No. 741,985. PATENTED OCT. 20, 1903.

# R. P. THOMPSON & E. KOEB.

## GAS ENGINE.

APPLICATION FILED DEC. 23, 1901. RENEWED AUG. 10, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1

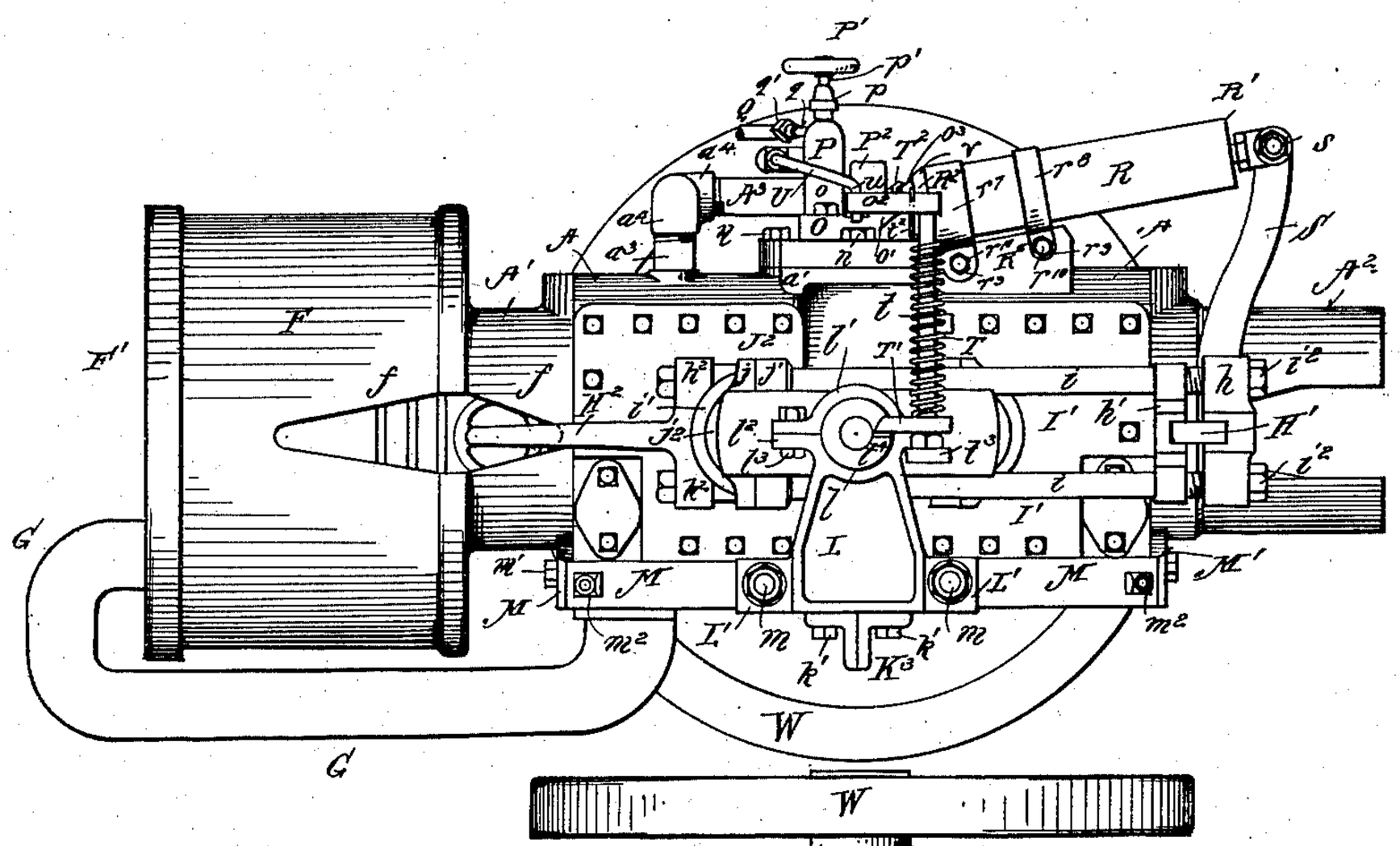

Fig. 2.



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NO MODEL. 2 SHEETS—SHEET 2.

Fig. 3.

