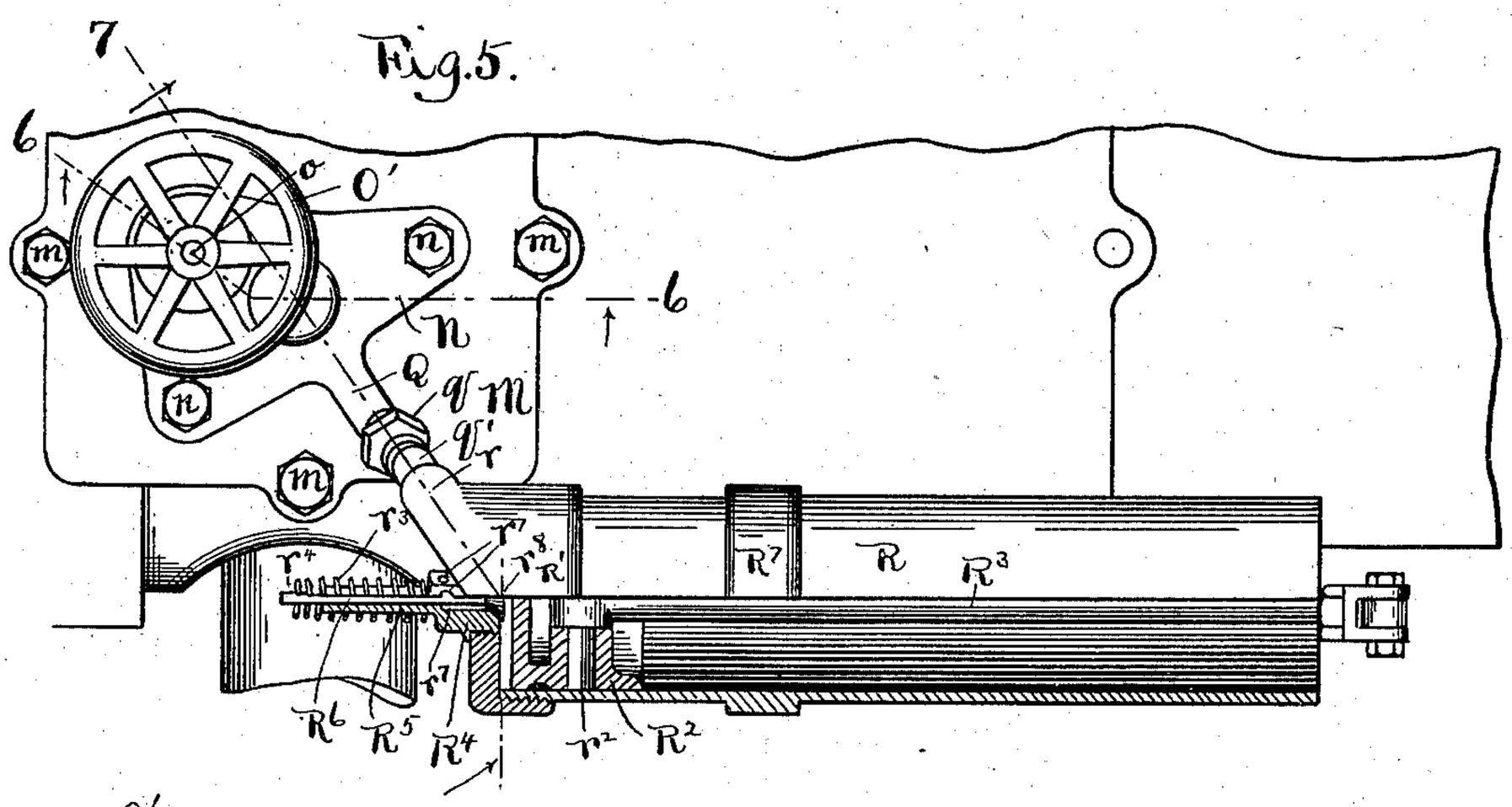
NO MODEL. 3 SHEETS—SHEET 3.

Fig. 5.



