(No Model.)

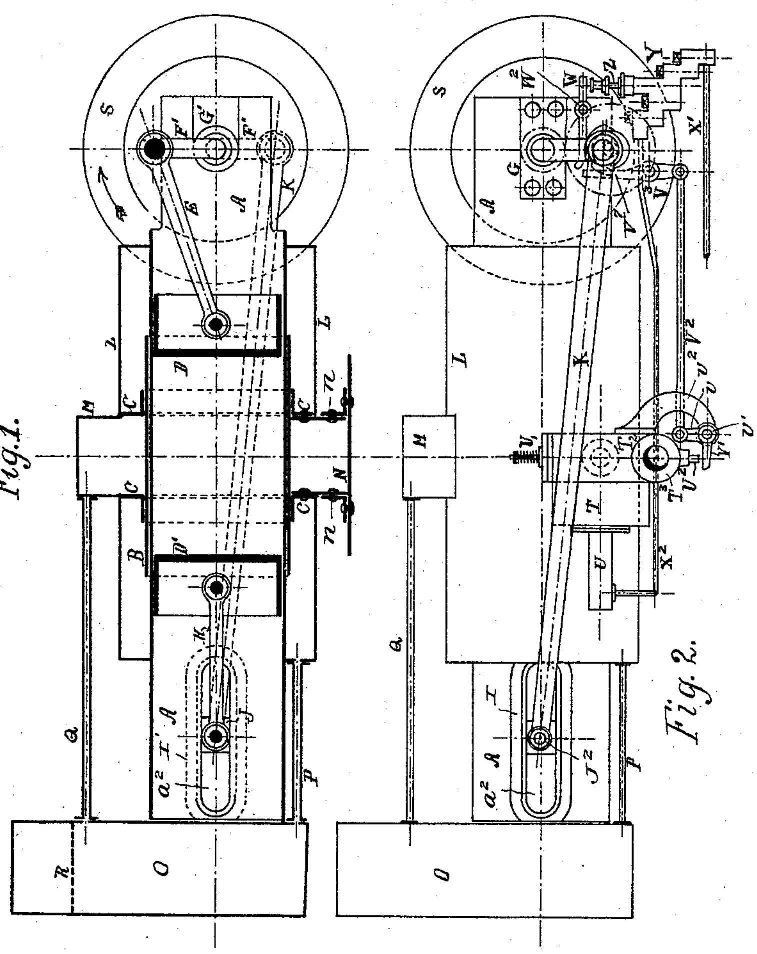
5 Sheets—Sheet 1.

E. E. LUDL.

EXPLOSIVE ENGINE.

No. 572,209.

Patented Dec. 1, 1896.



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(No Model.) 5 Sheets—Sheet 2.

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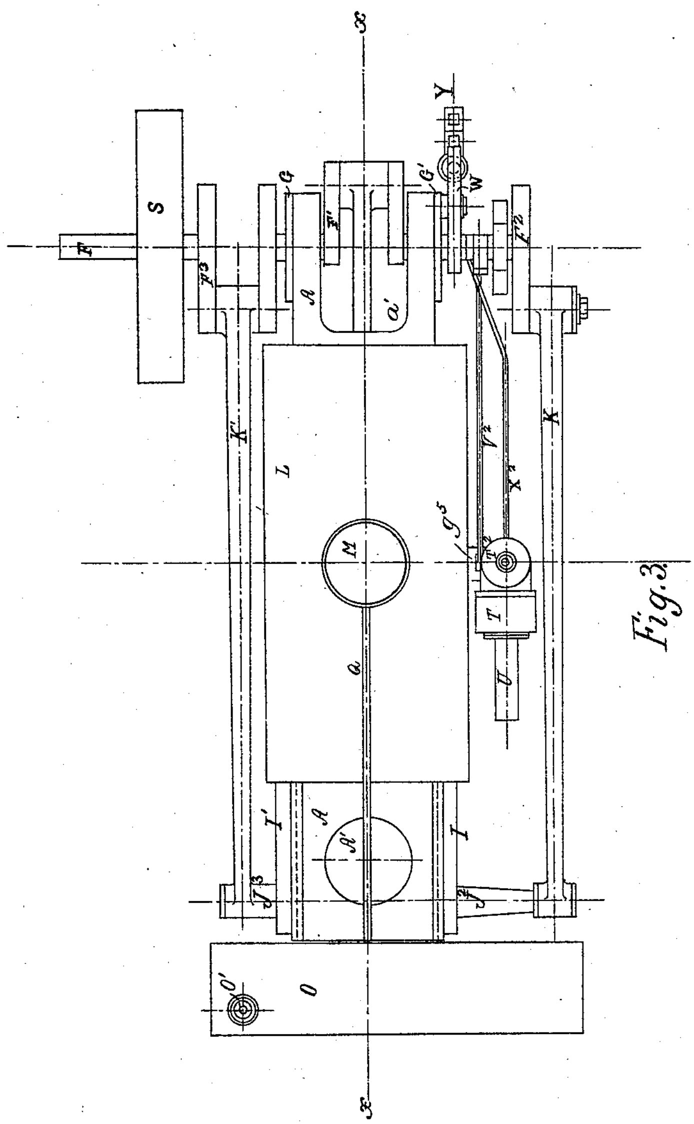

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5 Sheets—Sheet 3.