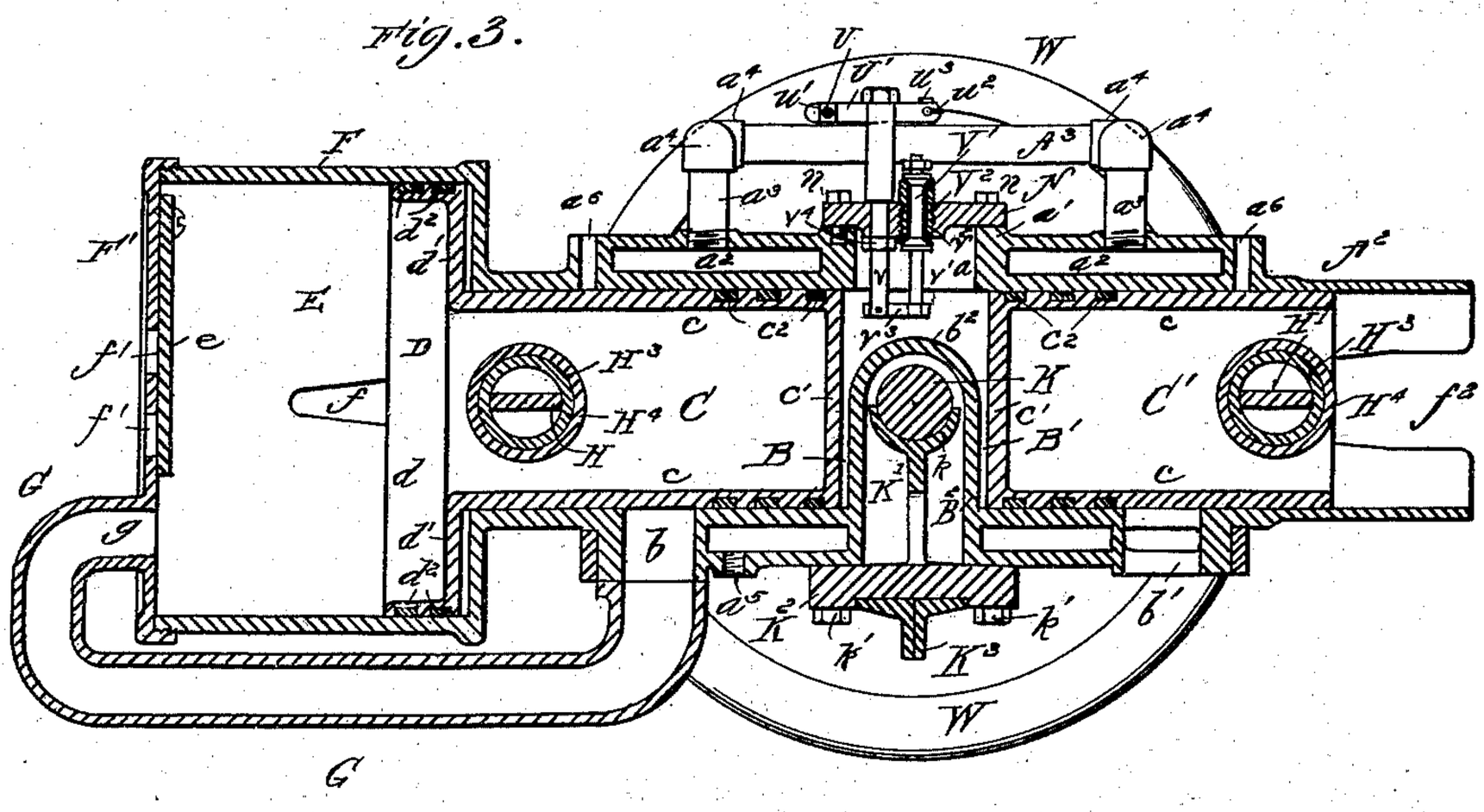


Fig. 4.

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# UNITED STATES PATENT OFFICE.

RALPH P. THOMPSON AND EMIL KOEB, OF SPRINGFIELD, OHIO.

## GAS-ENGINE.

SPECIFICATION forming part of Letters Patent No. 741,985, dated October 20, 1903.

Application filed December 23, 1901. Renewed August 10, 1903. Serial No. 169,040. (No model.)

*To all whom it may concern:*

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

This invention relates to the construction and operation of the several elements or parts which enter into the engine as a whole, and has for its object to insure a proper supply of air to the compression and explosion chamber of a two-cycle engine in conjunction with the movements or strokes of the power-pistons, to improve the construction and operation of the power-pistons and the connection therefor with the crank-shaft, to improve the mounting of the crank-shaft in its relation to the cylinder for the power-pistons, to enable a single cylinder to furnish a compression and explosion chamber, and a cylinder for each power-piston, to improve the means for supplying a cooling medium to the cylinder of the power-pistons and discharging such medium, to improve the coacting relation between the power-pistons and the force-pump for supplying air to the compression and explosion chamber, to improve the coacting relation between the power-pistons and the charging device for gasolene and air and the sparking means, to improve the frame or support on which the engine as a whole is mounted or carried, and to improve generally the construction and operation of the engine as a whole; and the invention consists in the features of construction and combination of parts, as hereinafter described and claimed.