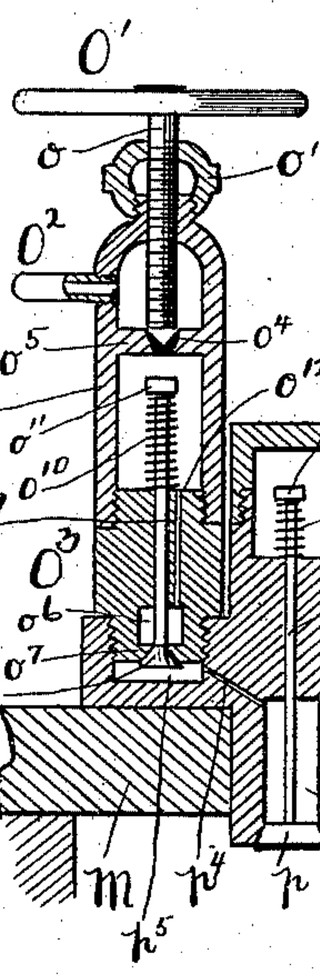
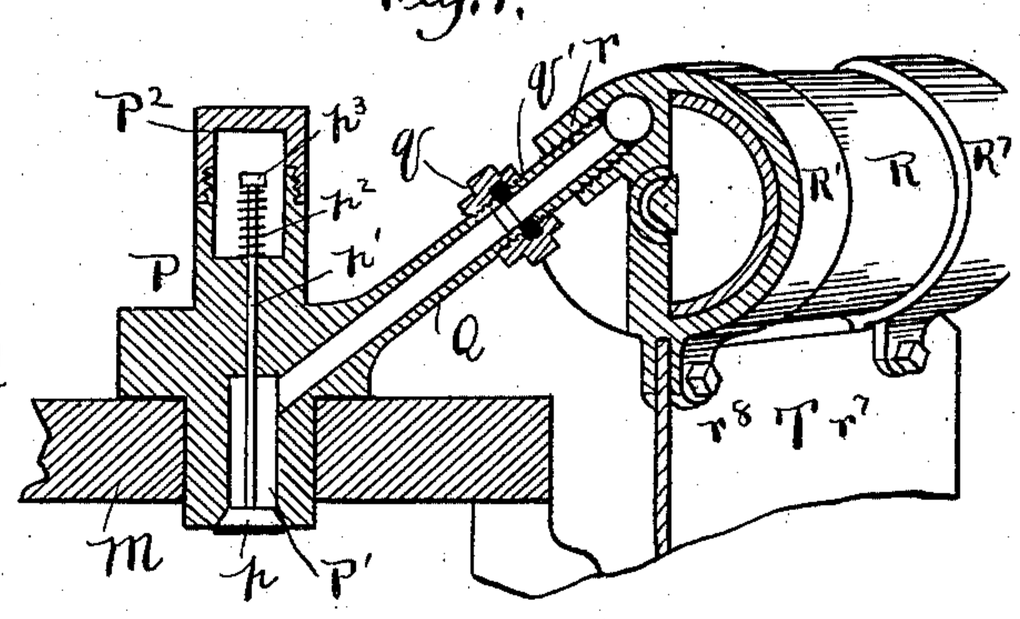


Fig. 6.

Fig. 7.



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No. 741,986. Patented October 20, 1903.

UNITED STATES PATENT OFFICE.

RALPH P. THOMPSON, OF SPRINGFIELD, OHIO.

OIL-INJECTOR FOR GAS-ENGINES.

SPECIFICATION forming part of Letters Patent No. 741,986, dated October 20, 1903.

Application filed January 31, 1902. Renewed August 10, 1903. Serial No. 169,041. (No model.)

To all whom it may concern:

Be it known that I, RALPH P. THOMPSON, a citizen of the United States, residing at Springfield, in the county of Clark and State of Ohio, have invented certain new and useful Improvements in Fuel-Injectors for Gas-Engines, of which the following is a specification.

It is the general practice in the charging of gasolene-engines, especially two-cycle types of such engines, to mix the fuel, usually gasolene or other hydro vapor, and the air for the charge previous to the admission of the charge into the explosion-chamber and to admit the charge after the exhaust of the previous charge has taken place, and as a consequence it is necessary for the exhaust to be completed and the fire to die out before the fresh charge is admitted, as otherwise the fresh charge already mixed and in condition for ignition and explosion in the chamber will ignite from the exhaust and "back fire."

The primary object of the present invention is to construct and locate an effective and reliable injector or charger by means of which the fuel vapor for the charge can be quickly and positively injected into the air for the charge after the air is introduced into the explosion-chamber and under compression therein.