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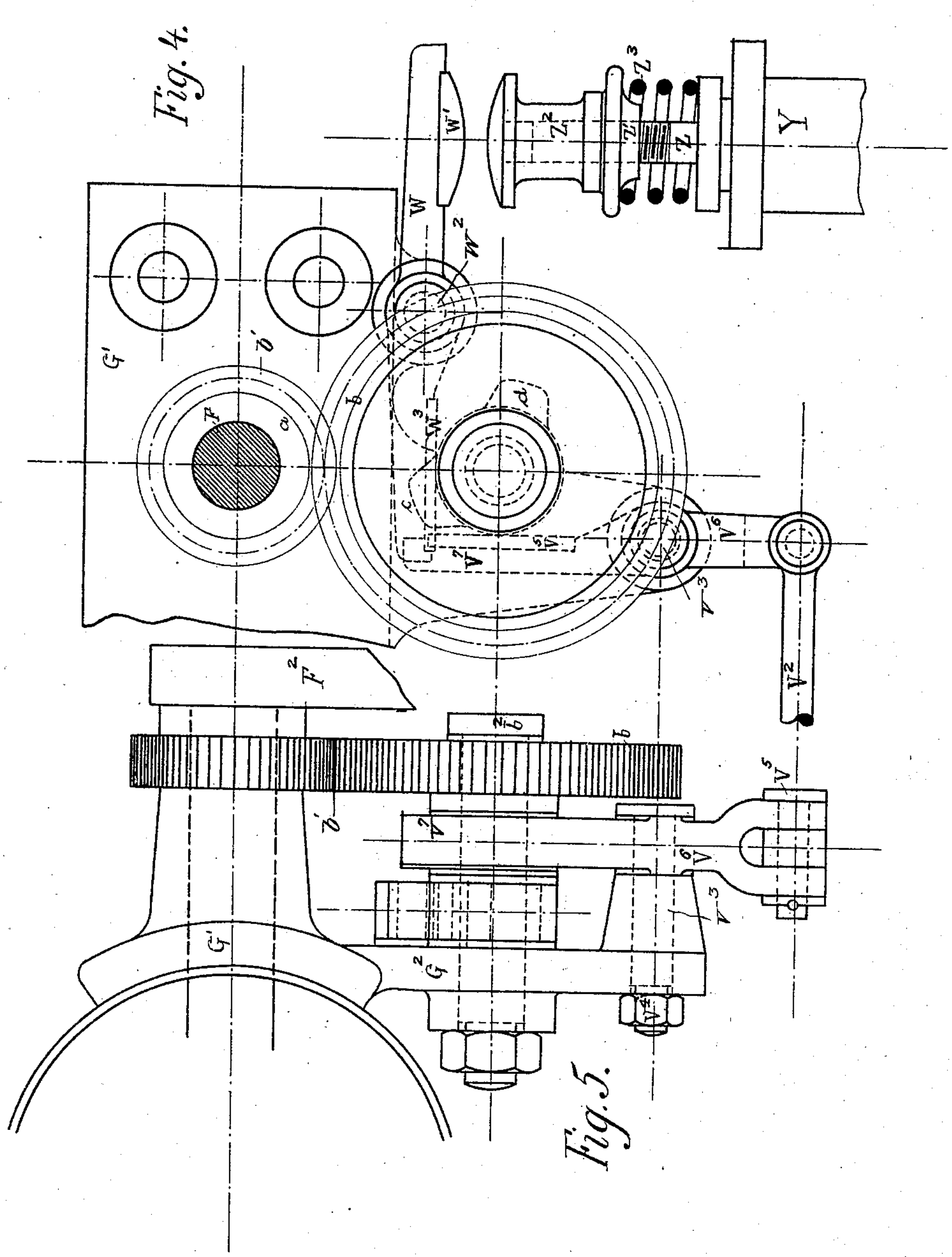
EXPLOSIVE ENGINE.

No. 572,209. Patented Dec. 1, 1896.



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(No Model.)

5 Sheets—Sheet 4.

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EXPLOSIVE ENGINE.

No. 572,209.