In the drawings illustrating the invention, Figure 1 is a side elevation; Fig. 2, a top or plan view; Fig. 3, a longitudinal section on the line 3 of Fig. 2, and Fig. 4 a bottom view.

The main cylinder proper, A, has at one end a neck A′ and at the other end an extension $A^2$, with a combined length for the main cylinder and the neck and extension to furnish the chambers and supports for the traverse of the power-pistons, which are located and operate on opposite sides of the center of the main cylinder. At the center of a cylinder longitudinally and on the upper side thereof is an opening $a$, surrounded by a wall $a'$, having a flat upper face, and on each side of the wall the body of the cylinder has a double wall forming a passage $a^2$, which passages are separated one from the other by the wall. The two passages $a^2$ are in communication with each other in the construction shown by short pipes $a^3$, entered into screw-threaded holes in the outer wall of the cylinder and connected by a coupling $a^4$ with a pipe $A^3$, the coupling shown consisting of two elbows and a short pipe between the elbows, and a discharge port or opening $a^5$ on the bottom is provided, so that the cooling medium can enter the passage on the closed side and filling such passage can flow through the connection formed by the pipe $A^3$ and its couplings between the two passages and enter the passage having the discharge or eduction port to flow out therefrom, thus furnishing a course of travel around each passage and from one passage to the other, by which the engine-cylinder will be kept cool. At each end of the main cylinder A is a port or opening $a^6$, forming a duct for supplying oil or other lubricant to the power-pistons, which operate in the main cylinder at each end thereof, as shown in Fig. 3.

The interior of the main cylinder forms as a whole a single explosion-chamber, with end chambers B and B′ for the travel of the power-pistons, and the piston-chambers B and B′ are separated for a portion of the diameter of the cylinder by an arched wall or bridge $B^2$, located in line with the charging opening or passage $a$ of the cylinder. An induction port or opening $b$ is located on one side of the wall or bridge and opens into the piston-chamber B, and an eduction-port $b'$ is located on the opposite side of the arched wall or bridge and opens into the chamber B′, the port or opening $b$ supplying fresh air to the explosion-chamber, and the port or opening $b'$ escaping the burned gases and vapors after each explosion. The arched or bridged wall does not extend to the top of the interior of the cylinder, leaving an opening $b^2$, so that when the pistons are at the limit of their return movement or stroke, as shown in Fig. 3, a compression and explosion chamber is formed between the two operating or power pistons and common to both of said pistons. A working or power piston C is located and operates in the chamber B, and a working or

power piston C′ is located and operates in the chamber B′, each piston having a reciprocating travel in its chamber to the limit of the stroke. Each working or power piston, as shown, has a body formed of a cylindrical wall or shell *c*, closed end wall or head *c′*, and circumferential packing-rings $c^2$ on the exterior at the inner end.

The piston C has a longer body than the piston C′ and at its outer or advanced end carries a piston D, which may be cast or formed with the piston C, and the piston D has a body formed of a cylindrical rim or shell *d*, an end wall *d′*, and circumferential packing-rings $d^2$ around the exterior of the rim or shell. The piston D is located and operates in a chamber E, with a cylinder or casing F, which may be formed with the neck or end extension A′ or may be separate therefrom and suitably attached thereto. The open end of the cylinder or shell F, as shown, is closed by a cap or cover F′, having therein perforations *f′*, closed by a flap-valve *e*, attached to the inner face of the cap or head, with its free end overlying the perforations or holes and closing the same when the valve is down and permitting the admission of air into the chamber E in front of the piston when the valve is raised. The cap or head F′ has therein a port or passage *g*, which communicates with a pipe or conduit G, leading to the induction-port *b* of the compression and explosion chamber. The shell or casing F, with its chamber E and the piston D, constitutes an air-pump for forcing air from the chamber E through the port or opening *g*, pipe or conduit G, and port or opening *b* when the port or opening *b* is uncovered. The chamber E of the pump and the piston are of an increased diameter over the chamber B and power-piston C, which gives the air-pump an increased capacity over the capacity of the compression and explosion chamber and if the piston of the pump was operative its full stroke a greater supply of air than required for use in clearing the explosion-chamber and furnishing fresh air for the next charge would be obtained. The regulation and control of the fresh-air supply from the pump is by means of the pump-piston and its cylinder and is obtained by utilizing only a length of stroke for the piston as is needed for the supply, allowing the piston to operate during a portion of its stroke without forcing air from the chamber to enter the compression and explosion chamber, and for this purpose openings or passages *f* in the shell or wall of the air-pump cylinder are provided, which openings or passages terminate at a predetermined point forward, leaving a sufficient length of stroke to furnish the supply of air necessary for clearance and charging purposes to be forced into the compression and explosion chamber.