A further object is to enable the injecting of the fuel vapor into the air to be attained at the proper time in relation to the movements of the power or working pistons and have the fuel vapor under a pressure sufficient to insure its projection into the air compressed in the explosion-chamber, completing the charge for explosion in the chamber before the power or working pistons reach the limit of their inward or return stroke or movement for the full compression of the air and fuel vapor for the charge.

A further object is to properly regulate and control the admission and projection of the fuel vapor for bringing the charge up to explosive condition and have the operation of regulating and controlling the admission and projection of the fuel vapor automatically performed.

A further object is to locate directly on the engine-cylinder the injector or charger for forcing the fuel vapor into the air for the charge and have the location one that will insure the operation of the injector or charger positively from and coincidently with the stroke or movements of the power or working pistons for the final projection of the fuel vapor to occur before the power or working pistons reach the limit of the inward or return stroke, and further objects will appear in the description.

The invention consists in the features of construction and combination of parts hereinafter described and claimed as new.

In the drawings, Figure 1 is a top or plan view of a gas-engine with the injector or charger for bringing the gasolene or other hydrocarbon vapors up to atmosphere mounted on the engine-cylinder and having its piston connected to and operated from the rocking cross-head of one of the power or working pistons; Fig. 2, a side elevation of the same, showing, as does also Fig. 1, the working pistons at the limit of their advance stroke, the projecting of the fuel vapor into the explosion-chamber having taken place before the power or working pistons reached the limit of their inward or return stroke; Fig. 3, a longitudinal sectional elevation of the engine, showing the position of the piston of the fuel injector or charger at the completion of its inward or compression stroke and the power or working pistons in the position they occupy relative to injector-piston at completion of its stroke; Fig. 4, a similar view to Fig. 3 with the piston of the fuel injector or the charger partly on its return stroke or movement and with the power or working pistons at the limit of their return movement or inward stroke, before which time the fuel vapor for the charge has been injected into the air in the explosion-chamber, completing the charge for explosion in the chamber; Fig. 5, a detail showing a plan view of a portion of the engine-cylinder and a plan view of the gasolene-supplying device with the injector for such device half in plan and half in section; Fig. 6, a detail in sectional elevation, taken on line 6 6 of Fig. 5, looking in the direction of the arrow; and Fig. 7, a detail in sectional elevation, taken on line 7 of Fig. 5, looking in the direction of the arrow.

As the present invention relates particularly to supplying the fuel element of the

charge to the air therefor by injecting the fuel into the air in the explosion-chamber and under compression therein, it is deemed necessary to show and describe only so much of a complete engine as will enable the construction, location, arrangement, and operation of the fuel injector or charger to be understood, and some of the parts shown will not be described in detail.

The engine shown is a type of two-cycle gas-engine having two pistons oppositely moving in a common or main cylinder A, which, as shown, has at one end a neck A′ and at the other end an extension A^2, completing the cylinder as a whole. At the longitudinal and transverse center of the main or engine cylinder, on the upper side thereof, is an opening a, surrounded by a wall a', having a flat upper face, and in line with the central opening a is a wall or bridge B^2, extending transversely of the cylinder and from the lower side thereof upward, so as to leave an opening or passage b^2 between its upper face and the inner face of the cylinder. This arched wall or bridge B^2 divides the interior of the main or engine cylinder, which is, in effect, a single explosion-chamber, into end chambers B and B′ for the power or working pistons. A passage a^2 encircles each end of the cylinder, each passage having a port a^3, by means of which and a suitable pipe or other connection (not shown) communication is established between the two chambers or passages within the wall of the cylinder for circulating water or other cooling medium through and around the chambers or passages to discharge at an eduction-port a^4, leading from one of the passages, for keeping the cylinder cool. The chamber B has located and traversing therein a piston C, and a similar piston C′ is located in and traverses the chamber B′, and each piston C and C′ in the construction shown is formed of a body c and a closed end c', with packing-rings c^2 around the exterior of the body adjacent to the closed end. The cylinder C, as shown, is lengthened and has on its end a piston D, formed of a wall or rim d and an end plate or head d', with packing-rings d^2 circumferentially around the wall or rim. The piston D is located in and traverses a chamber E in a cylinder or casing F, which may be formed with or suitably secured to the neck A′ of the main or engine cylinder, and, as shown, the open end of the cylinder or casing F is closed by a cap or head F′, having therein a port g, from which a pipe or conduit G leads to an induction-port b, opening into the chamber B of the main or engine cylinder, and from the chamber B′ of the main or engine cylinder an eduction-port b' leads. The cylinder or casing F and the neck A′, as shown, have in their walls a somewhat diamond-shaped opening, with a wide center e and tapered ends f and f' on each side of the wide center, and, as shown, the extension A^2 has in its wall an opening having a wide center e and a tapered end f', inwardly extending. These openings are for the purpose of permitting the reciprocation and rock of the cross-heads of the pistons C and C′ in traversing their respective chambers. The pistons in the arrangement shown are lubricated through ports or passages a^5 in the wall of the main or engine cylinder. The piston D with its cylinder or casing E constitute an air-pump for supplying air in a regulated amount to the main or engine cylinder, sufficient both for clearing the cylinder of a previously-exploded charge and for supplying fresh air for a new charge, the amount of air supplied being controlled by the extended opening f in the side walls of the cylinder or casing. This air-pump effects a clearance of the explosion and compression chamber between the two power or working pistons from a previously-exploded charge before the admission of a fresh charge to be exploded, which clearance is essential and necessary in order to prevent back fire and furnishes a supply of fresh air for a new charge by forcing the air into and through the explosion and compression chamber when the induction and eduction ports b and b' are both open, which occurs during a portion of the advance or outward stroke and a portion of the inward stroke of the power or working pistons. The air forced into the chamber with both ports open will exhaust a previously-exploded charge and clear the chamber wholly therefrom, and the air forced into the explosion and compression chamber after the eduction-port is closed with the induction-port still open will furnish the supply of fresh air for the next charge.