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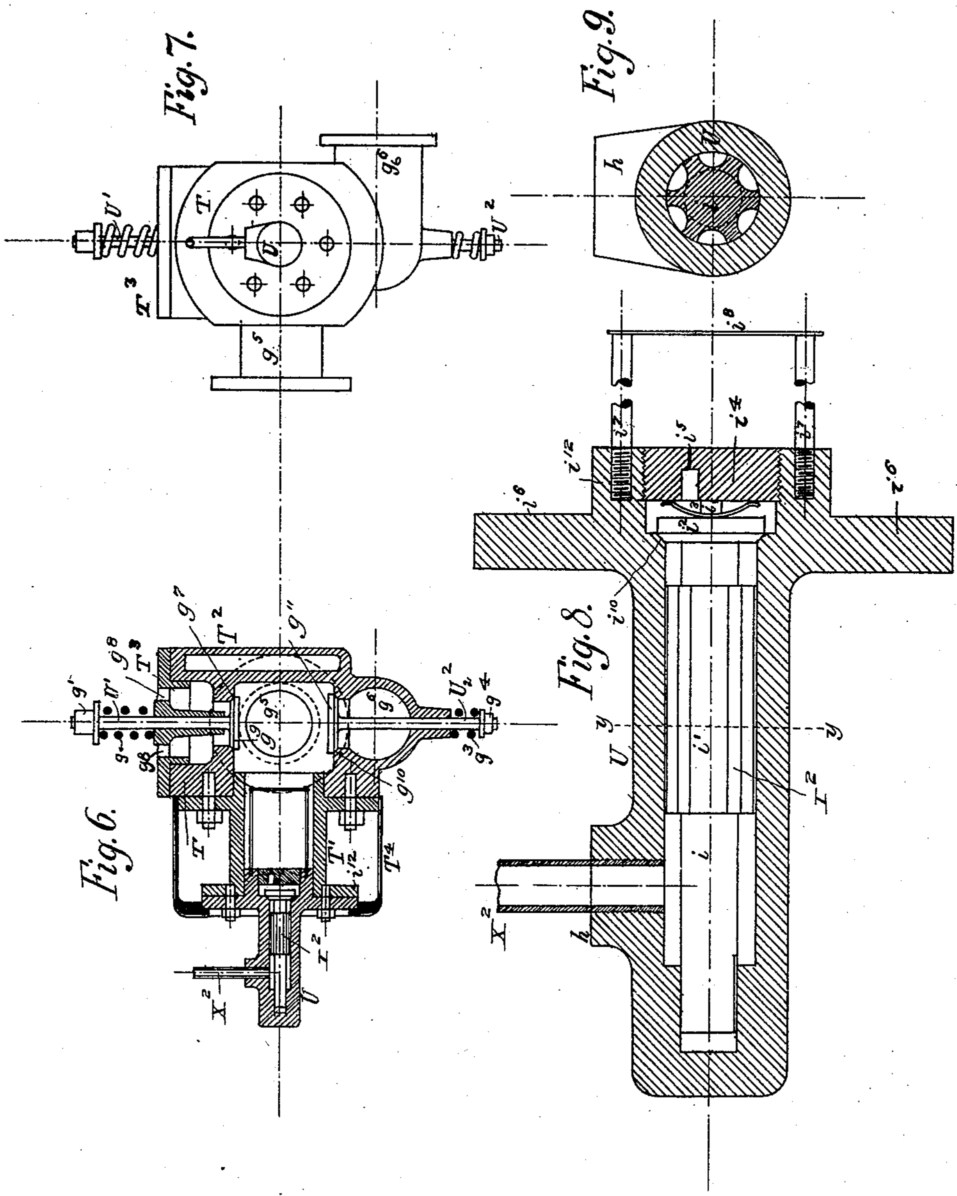

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

(No Model.)

5 Sheets—Sheet 5.

E. E. LUDL.

EXPLOSIVE ENGINE.

No. 572,209.

Patented Dec. 1, 1896.

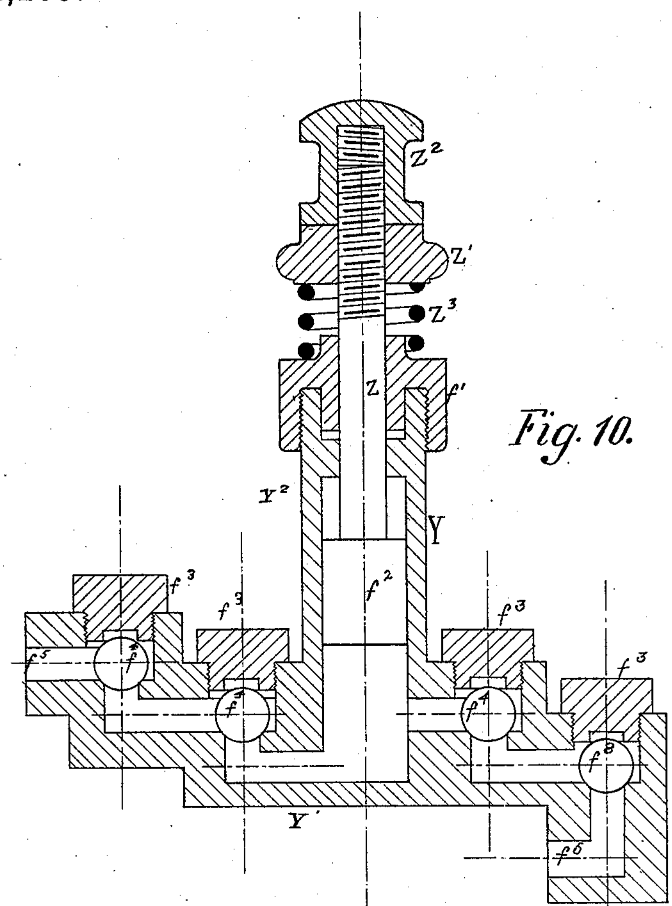
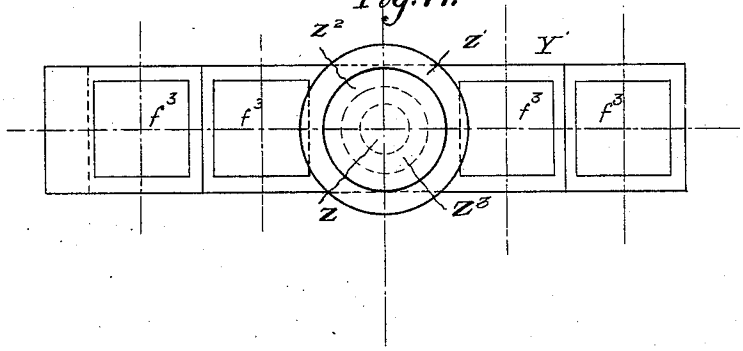


Fig. 10.