The air-pump and the special feature in its operation of having its piston operative to force air for a portion of the stroke only, in connection with a compression and explosion chamber and working or power pistons, one of which carries the pump-piston, are not herein claimed, as they form the subject-matter of an application filed by us in which the construction is fully shown, described, and claimed. The chamber formed between the pump-piston and the cap or head of the pump-cylinder as the piston reaches the terminus of the escape-openings is of a capacity to furnish the required amount of air for clearance and supplying air to the compression and explosion chamber with but little, if any, excess of supply of air over what is wanted for operation in the compression and explosion chamber. The engine, as shown in the drawings, is in the proper condition to receive a charge in the compression and explosion chamber for explosion therein to drive outward or advance the power-pistons. As the power-pistons are forced outward or advanced the piston C carries with it the pump-piston, and when the pump-piston reaches the outer terminus of the openings *f* air will not escape from the chamber E of the air-pump. As the pump-piston reaches the terminus of the escape-openings the piston C′ has reached the point where the eduction-port is open, allowing the gases, vapors, and products of the explosion to escape through the port, and with the further outward or advanced movement of the working or power pistons the induction-port is opened and the eduction-port is still further opened, and with the opening of the induction and eduction port the continued advance or outward movement of the pump-piston forces air from the pump-chamber through the port or passage *g*, pipe or conduit G, and induction port or passage into the chamber between the two working or power pistons, and the air is forced through this chamber and out at the eduction-port, effectually clearing the chamber of the gases, vapors, and products of the explosion. The inward movement or return stroke of the working or power pistons causes the piston C to return the pump-piston, and the return of the working or power pistons closes the induction and eduction ports for the air remaining in the chamber between the two working or power pistons to be gradually compressed therein for the next charge. Each outward or advance stroke of the working or power pistons operates as above described to force air into the compression and explosion chamber for clearance and charging purposes by the action of the air-pump, and each inward movement or return stroke of the working or power pistons compresses the air, as described, and these movements, operations, and results will continue until the engine is stopped or ceases to run.

The piston C is carried by a cross-head H, and the piston C′ is carried by a cross-head H′, each cross-head extending both sides of the piston which it carries. The cross-head H passes through the opening *f* in the pump-

cylinder and the neck A′, and the cross-head H′ passes through an opening $f^2$ in the extension $A^2$, which openings are of the requisite length for the strokes of the pistons, and, as shown, the openings are of an elongated diamond shape, widest at the center, the openings $f$ also serving as the air-escape openings for the air-pump. One end of the cross-head H extends straight out, as do both ends of the cross-head H′, and the other end of the cross-head H is turned at a right angle to the main body and forms an arm or extension $H^2$, standing parallel with the side of the engine-cylinder. Each straight extended end of the cross-head H and the cross-head H′ has secured thereto eye-blocks $h$ and $h'$, and the arm $H^2$ of the cross-head H has at its end an eye-block $h^2$. The straight-out extended end of the cross-head H has connected thereto a crank-rod I, and a crank-rod I is also attached to the end of the arm $H^2$ at the other end of the cross-head. The cross-head H′ at each end thereof has connected thereto a crank-rod I′, and the crank-rods are so arranged that the rod I on one side is outside of the rod I′ and on the opposite side is inside of the rod I′, as shown in Fig. 2. Each crank-rod is formed of a rod bent on itself into a yoke shape, so as to have an arm $i$ on each side and a curved end $i'$, and the free end of each arm is screw-threaded and passes through the eye-blocks at the ends of the respective cross-heads and receives nuts $i^2$, by means of which the rods are drawn solid against their respective cranks. The crank-rods I each run to a crank J on a crank-shaft K, and the crank-rods I′ each run to a crank J′ on the crank-shaft K, and each crank-rod is connected to the cross-pin of its crank by a box or bearing $J^2$, formed of two half-boxes $j$ and $j'$, encircling the crank-pin, with the half-box $j$, having a semicircular head $j^2$ receiving the curved end $i'$ of the cross-rod, as shown in Figs. 1 and 2. The cranks J and J′ project oppositely to each other from the crank-shaft, as usual, and in location the crank J on the outside is in line with a crank J on the inside, and a crank J′ on the outside is in line with a crank J′ on the inside, which arrangement is permitted by locating the crank-rods outside and inside, as described.