The piston C is carried by a cross-head H, which projects on each side of the neck A′, and one end, as shown, projects in a straight line, while the opposite end is turned at right angles and forms an extension H^2, standing parallel with the body or wall of the main or engine cylinder. The working or power piston C′ is carried by a cross-head H′, both ends of which project in a straight line on opposite sides of the extension A^2 of the main or engine cylinder. The straight projecting end of the cross-head H and both of the projecting ends of the cross-heads H′ are provided with heads or blocks h and h', and the extended end H^2 of the cross-head H is provided with a head or block h^2, as shown in Figs. 1 and 2. The cross-head H has connected to each end a rod I, each of which leads to a crank J on a shaft K, and each end of the cross-head H′ has connected thereto a rod I′, which leads to a crank J′ on the crank-shaft K, so that the connecting-rod I on one side of the engine is outside of and on the opposite side of the engine inside of the connecting-rod I′, giving the connecting-rods a staggered arrangement. Each connecting-rod I and I′ is formed of a rod bent on itself to have two arms or members j, a curved closed end j', and an open end, with the arms or members at the open end each screw-threaded to

receive a nut j^2, as shown in Figs. 1 and 2. Each crank-pin of the cranks J and J′ is encircled by a box J^2, formed of two half-boxes j and j', with the outer face of each half-box j' conforming to the curvature of the closed end of the connecting-rod, into which the curved face of the half-box fits, and each half-box is provided with an ear or eye j^3 for the passage of the arms or members of the connecting-rod, so that by slipping the arms or members through the eyes or ears of the half-boxes when in place and through the heads or blocks h and h' and h^2 and entering the nuts j^2 onto the ends of the connecting-rods the cross-heads will be connected each with its respective crank. The center of the crank-shaft passes through the body of the engine-cylinder, under the arch of the wall or bridge B^2, and, as shown in Figs. 3 and 4, is supported at each end by a standard L, having a half-box k at its upper end and extending up from a cross-plate L′, attached by bolts l to the bottom of the engine-cylinder in the construction shown.