Fig. 11.



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UNITED STATES PATENT OFFICE.

EDUARD EUGENE LUDL, OF NEW YORK, N. Y.

EXPLOSIVE-ENGINE.

SPECIFICATION forming part of Letters Patent No. 572,209, dated December 1, 1896.

Application filed December 13, 1895. Serial No. 572,063. (No model.)

To all whom it may concern:

Be it known that I, EDUARD EUGENE LUDL, a subject of the Emperor of Austria-Hungary, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Explosive-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to explosive-engines of that class in which the charge of explosive mixture is drawn into the power-cylinder by suction created by outward movement of two pistons, compressed by the inward movement of the pistons, ignited by the internal heat of the cylinder and by friction due to compression, and finally expelled through an exhaust-valve before a fresh charge of explosive mixture is fed to the power-cylinder.

It is my purpose to provide a compact and comparatively light explosive engine or motor which is especially designed for propelling all manner of vehicles, including wagons, coaches, carriages, railway passenger and freight cars, boats, and machinery or appliances in general which require the application of propulsive power, and in my motor or engine I propose to utilize a suitable liquid hydrocarbon which can be stored in a tank accessible at all times, such liquid hydrocarbon being either petroleum, naphtha, kerosene, benzin, or any other fluid capable of admixture with air and of then being exploded when subjected to compression and heat to produce a charge of gaseous vapor which will, under regulated admission to the power-cylinder, operate to force the two pistons therein away from each other.

The main objects of my invention are to avoid concussion and vibration and to utilize the power ordinarily wasted by such concussion; the production of a simple, economical, and more powerful engine for a given size and weight; strength and simplicity in the construction and arrangement of parts; a perfectly-balanced engine; improved means for automatically supplying the hydrocarbon liquid in regulated quantities to the power-cylinder; an improved mechanism for vaporizing the hydrocarbon and for commingling atmospheric air therewith to produce the explosive charge for supplying the same to the power-cylinder; improved mechanism which is operated positively and automatically to exhaust the charge from the power-cylinder after the energy of the charge has been utilized, and improved means for preventing excessive heating of the power-cylinder and adjacent parts while permitting the temperature of the power-cylinder to be kept at the required heat for igniting the charge in connection with the compression of the charge by the inward movement of the two pistons.

An engine constructed in accordance with my invention may be made more compact and lighter as a whole, which renders it specially adapted for use as a motor for vehicles, boats, &c., as well as industrial purposes. Owing to the balance secured in and between the operative parts the engine is practically free from vibration, which enables the engine to be used for domestic and other purposes without provision of a special foundation and without fear of imparting a jarring motion to the structure.

With these ends in view my invention consists in the combination of devices and in the construction and arrangement of parts, which will be hereinafter fully described and claimed.

To enable others to understand my invention, I have illustrated the preferred embodiment of the same in the accompanying drawings, forming a part of this specification, in which—

Figure 1 is a longitudinal central sectional view of the gas-engine on the plane indicated by the dotted line *x x* of Fig. 3. Fig. 2 is an elevation looking at the side on which the valve-box, the liquid-vaporizer, and regulating mechanism are located. Fig. 3 is a top plan view. Fig. 4 is a detail view, in end elevation, of a part of the regulator mechanism and a part of the oil-pump, the view illustrating the parts in full size for a four-and-a-half ($4\frac{1}{2}$) horse-power engine; and Fig. 5 is a side elevation of the parts shown by Fig. 4. Fig. 6 is a vertical cross-sectional view through the valve-box and the liquid-vaporizer. Fig. 7 is an end elevation of the parts shown by Fig. 6, illustrating the nipple by which the valve-box is fastened to the power-cylinder and the exhaust-nozzle. Fig. 8 is an enlarged longitudinal sectional view through the valve and the baffle-plate of the vaporizer, and Fig. 9 is a detail cross-sectional view through the valve I^2 on the plane indicated by the dotted line $y\ y$ of Fig. 8. Fig. 10 is an enlarged vertical sectional view through the oil-pump, and Fig. 11 is a detail plan view of the pump shown by Fig. 10.

Like letters of reference denote corresponding parts in all the figures of the drawings.

In a gas-engine designed for service in the propulsion of vehicles, boats, &c., such as I have illustrated in the drawings, it is necessary that the parts shall be built as light as possible consistent with strength and durability to successfully withstand the strain due to the explosion of the charge in the power-cylinder. I construct the cylinder A of my gas-engine of a single piece of drawn seamless steel tubing of appropriate length and having both ends thereof open, as shown by Fig. 1 of the drawings. To strengthen this cylinder A at the central part, where the explosion of the gaseous charge takes place and where the cylinder is exposed to the greatest heat and strain, a jacket-reinforcement B is shrunk around the cylinder, said jacket B being also made from a seamless steel tube. The jacket B is, however, of less length than the cylinder A, so as to leave parts of the cylinder exposed beyond the ends of the jacket B to better enable the cooling fluid to circulate around the cylinder; and the cylinder and jacket are further strengthened by the angular or L-shaped rings or bands C C, Fig. 1, which are shrunk around and upon the jacket B near the middle thereof. These reinforcement bands or rings also serve the useful purpose of furnishing a means for the attachment of the pillar-plate N to the vehicle, boat, foundation, &c. The pillar-plate N is a substantial metallic plate or casting having the clips $n\ n$, which afford the means for substantially uniting the bands or rings C C and the pillar-plate N, the parts being riveted together, as shown by Fig. 1, or otherwise fastened.