The crank-shaft K passes through the engine-cylinder at its center longitudinally and beneath the top of the arched wall or bridge $B^2$, as shown in Fig. 3, and on each side is supported by an upright or standard K′, having a half box or bearing $k$, as shown in Fig. 3. The standards or uprights extend up from a plate $K^2$, attached to the bottom of the engine-cylinder by bolts $k'$ or otherwise, and the plate $K^2$ is carried by angle beams or irons $K^3$, attached to the main frame, on which the engine as a whole is supported. Each outer end of the crank-shaft is supported by a post or standard L, having a journal box or bearing at its upper end formed by a half-box $l$, integral with the standard, and a removable half-box $l'$, each half-box having ears $l^2$ for the passage of bolts $l^3$, by means of which the removable half-box is attached and held in place. Each post or standard L has on each side projecting ears L′, which receive a flat bar M, standing edgewise and secured to the ears by bolts $m$, as shown, or in any other suitable manner, and a flat bar M′, standing edgewise, is secured to the end face of the engine-cylinder at each end by bolts $m'$, as shown, or otherwise. The flat bars M and M′ overlap each other at the ends, and the overlapping ends receive a bolt $m^2$, by which the bars are firmly united one to the other, forming a firm and rigid main frame for supporting the engine as a whole.

The flat face of the wall $a'$ has mounted thereon a plate N, secured in place by bolts $n$ or otherwise, and on the plate N is mounted a plate or head O, secured in place by bolts $o$ or otherwise. A shell or casing P extends up from the head or plate O and has therein a gasolene-passage, the inflow of gasolene into which is controlled by a needle valve or point on a stem $p'$, which is encircled by a packing box or cap $p$ on the neck or head of the shell or casing and is actuated by a hand-wheel P′ or otherwise. The head or plate O has also a plug or shell $P^2$, in which and the head or block is a receiving-chamber, (not shown,) exit from which is into the opening or passage $a'$ for admitting a charge of gasolene and air into the chamber. The gasolene enters the shell or casing P from a suitable source of supply through a pipe Q, connected by a coupling $q'$ with a nipple $q$, leading into the shell or casing P and in communication with the passage therein. (Not shown.) The head or plate O has extending out therefrom diagonally in the arrangement shown a tube $o'$, which is connected by a coupling $o^2$ with a pipe $o^3$, attached to the discharge $r$ of an air-injector. The air-injector is formed of a cylinder R, having therein a piston or plunger connected with a stem R′, and the discharge end of the cylinder is closed by a cap $R^2$, screw-threaded into the axial center of which is a block $R^3$, having a central passage and openings $r^3$ to the atmosphere. Extending out from the block is a tube $r^4$, carrying a valve-stem $R^4$, having a valve controlling the admission of air into the cylinder of the air-injector in front of the piston, and the valve is closed and held normally closed by a spring $r^5$, working against a pin $r^6$ in the end of the valve-stem, as shown in Fig. 2. The forward stroke of the piston of the air-injector forces air from the discharge $r$ through the connection leading therefrom into the receiving-chamber of the head or plate O to there mix with the gasolene admitted to such chamber through the pipe Q and the passage in the shell or casing P, and on the return stroke of the piston of the air-injector the valve of the stem $R^4$ opens, admitting air into the cylinder of the injector in the front of the pis-

ton, so as to bring the gasolene up to atmosphere. This gasolene and air feed, in conjunction with the air-injector for bringing the charge up to atmosphere, forms the subject-matter of another application, and the same is not herein specifically described and claimed.

The outer end of the stem R′ has thereon a fork or coupling $r'$, between the ears of which is entered the end of an arm S, which is pivotally held in place by a pin or bolt $s$ to allow of the necessary rock of the stem R′ for the movements of the piston or plunger which it carries. The lower end of the arm S is attached to one end or arm of the cross-head H′ in any suitable manner so as to be rigid therewith and have a reciprocating movement given thereto coincident with the reciprocating movement of the cross-head. The cross-head H′, as well as the cross-head H, has a rocking or oscillating movement to permit of the movement of the crank-rods and crank, and for this purpose each cross-head is secured in a tube or sleeve $H^3$, which turns in a tubular support or bearing $H^4$, attached to each working or power piston near its outer end, as shown in Fig. 3, and in order to permit of this rocking movement, which turns the flat portion of each cross-head angling, each opening $f$ and $f^2$ is made widest at the point where the greatest angle or rise of the flat cross-head occurs. The reciprocating movement given to the stem R′ actuates the piston or plunger of the injector, and this operation occurs so as to force air into the receiving-chamber for admission to the compression and explosion chamber as the working or power pistons reach the position shown in Fig. 3.