The flat face of the wall a' has mounted thereon a plate M, which is held in place by bolts m or otherwise, and on this plate M is mounnted a second plate or head N, secured in position on the plate M by bolts n or otherwise. The plate or head N has thereon a shell or casing O, in which is a passage for admitting the gasolene or other hydrocarbon vapor for the charge, and this passage is controlled by a needle-valve on a stem o, passing through a stuffing-box o' and operated by a hand-wheel O′ or any other suitable means. The shell or casing O, as shown, is threaded onto the end of a plug O^3, which plug, as shown, is threaded into the plate N. The shell or casing is divided by a cross-wall or partition o^5 into an upper chamber and a lower chamber, and into the upper chamber the supply-pipe O^2 for the gasolene leads. The cross-wall or partition o^5 has therein a port o^4, controlled by the pointed end of the needle-valve, allowing the gasolene to escape from the upper chamber into the lower chamber. The plug O^3 at its entered end into the plate N has a chamber o^6, leading from which is a port o^7, controlled by a disk valve o^8 on a rod o^9, passing through the body of the plug, and the valve is held to its seat by a coiled spring o^{10}, located around the rod or stem o^9 and between the end face of the plug O^3 and a head o^{11} on the end of the rod or stem, and, as shown, a small passage o^{12} through the plug furnishes communication between the lower chamber of the shell or casing and the chamber o^6, keeping the last-named chamber supplied with gasolene. The plate or head N also has thereon a cylinder or casing P, in which is a valve or stem p', having at its end a disk valve p, controlling the discharge from the fuel-chamber P′ for the gasolene and air to be projected through the opening a into the air in the explosion and compression chamber and complete the charge to be exploded in the chamber and operate the working or power pistons. The valve-disk p is held normally closed by a coil-spring p^2 around the stem p' and between a head on the stem and the bearing for the stem in the cylinder or casing. A passage p^4 in the plate N furnishes communication between the fuel-chamber P′ and a chamber p^5 in the plate N below the end of the plug O^3, so that with the opening of the disk valve o^8 gasolene can flow into the chamber p^5 and pass from said chamber into the fuel-chamber P′ through the passage p^4, supplying the required amount of gasolene to the fuel-chamber.

A tubular stem Q, having a passage therein, extends out from one side of the plate or head N, with its passage in communication with the fuel-mixing chamber P′ of the plate or head, and on the outer end of this tubular stem is a coupling-nut q, by means of which and a pipe-section q' attachment is made to the discharge-nipple of a fuel injector or charger for supplying a fuel charge to the explosion-chamber when the valve of the fuel-chamber is opened. The air injector or charger in the construction shown is formed of a cylinder R, closed at one end by a cap or head R′, having thereon the discharge-nipple r, which is connected with the tubular stem Q, leading to and communicating with the mixing-chamber. The cylinder R has located therein a piston R^2, pivotally attached to a stem R^3 by a pin or pivot r^2, so that the piston can be reciprocated in the cylinder and draw in and force out the air required for charging the explosion-chamber with the gasolene or other hydrocarbon vapor for the fuel of the explosion charge. The cap or head R′ has screw-threaded thereinto a plug R^4, in which is a passage r^7, having communication with the exterior air through ports or passages r' and terminating in a valve-seat at its discharge end. A tube or hollow stem R^5 extends out from the plug R^4 and carries a valve-stem R^6, on which is a disk or other valve r^8, which seats and closes the passage in the plug, and, as shown, the disk or other valve is held normally seated and returned to its seat by a coil-spring r^3, one end of which abuts against the face of the plug and the other end against a cross-pin r^4 through the valve-stem. The outer or free end of the piston-rod R^3 is connected with an arm or upright S, attached at its lower end in any suitable manner to the cross-head H′, so as to move with the cross-head, and, as shown, the piston-rod is attached to the arm or standard by a fork s on the end of the rod and a pivot-bolt s', passing through the fork and the end of the arm or upright. The band or rim of the head R′ has on its under side ears r^5, and on the body of the cylinder is a band or rim R^7, having on its under side ears r^6, between which ears r^5 and r^6 is entered the edge of a plate-support T, extending up from the main or engine cylinder, through

which plate and the ears bolts *t* pass, attaching the fuel-charge injector directly to the main or engine cylinder and in close proximity to the explosion and compression chamber of the engine and in the best possible relation to the chamber for projecting the fuel charge into the chamber.