To keep the cylinder A from being heated excessively by the explosion of the hot gaseous charges in the cylinder between the two trunk-pistons D D′, a special cooling apparatus is provided which supplies and maintains a circulation of water around the cylinder, its jacket B, and the bands or rings C C. The cooling apparatus has a casing L, preferably cylindrical in form and of length which exceeds the length of the jacket B, but is less than that of the cylinder A, so that the ends of the cylinder protrude through and beyond the cooling-casing L, Figs. 1, 2, and 3. This jacket has its flanged ends fitted closely to the cylinder to prevent leakage, and it surrounds the cylinder, the jacket, and the bands to provide free spaces for the circulation of the liquid. From the top side of the casing L rises the steam-dome M.

O is the supply-tank, situated adjacent to one end of the cylinder A or any convenient point. P is the feed-pipe, and Q is the condensing return-pipe. The feed-pipe P has its ends connected to the lower part of the tank O and to the lower part of the casing L, at one end of the latter, so as to supply cold water from the tank to the casing L. The pipe Q is connected at one end to the steam-dome M and at its other end to the tank O, near the upper part thereof. The function of the pipe Q is to partially condense the steam taken from the dome M and return the water of condensation to the tank O, and the pipe P is to replace the water which has been converted into steam by the boiling water in the casing L, whereby the temperature of the cylinder A is kept at a substantially uniform temperature of 105° Celsius, which is the temperature of boiling water and which is necessary in order to attain the ignition and explosion of the gaseous charge when compressed by the inward movement of the two pistons.

The right-hand protruding end of the cylinder A has vertical slots a' produced therein (see Fig. 3) for the passage of the central crank F′ of the crank-shaft F, and in the left-hand protruding end of said cylinder are produced the longitudinal horizontal slots a^2, which are in opposite walls of the cylinder and are in horizontal alinement with each other. To the outside of the left-hand end of the cylinder are fastened the horizontal guides I I′, which are coincident with the slots a^2 of the cylinder, and across this end of the cylinder, so as to pass through the slots a^2 and the guides I I′, is arranged the horizontal cross-head J, which is fitted in the guides to be maintained in proper position therein and to be free to slide back and forth in said guides and the slots a^2 in the cylinder, said protruding ends of the cross-head being provided with the trunnions or pins J^2 J^3. (See Fig. 3.)

D D′ are the two trunk-pistons which are fitted in the cylinder A to reciprocate therein simultaneously in opposite directions.

To the right-hand protruding end of the cylinder A, opposite to the slidable cross-head J, are fastened the two shaft-bearings G G′, (see Figs. 1, 2, and 3,) and in the bearings is journaled the triple-crank shaft F. The central crank F′ of this shaft stands at right angles to the two side cranks F^2 F^3 of said shaft, and the shaft is so arranged that the central crank F′ is in line with the axis of the cylinder A, while the two side cranks are positioned to enable them to be connected to the slidable cross-head J by external pitmen K K′. (See Fig. 3.) The pitmen K K′ are arranged externally to the power-cylinder and on opposite sides thereof, and the right-hand ends of said pitmen are connected to the cranks F^2 F^3 of the shaft F, and the other ends of the pitmen are connected to the trunnions J^2 J^3 of the slidable cross-head J.

To the piston D′ is connected one end of the pitman H, which has its other end pivoted to the cross-head J. A pitman E has its ends pivoted to the piston D and to the central crank F′ of the shaft F, respectively, (see Fig. 1,) and during the rotation of the shaft and the reciprocal play of the piston D the pitman E is adapted to play in the vertical slots *a′* of the cylinder A, as will be obvious.

It will be observed that the crank-shaft, the pistons, the cross-head, and the connections between the parts are arranged in a common central plane of action coincident with that of the longitudinal axis of the power-cylinder, so that the force of the explosion of the gaseous charge between the two pistons is counterbalanced and evenly distributed to the cranks of the power-shaft F.

S is a balance-wheel keyed or otherwise fastened to the power-shaft.

In my improved engine I have provided a valve-box T, which communicates centrally with the power-cylinder and on a plane between the limits of the instroke of the two pistons, and this valve-box is constructed to receive the vapor from the valved vaporizer U, to draw in a supply of atmospheric air through the air-valve g^9 for admixture with the vapor, and to exhaust the waste gaseous vapor through the exhaust-valve g^{11} after the charge has been exploded and utilized, the exhaust-valve being positively actuated by devices operated at proper intervals of time from the power crank-shaft F. I have also provided means for supplying the liquid hydrocarbon under pressure to the valved vaporizer U, in which embodiment of my invention I use what will hereinafter be called an "oil-pump," which is designated by the letter Y and is arranged for operation in conjunction with positive actuating contrivances impelled from the power crank-shaft F to force the liquid under pressure and at certain determined intervals into the vaporizer in a manner to automatically open the controlling-valve of said vaporizer.