The spark to explode the charge is obtained by electrical contact in the construction shown. To operate the contact, a rod T, mounted at its lower end in a step $t^3$, extending out from an ear $l^2$, is located on one side of the engine and extends upward, as shown in Fig. 1, and has attached to its lower end a finger T′ and to its upper end an arm or lever $T^2$, and encircling the rod between the finger and the arm is a coil-spring $t$, one end, $t'$, of which, as shown, engages a bolt $l^3$, and the other end, $t^2$, is hooked over the arm $T^2$, so that the spring is under a tension to hold the finger against a cam-face $t^4$, formed, as shown, on the end of the crank-shaft K, so as to revolve therewith, but which could be a separate piece attached to the end of the crank-shaft, so long as it would operate to engage the finger and at the proper time allow the end of the finger to drop from the end of the shaft into the recess of the cam for the spring to rock the arm $T^2$ and make the contact and have the end of the finger as it rides out of the cam-recess onto the end face of the shaft return the finger to normal position, carrying with it the arm $T^2$, breaking the contact and interrupting the electric circuit. A rod U has one end $u$ entered into an eye on the arm $T^2$, and its other end is adjustably connected with a cross-bar U′ by the end of the rod passing through the end of the bar and with the end of the bar held between adjusting-nuts $u'$, screw-threaded onto the end of the rod, as shown in Fig. 2. The cross-bar U′ is secured to a binding-post V, having a stem $v$ extending through the plate N into the compression and explosion chamber, and adjacent to the binding-post V is a second binding-post V′, having a stem $v'$ likewise extending down into the compression and explosion chamber. As shown, the binding-post V′ is carried by a plug $V^2$, screw-threaded into the plate N and having a lining of non-conducting material $v^2$ surrounding the binding-post. The lower end of the stem of the binding-post V carries a contact-arm $v^3$, by means of which the circuit between the two binding-posts can be completed in the usual manner. The binding-posts each have connected thereto a conductor leading from a battery or other source of electric energy. (Not shown.) The rocking of the post T through the rod U vibrates the bar U′ and rocks the movable binding-post V to move the arm $v^3$ into and out of contact with the binding-post stem $v'$ to make and break the electric circuit and produce a spark for igniting the charge, and the ignition occurs as the working or power pistons reach the limit of their inward stroke, at which time the gasolene and air are admitted to the compressed air in the compression and explosion chamber, so that with the operation of the igniter the charge will be exploded and the pistons given their outward movement or advance throw. The engine, as shown, has a single fly-wheel W, attached to one end of the crank-shaft, which leaves the other end of the crank-shaft free for the locating thereon of the cam-face, by means of which the charge-igniter is actuated, and the cam-face is located so as to move the bars actuated therefrom at the proper time to produce the spark when the working or power pistons are in position to be forced outward by the explosion of the charge.

The connecting-rod for the cranks, each made of a single piece turned on itself to have a curved end, makes a very simple, effective, and reliable connecting-rod, and the rod is readily attached to the crank-pin and to the cross-head, to do which all that is necessary or required is to slip the half-boxes onto the crank-pin, pass the two arms of the connecting-rod through the eyes of the half-boxes, with the curved edge face $j^2$ of the half-box $j$ in position to receive the curved end of the connecting-rod, and then pass the free ends of the rod through the eye blocks or heads $h$ and $h'$ for the reception of the nuts $i^2$, by tightening which the rod will be firmly connected with the cross-head and with its crank. The removal of the rod is easily effected, requiring only the withdrawal of the nuts $i^2$ from the free ends of the arms and then drawing the arms clear of the blocks or heads $h$

and *h'* and clear of the half-boxes, which disconnects the rods from the cross-head and its crank. The connecting-rod thus formed distributes the strain on both of its arms, giving an additional resistance against strain and equalizing the pull or draw between the cross-heads and the cranks of the shaft uniformly on both sides of the center of the cranks and of the cross-heads, which, in connection with the staggered arrangement for the connecting-rods, insures perfect and equal pull on the cranks in the operation of the engine without a strain that will affect the mounting of the shaft in its boxes or bearings.