Each cross-head in order to have the necessary oscillation or rock for the operation of the cranks has a tubular or circular center H^3, which enters a tubular or circular bearing H^4 in each power or working piston, and as the rocking cross-head changes its angling relation in the movements of the piston a rising-and-falling movement will be given to the outer end of the piston-rod R^3, and such rising-and-falling movement is permitted by the pivot r^2 between the end of the piston-rod and its piston. The arm S, rigidly attached to one of the rocking cross-heads of the engine, forms, in effect, a part of the connecting-rod between the power and working piston and the shaft, so that this arm, which operates the fuel-charge-injector piston, is in fact an extension of the connecting-rod extending out from the pivotal point of the rocking cross-head at right angles to the connecting-rod proper of the power or working piston. This arm thus extending at right angles to the piston connecting-rod from the pivotal point of the rocking cross-head and being in fact a part of the piston connecting-rod is given a throw or movement that is simultaneous with the throw or movement of the connecting-rod. At the pivotal point of the rocking cross-head the movement is a reciprocating one; but at each point farther out on the arm the movement is more and more affected by the annularity of the connecting-rod at the different positions of the stroke, causing the extreme outer end to describe an arc of a circle with the rock of the cross-head. The complex movement of this arm is taken advantage of to affect fuel-charge-injector piston, enabling the injector to finish its stroke ahead of the full compression-stroke of the working piston a sufficient distance to inject the fuel into the working cylinder and saturate the air therein under compression, charging the air with the fuel and producing a mixture within the working cylinder in the explosion and compression chamber between the two pistons that burns completely upon being fired. This injecting of the fuel charge directly into the air under compression in the working cylinder constitutes a novel feature of the invention and is a distinct improvement and one that is absolutely essential to gas-engines, especially those of the two-cycle type, which at this stage of the art are not recognized as the equal of the four-cycle engines, particularly for automobile use. An objection and drawback to the two-cycle gas-engines arises from the fact that each advance or outward stroke is a working stroke, leaving only the interval between each working stroke to suffice for effecting the explosion of the exhaust and the receiving of a fresh charge of air and fuel before compression takes place. It is therefore customary to mix the fuel and air and admit them after the exhaust takes place; but in so doing with the ordinary type of two-cycle engines the exhaust must take place and the fire die out before the fresh charge is admitted; otherwise the fresh charge already mixed with hydrocarbon will ignite from the exhaust and back fire is liable to occur. The present invention overcomes the objection and defect above noted, as the fresh air for the charge is admitted simultaneously with the expelling of the exhaust through the action of the large air-pump, the piston of which forces a supply of fresh air in to drive out the exhaust and at the same time provides a charge of fresh air, into which the fuel-charge injector projects the fuel charge of hydrocarbon as compression takes place, the piston of the injector finishing its stroke, by reason of the right-angle extension to the connecting-rod, in ample time for the fuel to thoroughly mix before the charge is fired. While this fuel-charge injector is shown on an engine with two working pistons, it is to be understood that it is adapted for use with any engine on which the same movement of connecting-rod with extension to operate the fuel-charge injector can be employed.

The operation of the fuel-charge injector is as follows: The gasolene for the charge is taken from a tank or other source of supply through a supply-pipe O^2, connected by a coupling o^2 with a nipple o^3, which is in communication with the upper chamber of the shell or casing O'. From the upper chamber the gasolene flows through the port o^4 into the lower chamber of the shell or casing, the end of the valve-stem *o* being properly adjusted to control the flow through the port, and from the lower chamber of the shell or casing the gasolene flows through the passage o^{12} into the chamber o^6 and is held in the chamber o^6, with the valve o^8 closed. The gasolene is retained in the chamber o^6 until the valve o^8 is opened, allowing the gasolene to escape into the chamber p^5 and flow through the passage p^4 into the fuel-chamber P', to be there mixed with the air, and with the discharge-valve o^8 for the gasolene open the discharge-valve *p* for the fuel or mixing chamber P' is closed and remains closed until the discharge-valve for the gasolene is closed, and when the discharge-valve o^8 for the gasolene is wholly closed the discharge-valve *p* for the fuel charge can be opened to project the fuel charge into the explosion-chamber. The opening of the charging-valve is attained from the strokes of the piston of the fuel injector or charger. The outward movement of the piston serves to positively close and hold closed the discharge-valve from the fuel-charge chamber, and the return or inward movement of the piston serves to positively open the discharge-valve