The oil-pump Y is operated and the exhaust-valve U^2 opened by means of cams on a single driving-gear *b*, which is loosely mounted on a fixed bolt or pin b^2, which is fastened to a pendent arm G^2 of one of the bearings G′ for the power-shaft. (See Figs. 4 and 5.) The driving-gear *b* is shown as a straight spur-wheel meshing with the small gear *b′*, which is fastened to the crank-shaft F to rotate therewith, and said gear *b* has twice the number of teeth that the gear *b′* has, so that the gear *b* makes half the number of revolutions that the shaft F makes in the same time. The hub of the single driving-gear is extended to one side to accommodate the two cam-shaped projections *c d*, which are spaced as shown by Fig. 5 and lie in different radial positions to the hub, as indicated by Fig. 4, and the cam *d* is adapted to actuate the horizontal pump-piston lever W, while the cam *c* is designed to move the vertical exhaust-valve lever V. The vertical valve-lever V is hung or fulcrumed at an intermediate point of its length on the pin or bolt V^3, fastened to the pendent arm G^2, and the upper arm V^7 of said valve-lever lies in the path of the cam *c*. To the lower short arm V^6 of said valve-lever is pivoted one end of the rod V^2, which extends horizontally beneath the cylinder to a point below the valve-box T. (See Figs. 2 and 3.) This end of the rod V^2 is pivoted to the vertical arm *v* on the rock-shaft *v′*, which is journaled in a curved hanger v^2, fastened to the valve-box T, as shown, and said rock-shaft *v′* is further provided with a lifting finger V′, which extends horizontally from the shaft and lies below the foot of the exhaust-valve stem U^2. (See Fig. 3.)

The valve-box T constitutes a single casting having the water-jacket T^2, and one side of the box is open to receive the casting T′, forming the vaporizer-chamber, while one end of said valve-box is open to receive the tubular nipple g^5. This nipple g^5 is flanged and bolted to one side of the power-cylinder A in a manner to communicate centrally therewith, and said nipple serves to support the valve-box and gas-generator or vaporizer on the cylinder, as well as to establish communication between the valve-box and the cylinder.

The casting T′ is preferably of cylindrical form, with open flanged ends to enable the casting to be applied laterally and bolted to the open side of the valve-box T, as shown by Fig. 6, and said casting forms the chamber in which the oil or liquid hydrocarbon is converted into vapor before it passes to the valve-box T to be mixed with atmospheric air. This casting T′ is surrounded by a water-jacket T^4, to which water is admitted for the purpose of circulating around the casting T′ and prevent the walls of the vaporizer-chamber from being heated excessively by the heat derived from the explosion of the gaseous charge in the cylinder A. The upper open end of the valve-box T is provided with a fixed cap T^3, in which are produced the air-inlet ports g^8, and the upper part of the valve-box has a seat g^7 for the air-valve g^9 on the lower end of the vertically-movable stem U′, which passes through a guide, as shown by Fig. 6.

On the upper part of the valve-stem U′ is fitted the coiled lifting-spring *g*, one end of which is seated against the cap T^3 and the other end against the head *g′*, fastened to the upper extremity of the stem U′. The function of this spring is to normally hold the air-valve against its seat in the box T, but when the pistons D D′ are forced away from each other, and thus produce a suction through the valve-box to draw in the charge of gaseous vapor, the power of the suction is sufficient to overcome the resistance of the spring and open the air-valve, so as to permit a proper quantity of atmospheric air to pass into the valve-box to be mixed with the vapor produced by conversion of the oil or liquid hydrocarbon. The lower part of this valve-box is shaped to form the exhaust chamber or nipple g^6, and above this chamber is a seat g^{10} for the valve g^{11} on the vertically-movable stem U^2, which passes through a suitable guide. The exhaust-valve is normally held pressed down against its seat by the spring g^3, which bears against the guide and the nut g^4, but the exhaust-valve is opened when the finger V′ is lifted by the cam c acting against the lever V, as will be understood.

The supply of liquid hydrocarbon to the vaporizer or generator chamber T is regulated by means of the valve I^2, which operates in the shell U. (Shown in Figs. 2, 3, 6, 7, 8, and 9.) This shell U is arranged in a horizontal position, and it is formed with a chamber which is open at one end and closed by an integral head at the other end, as shown by Fig. 8. This open end of the valve-shell U has an annular radial flange i^6 and a projecting axial boss i^{12}, and said shell U is arranged so that the boss i^{12} fits in the outer open end of the casting T′, while the flange i^6 bears against the flat side of said casting T′ to enable the valve-shell U to be bolted in a fixed position on the casting T′, as shown by Fig. 6. The valve-chamber in the shell U is contracted at its outer end and enlarged at its inner end, (see Fig. 8,) and in said enlarged inner end of the chamber is a seat i^{10} for the head i^2 of the valve i i'. The axial boss i^{12} is threaded to enable a threaded plug i^4 to be screwed into the open larger end of the valve-shell U, and a needle-like orifice i^5 is provided axially in this plug i^4 to permit the oil or hydrocarbon fluid to pass into the vaporizer-chamber T′ when the pump Y is operated to impel the fluid against the valve i i' i^2 and open the same against the pressure of the spring i^3. The part i of the valve is fitted in the contracted end of the valve-chamber and the part i' has the radial wings (shown by Fig. 9) whereby the valve is properly supported and guided in the shell U, and the valve is adapted to be surrounded by the oil or liquid hydrocarbon. The spring is arranged between the valve-head i^2 and the plug i^4, so as to normally force the head i^2 against the seat i^{10} and prevent the oil from flowing except when the pump is operated to inject the liquid hydrocarbon under pressure against the valve to open the latter and force a limited quantity of the hydrocarbon fluid through the needle-like orifice i^5 in the plug i^4. The liquid forced through the needle-like orifice i^5 strikes against a baffle-plate i^8, which is held at a suitable distance from the plug i^4 by means of the rods i^7, which are attached to the plate i^8 and the shell U. This baffle-plate i^8 is arranged in the vaporizer-chamber T′, and it serves to break up the jet of hydrocarbon fluid into a spray to enable the fluid to be vaporized to the best advantage in the chamber T′.