The strokes of the working or power pistons and the pump-piston are so regulated and timed as to force the air for clearance and for a new charge into the compression and explosion chamber as the working or power pistons travel outward, or on the advance stroke, for clearance and as the pistons travel inward, or on the return stroke, for compressing a new charge, and this operation is in such correlation with the operation of the gasolene and air feed and the air-injector for bringing the charge to atmosphere as that the air-injector operates to project a charge of gasolene and air up to atmosphere into the compression and explosion chamber as the working or power pistons reach the limit of their inward or return stroke, and as this point is reached the cam on the end of the crank-shaft reaches a point where the finger of the rocking rod drops into the cam-recess for the rod to operate the igniter or spark-producer and cause an explosion. It will thus be seen that the movements of the working or power pistons, the air-pump for clearance and supplying fresh air to the compression and explosion chamber, the gasolene and air feed, the air-injector for bringing the charge to atmosphere, and the igniter all have a unity of operation and are all dependent upon the revolution of the crank-shaft, so that with the revolutions of the shaft the several parts will work in unison and at the proper time to perform their respective operations. The engine as a whole is supported upon the frame, and the various coacting parts therefor are carried by the main or engine cylinder proper, making the engine very compact and strong and durable, and at the same time the arrangement is one which gives ready access for repairs or adjustment, as may be required.

We claim—

1. In a gas-engine, the combination of a power-piston, a cross-head for the piston, a connecting-rod for each end of the cross-head, each rod formed from a single piece bent on itself to have a pair of arms with an open or free end for attachment to the cross-head and a closed curved end, a crank for each connecting-rod having its crank-pin entered into the circle of the closed curved end of the rod, and a shaft having the cranks thereon, substantially as described.

2. In a gas-engine, the combination of a power-piston, a cross-head for the piston, eye-blocks on each end of the cross-head projecting both sides of the head, a connecting-rod for each end of the cross-head, each rod formed from a single piece bent on itself to have a pair of arms with an open or free end and a closed curved end, a crank for each connecting-rod, a pair of half-boxes encircling each crank-pin, each half-box having an eye on each end and one of the pair of half-boxes having a curved face fitting the closed curved end of the connecting-rod with the arms of the rod passing through the eyes of the half-boxes and the cross-head blocks and receiving nuts on their free ends, connecting the cross-heads with the cranks, and a shaft having the cranks thereon, substantially as described.

3. In a gas-engine, the combination of power-piston, a cross-head for each piston, one cross-head having a straight projecting end and a right-angle-turned end and the other cross-head having both ends projecting in a straight line, a single eye-block on the end of the cross-head and having a right-angle turn, a pair of eye-blocks on each straight projecting end of the cross-heads, the eye-blocks extending both sides of the cross-head, a connecting-rod for each end of each cross-head, each rod formed of a single piece bent on itself to have a pair of arms with an open or free end and a closed curved end, a crank for each connecting-rod, a pair of half-boxes encircling each crank-pin each half-box having an eye on each end and one of the pair of half-boxes having a curved face fitting the closed curved end of the connecting-rod, the arms of the rod passing through the eyes of the half-boxes and the cross-head blocks and receiving nuts on their free ends, connecting the cross-heads with the cranks, and a crank-shaft having the cranks thereon, substantially as described.

4. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeves turn permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having the cranks thereon, substantially as described.

5. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the

chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-head to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, a shaft having cranks thereon, said shaft supported by bearings, a framework common to said bearings and said engine-cylinder, and an air-pump supplying fresh air to said cylinder, substantially as described.

6. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having cranks thereon, said shaft supported in bearings upon a framework attached to the engine-cylinder, the central part of said shaft occupying a space or opening, crosswise of the central part of the engine-cylinder, properly walled about the shaft, rendering the space occupied by said shaft as small as possible substantially as described.

7. In a gas-engine, the combination of an engine-cylinder, a chamber without the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having cranks thereon said shaft lying in a plane with the center of the engine-cylinder and having the walls of the engine-cylinder arched around a space to accommodate the shaft in this position, substantially as described.

8. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of the cross-head, a crank for each connecting-rod, and a shaft having cranks thereon, said shaft lying with its axis in a plane with the axis of the engine-cylinder, and having provided therefor in this position, a gap or opening in the engine-cylinder, properly walled to preserve the functions of the engine-cylinder, substantially as described.

9. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having cranks thereon, and an air-pump supplying fresh air to said engine-cylinder, substantially as described.

10. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having cranks thereon, said shaft supported by a framework attached to said engine-cylinder, substantially as described.

11. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operated at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having cranks thereon, the central part between cranks of said shaft lying in a space formed on the sides and top by cross-walls in the engine-cylinder, substantially as described.

12. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber, and a chamber for the power-pistons, power-pistons one located and operating at

each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a rocking bearing consisting of a tubular sleeve fixed to the cross-head and a tubular sleeve fixed to the piston and in which the cross-head sleeve turns permitting the cross-heads to rock in use, a connecting-rod for each end of the cross-head, a crank for each connecting-rod, a shaft having cranks thereon, said shaft supported by bearings, and a framework attached to the engine-cylinder, substantially as described.

13. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a tubular central portion fitting a tubular bearing carried by the piston coacting with the cross-head permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having the cranks thereon, substantially as described.

14. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and chambers for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a cross-head for each piston each cross-head having a tubular central portion fitting a tubular bearing carried by the piston coacting with the cross-head permitting the cross-heads to rock in use, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, and a shaft having the cranks thereon and lying with its central portion in a walled space arched through the explosion-chamber, substantially as described.

15. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the engine-cylinder within the chamber, a pump for supplying air to the chamber of the cylinder, having its cylinder in continuation of the engine-cylinder and having its piston connected with and actuated from one of the power-pistons and having a coöperating relation with the power-pistons for the pump to act and clear the compression and explosion chamber during the outward or advance stroke of the power-pistons, a cross-head for each power-piston, connecting-rods, one for each end of each cross-head, a crank for each connecting-rod, and a shaft carrying the cranks, substantially as described.

16. In a gas-engine, the combination of a piston-chamber, power-pistons within the chamber, a pump for supplying air to the chamber of the cylinder and having its cylinder in continuation of the engine-cylinder and having its piston connected with and operated from one of the power-pistons for clearing the compression and explosion chamber during the outward movement or advance stroke of the power-pistons, a cross-head for each piston having a rocking bearing, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, a shaft carrying the cranks, a gasolene-feed and an air-injector in juxtarelation to the gasolene-feed and operating to project air into the gasolene and commingle and eject the gasolene and air and having its piston actuated from the movement of one of the cross-heads to eject the charge into the compression and explosion chamber as the power-pistons reach the limit of their inward movement or return stroke, substantially as described.

17. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the cylinder within the chamber, an air-supply pump having its cylinder in continuation of the engine-cylinder and having its piston connected with and operated from one of the power-pistons for supplying air to the compression and explosion chamber for clearance of the chamber and furnishing a charge of fresh air, a gasolene-feed in communication with the compression and explosion chamber, and an air-injector in juxtarelation to the gasolene-feed and operated from a power-piston for forcing a charge of gasolene and air into the compression and explosion chamber as the power-pistons reach the limit of their inward movement or return stroke, substantially as described.

18. In a gas-engine, the combination of an engine-cylinder, a chamber within the cylinder constituting a compression and explosion chamber and a chamber for the power-pistons, power-pistons, one located and operating at each end of the cylinder within the chamber, an air-supply pump having its cylinder in continuation of the engine-cylinder and having its piston connected with and operated from one of the power-pistons and supplying air during a portion of its stroke for clearing the compression and explosion chamber during the outward movement or advance stroke of the power-pistons and furnishing air for the next charge during the inward movement or return stroke of the power-pistons, a gasolene-feed, and an air-injector in juxtarelation to the gasolene-feed and operating to project air into the gasolene and commingle and eject the gasolene and air and actuated from a power-piston to force a charge of gasolene and air into the compression and explosion chamber as the power-pistons reach the limit of their inward movement or return stroke, substantially as described.

19. In a gas-engine, the combination of an engine-cylinder, a cross arch or wall at the

center longitudinally of the cylinder, forming a compression and explosion chamber and piston-chambers within the cylinder, two power-pistons, one on each side of the dividing cross-wall, a cross-head for each piston, connecting-rods one for each end of each cross-head, each cross-head having an outer and an inner connecting-rod, a crank one for each connecting-rod, a shaft carrying the crank with the body of the shaft passing through the engine-cylinder below the arch or wall, supports for the body of the crank below the arch or wall, a plate carrying the supports, and cross-bars having the plate carried thereon, substantially as described.

20. In a gas-engine, the combination of an engine-cylinder and a frame comprising four bars standing edgewise and arranged in pairs, one pair for the sides of the cylinder and the other pair for the ends of the cylinder, each pair having its ends overlapping the adjacent bars with the overlapping ends united one to the other, substantially as described.

21. In a gas-engine, the combination of an engine-cylinder, power-pistons working in the engine-cylinder, one piston at each end of the cylinder, a cross-head for each piston, a connecting-rod for each end of each cross-head, a crank for each connecting-rod, a crank-shaft carrying the cranks and having its body passing through the cylinder crosswise at the longitudinal center, supports for the body of the crank-shaft below the cylinder, journal-box standards, one at each end of the crank-shaft, a plate for the crank-shaft supports, cross-bars carrying the plate, and a frame comprising bars set edgewise, two of the bars having the journal-box standards attached thereto and two of the bars attached to the end of the body of the cylinder, with the bars overlapping each other at their ends and secured one to the other at the overlapping ends, substantially as described.

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