of the fuel-charge chamber. The valve for the admission of air into the fuel-charge injector is opened with the outward traverse or stroke of the piston, at which time the eduction-valve of the mixing-chamber is closed, and the air thus sucked in is sufficient in quantity to charge the gasolene up to atmospheric pressure and insure the projection of the fuel charge into the chamber between the two working or power pistons. The air drawn into the cylinder of the injector or charger on the return stroke or movement of the piston is forced into the fuel-charge chamber, commingling with the gasolene or other hydrocarbon vapor and bringing the vapor, which is normally below the pressure of the atmosphere, up to the pressure of the atmosphere for discharge into the explosion-chamber. The gasolene or other hydrocarbon vapor is drawn into the fuel-charge chamber with the outward movement or stroke of the piston of the fuel-charge injector, and this movement of the piston is coincident, or nearly so, with the outward travel or advance stroke of the power or working pistons, and at the same time the air for charging up to the pressure of atmosphere the gasolene vapor is drawn into the fuel-charge injector. The eduction of the gasolene or other hydrocarbon vapor and air from the fuel-charge chamber takes place as the piston of the fuel-charge injector is at the completion of its return or inward stroke, which stroke is finished and the return stroke started before the completion of the inward or return stroke of the power or working pistons. The relative positions of the injector-piston and the power or working pistons at the time the injector-piston has operated to open the eduction-valve and discharge the explosive mixture of vapor and air for the charge into the explosion-chamber or the chamber between the two power or working pistons are shown in Fig. 3. The completion of the return stroke of the power or working piston takes place after the fuel-charge-injector piston has operated and opened the eduction-valve from the mixing-chamber and discharged the explosive mixture or vapor and air into the explosion-chamber and the piston of the fuel-charge injector has made a slight outward stroke sufficient to close the eduction-valve from the fuel-charge chamber. The relative positions of the respective pistons at the time the charge is ready for explosion are shown in Fig. 4. The explosion as it takes place forces out the power or working pistons, and as the eduction-valve from the mixing-chamber has been closed prior to the explosion of the charge none of the gases from the exploded charge can enter the mixing-chamber. It will thus be seen that the fuel charge for the explosion is directly injected into the air under compression in the explosion-chamber without the necessity of a previous mixing of the fuel charge and the air outside of the explosion-chamber and that the movements for obtaining these results are attained by the unity of movement between the piston of the fuel-charge injector and the power or working pistons, arising from the fact that the piston of the fuel-charge injector is actuated by a continuation of the connecting-rod of the power or working pistons through the movements of the rod, as already described.

What I regard as new, and desire to secure by Letters Patent, is—

1. In a gas-engine, the combination with a gasolene or hydrocarbon feed for the vapor of the explosive charge, of a fuel-charge injector having a reciprocating piston and having the reciprocating movements of its piston given thereto from a rocking pivotal connection at one end of a connecting-rod, the rocking pivotal connection having a straight-line travel coincident with the travel of the power or working piston of the engine and the opposite end of the connecting-rod having an attachment to a crank on the power-shaft of the engine, the rising-and-falling movements of the crank-shaft end of the connecting-rod rocking the pivotal connection and advancing and receding the injector-piston for the advance of the injector-piston to force the explosive charge into the air under compression in the explosion-chamber, substantially as described.

2. In a gas-engine, the combination with a gasolene or hydrocarbon feed for the vapor of an explosive charge, of a fuel-charge injector operative to force the fuel charge into the air under compression, an arm or standard, and a rocking cross-head of a power or working piston of the engine having the arm or standard rigidly connected thereto for the arm to operate the piston of the fuel-charge injector with the movements of the rocking cross-head from the strokes of the power or working pistons, substantially as described.

3. In a gas-engine, the combination with a gasolene or hydrocarbon feed for the vapor of an explosive charge, of a fuel-charge injector operative to force the vapor of the fuel charge into the air under compression, an air-valve for the injector, an arm or standard for operating the piston of the fuel-charge injector and a rocking cross-head of a working or power piston of the engine having the arm or standard rigidly connected thereto for operating the fuel-charge injector for the vapor with the movements of the rocking cross-head from the working or power pistons, substantially as described.

4. In a gas-engine, the combination with a gasolene or hydrocarbon feed for the vapor of the explosive charge of a fuel-charge injector having a piston with a piston-rod and mounted on the engine-cylinder and operative to directly force the fuel charge into the air under compression in the engine-cylinder, a connecting-rod having one end pivotally connected with a working or power piston of the en-

gine and having its opposite end attached to a crank on the power-shaft of the engine, giving the pivoted end a rocking action from the rising-and-falling movements of the crank end of the connecting-rod, and an extension of the connecting-rod, at its pivotal end, attached to the piston-rod of the fuel-charge injector for reciprocating the piston-rod from the rocking action of the pivotal end of the connecting-rod, giving a unity of movement between the connecting-rod and the injector-piston for the piston of the injector to operate at the proper time in relation to the position of the power or working piston of the engine and inject the fuel charge into the chamber of the engine-cylinder before the power-piston finishes a return stroke, substantially as described.