The oil-pump Y is shown in detail by Figs. 10 and 11 and in operative relation to the power-shaft F by Fig. 2. The pump comprises the step-shaped casing Y′ and the piston-cylinder Y^2, all cast in a single piece, said cylinder Y^2 being arranged in a vertical position about midway of the casing Y′. The lower end of the casing has the suction-nipple f^6, to which is connected one end of the suction-pipe X′, Fig. 2, which pipe leads to a tank or other source of supply for hydrocarbon fluid. The opposite upper end of the casing Y′ has a nipple f^5, to which is attached one end of the feed-pipe X^2, which leads and is attached to the nipple h of the valve-shell U. In the suction side of the casing Y′, on one side of the piston-cylinder, are the ball check-valves f^8, which find seats in the zigzag passage leading to the piston-chamber Y^2, and these valves are adapted to open when the piston f^2 is lifted by the spring Z^3 to permit the oil to be drawn into the piston-chamber, but are closed when the piston f^2 is forced down. In the zigzag rising passage leading from the piston-chamber are the ball-valves f^4, which are adapted to be closed when the piston f^2 ascends to prevent backward flow of the oil in the pipe X^2, leading to the shell U, but when the piston f^2 is forced down these valves f^4 are lifted from their seats and opened for the oil to flow under pressure from the piston-chamber Y′ into the shell U, so as to open the valve I^2 and be forced in a jet or stream against the baffle-plate i^8.

The upper end of the piston-cylinder is closed by means of the stuffing-box cap f', through which passes the piston-rod Z, and on this piston-rod is placed the coiled spring Z^3, which bears against the cap f' and the nut Z′, screwed on the threaded end of the rod Z, this nut being held by a check-nut Z^2, formed with a solid head to receive the impact of the lever W. Access may be had to either of the check-valves in the pump-casing through openings which are closed by the removable heads f^3, adapted to be screwed to the casing. (See Figs. 10 and 11.)

The horizontal lever W is hung or fulcrumed at an intermediate point of its length on the bolt or pin W^2, fastened to the cylinder A, (see Fig. 4,) and the arm W^3 of this lever is arranged in the path of the cam d of the hub of the drive-gear b, so that the arm W^3 of the lever is adapted to be raised by the cam d at each revolution of the gear b. This lever W is normally held by a spring or its equivalent in the path of the cam d, to be struck thereby, and the other arm, W′, of this lever is arranged over the headed nut Z^2 of the pump piston-rod Z, so as to strike the latter and force the piston f^2 down when the cam lifts the arm W^3 of said lever.

The operation may be described briefly as follows: Assuming that the pistons D D′ are at the inner limit of their movement in the power-cylinder A, the balance-wheel S is turned in the direction indicated by the arrow in Fig. 1. The rotation of the shaft F causes gear b' to rotate the gear b and turn the cams c d, so that the cam d lifts the lever W to press down the piston f^2 of the oil-pump, so as to force the oil through the pressure-pipe X^2 to the shell U, open the valve I^2, and inject the oil in a jet or stream against the baffle-plate i^8, which disperses or breaks up the stream. The hot walls of the vaporizer T′ convert the oil into vapor, which is drawn by suction into the valve-box T, and at the same time the air-valve U′ is opened to permit air to flow into the box T and commingle with the vapor. The suction is created by the outward movement of the pistons D D′, which draws into the cylinder the charge of explosive gaseous mixture, by which time the pistons D D′ are at the outward limit of movement in the cylinder A and the cam d has passed the lever W, so as to permit the spring to lift the piston f^2 of the oil-pump. The two pistons D D′ are now forced inward or moved toward each other, the valves g^9, g^{11}, and I^2 being closed, so that the pistons compress the charge of gaseous vapor until the pistons nearly reach the limit of inward movement, and at this time, owing to the action of the hot walls of the cylinder A on the gaseous charge and the compression of the gaseous charge between the two pistons D D′, the charge of gaseous vapor is ignited and exploded in order to again force the pistons D D′ outward toward the ends of the cylinder A. The cam d now acts against the lever V to actuate the rod V^2 and lift the finger V′ to open the exhaust-valve U^2, and the inward movement of the pistons D D′ expels the charge of exploded gaseous vapor out through the valve U^2 and the nipple g^6, after which the cam d actuates the pump to force a fresh supply of oil into the vaporizer T′ to repeat the operations.

The walls of the vaporizer T′ are heated before the engine is started by a suitable type of primary heater or burner, the flame or heat from which is supplied to the vaporizer or generator shell T′, so as to bring the shell up to the required temperature for vaporizing the liquid hydrocarbon to be pumped into the shell T′. I have not shown this primary heater or burner in this application, as any suitable or preferred heater may be used for the purpose as common in some types of explosive gas-engines.