5. In a gas-engine, the combination with a gasolene or hydrocarbon feed for the vapor of the explosive charge, of a fuel-charge injector having a piston with a piston-rod and mounted on the engine-cylinder and operative to directly force the fuel charge into the air under compression in the engine-cylinder, a connecting-rod having one end pivotally connected with a working power-piston of the engine and having its opposite end attached to a crank on the power-shaft of the engine, giving the pivoted end a rocking action from the rising-and-falling movements of the crank end of the connecting-rod, and an arm rigidly connected with and forming an extension of the connecting-rod adjacent to the pivotal end of the connecting-rod, said arm pivotally connected with the rod of the injector-piston, giving a unity of movement, and a coacting relation between the connecting-rod of the power or working piston and the fuel-charge-injector piston for injecting the fuel-charge into the chamber between the power-pistons, substantially as described.

6. In a gas-engine, the combination with the gasolene or hydrocarbon feed for the vapor, a fuel-charge chamber, a valve for the chamber of the explosive charge of a fuel-charge injector mounted on the engine-cylinder, a reciprocating piston for the injector, an air-valve opened on the outward stroke of the piston, a stem or rod for the piston, a standard or upright having a pivotal connection with the stem or rod of the piston, a rocking cross-head carrying the standard or upright fixedly attached thereto, a connecting-rod from the cross-head and a working or power piston of the engine for the rocking cross-head for operating the fuel-charge injector from and in unison with the movements of the connecting-rod to open and close the valve of the fuel-charge chamber before the full return stroke of the working or power pistons is completed, charging the air in the chamber between the working or power pistons with the fuel, substantially as described.

7. In a gas-engine, the combination of a fuel-charge injector having a piston with a piston-rod, a fuel-charge chamber receiving thereinto the vapor or other fuel charge for the received charge to be forced into the air of the explosive charge in the engine, the injector and the charge-chamber both mounted on the cylinder of the engine and having communication one with the other, a rocking pivot connected with the piston-rod of the injector, a rod between the rocking pivot and a crank on the power-shaft of the engine for giving the piston of the injector its reciprocating movements from the rocking action of the pivot derived from the rising-and-falling movement of the connecting-rod, operating the fuel-charge injector from and in unison with the movements of the connecting-rod to open and close the valve of the fuel-charge chamber before the power or working pistons of the engine reach the limit of the return stroke, substantially as described.

8. In a gas-engine, the combination of an engine-cylinder having an interior constituting a chamber for the power or working pistons, and a compression and explosion chamber, reciprocating pistons one at each end of the chamber of the engine, an air-pump forcing air into and through the chamber of the engine-cylinder, clearing the chamber of an exploded charge and supplying fresh air for the next charge, a fuel-charge chamber mounted on and communicating with the chamber of the engine-cylinder between the power or working pistons, a valve controlling the communication between the fuel-charge chamber and the engine cylinder or chamber, a fuel-charge injector mounted on the engine-cylinder and having a reciprocating piston with a piston-rod, a connecting-rod attached at one end to a crank on the power-shaft and having a rocking pivotal connection at the opposite end, the pivotal connection having a straight-line travel coincident with the travel of a working or power piston, and an extension of the connecting-rod at the pivoted end thereof and connected to the piston-rod of the injector for the rocking action of the pivotal end of the connecting-rod derived from the rising-and-falling movement of the crank end of the rod to open the valve of the fuel-charge chamber with the advance of the piston of the injector, substantially as described.

9. In a gas-engine, the combination of an engine-cylinder having an interior constituting a chamber for the power or working pistons and a compression and explosion chamber, reciprocating pistons one at each end of the chamber of the engine-cylinder, an air-pump operated from one of the power or working pistons and forcing air into and through the chamber of the engine-cylinder clearing the chamber of an exploded charge and supplying fresh air for the next charge, a fuel-charge chamber mounted on the engine-cylinder and communicating with the chamber

of the engine-cylinder between the power or working pistons, a valve controlling the communication between the fuel-charge chamber and the engine-cylinder chamber, a fuel-charge injector mounted on the engine-cylinder, a connecting-rod of the engine, a rocking cross-head for the rod, an arm extending from the rocking cross-head and pivotally attached to the piston-rod of the injector and a power or working piston carrying the cross-head, substantially as described.

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Witnesses:
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