In the generation of power for practical application to vehicles of any character by a motor embodying my invention it is necessary to ascertain the amount of fuel necessary to generate the required power. This condition having been determined my apparatus is adjusted to regulate the volume of liquid hydrocarbon to be forced in the vaporizer T′, and this regulation of the apparatus is effected of the oil-feed pump by turning the screw-nuts Z′ and Z^2 up or down, according as it is desired to increase or diminish the stroke of the pump-piston in the forcing-cylinder Y, whereby the quantity of oil supplied by the pipe X^2 to the vaporizer may be regulated. As has been explained, the pressure of the oil against the valve I^2 when the pump-piston is on its downstroke opens the valve and the oil is forced in a thin stream or spray through the port i^5 into the vaporizer T and against the baffle-plate i^8. My baffle-plate is not designed and arranged, as in some prior devices, to scatter the fuel for admixture mechanically with atmospheric air. I have arranged my baffle-plate in the vaporizer between the oil-feed valve I^2 and the valve chest or box to which the atmospheric air is admitted through the air-valve g^9 in order that the oil may be thoroughly converted into gaseous vapor before it is commingled in the cylinder with the atmospheric air. The needle-like stream or jet flowing through the orifice i^5 distributes itself on the baffle-plate i^8 in very minute portions and covers the interior walls of the vaporizing-chamber T′ with a fine oil mist or spray, which insures almost instantaneous vaporization of the oil. I arrange this baffle-plate i^8 within the vaporizer-chamber so that its edges nearly touch the interior surfaces or walls of the vaporizer-chamber, as seen in Fig. 6, but do leave a small surrounding space, say about one thirty-second of an inch, between the parts, and by producing this narrow space within the vaporizer for the flow of the gaseous vapor into and through the valve chest or box to the working cylinder, and by quickly converting the oil into such gaseous vapor by breaking it up against the baffle-plate into a fine mist or spray and by bringing it into contact with the hot walls of the generator-chamber, the gaseous vapor is held back in check and accumulates under pressure in that part of the vaporizer T′ between the baffle-plate and the oil-feed valve I^2. The increased pressure of the gaseous vapor confined within the hot vaporizer T′ results in an increased temperature of oil particles thus vaporized, but the gaseous vapor is not ignited at a point in front of the baffle-plate because the air-valve g^9 is attached to the valve-chest back of the baffle-plate or at a point between the working cylinder and the baffle-plate, and said valve g^9 is kept closed until the pistons D D′ reach a certain point in their outward movement. As the pistons D D′ move outward and create the suction necessary to draw out the explosive charge the gaseous vapor in the vaporizer T′ is first drawn through the nipple g^5 and the valve chest or box into the comparatively cooled cylinder-space, where said gaseous vapor decreases in temperature and condenses at the same time, and when the pistons reach the desired points in their outward movements the automatic air-valve g^9 is opened and allows at this time the admission of atmospheric air into the cylinder when the cylinder is not fully filled with the gaseous vapor unmixed with air, so that the admixture of atmospheric air with the gaseous vapors takes place within the cylinder during the last portion of the outward movement of the pistons D D′.

By the described operation of excluding the admission of air to the working cylinder until after the gaseous vapors have filled the space between the trunk-pistons and not opening the air-valve g^9 until after the pistons have traveled a certain distance in their outward movement, so as to create a suction strong enough to overcome the resistance of the air-valve spring g, the gaseous vapor occupying the center of the working cylinder is mixed with a larger volume of air than the strata of gaseous vapor next the trunk-pistons D D′; and this operation secures an increased pressure when the charge is exploded over an equal admixture of gaseous vapor with air which in other types of explosive-engines is effected by commingling the gaseous vapor and air before the charge is admitted to the cylinder, with the result that the vapor is ignited and a portion of the charge is consumed before the charge is admitted to the cylinder, thus reducing the pressure secured in the cylinder by explosion of the charge and resulting in a certain amount of waste of the hydrocarbon used in developing the energy for operating the engine or motor.

In my improved gas-engine a vaporizer is used in which the liquid is converted into vapor and supplied to the working cylinder to partially fill the same before the air-valve is opened automatically or by suction created by the outward movement of the pistons to admit air to the gaseous vapor occupying the space between the pistons after said pistons have begun their outward movement and before they complete that outward movement.

My oil-feed valve and the air-valve are entirely automatic in their operation, the former being opened solely by the pressure of the fluid hydrocarbon injected under pressure against the same and into the vaporizer, and the latter valve operating automatically when the suction in the working cylinder is of sufficient power to overcome the resistance of the spring which normally holds the air-valve to its seat. The exhaust-valve g^{11} is positively and mechanically actuated by connections with the engine-shaft to open said exhaust-valve at the proper intervals of time.

The power generated by the motor can be regulated by adjusting the oil-feed pump, as heretofore described, to supply more or less liquid hydrocarbon to the vaporizer, and by regulating the resistance of the spring to the air-valve and by properly adjusting the controlling-spring and nuts on the piston-stem of the oil-pump I can produce with an engine having a working cylinder about six inches (6″) in diameter energy equivalent to that obtained from motors ranging from three to nine horse power.

My construction of the central tube A of the cylinder with its central part jacketed for cooling the hottest parts of the cylinder, with the longitudinal slots for guidance of the cross-head of one end, and with its opposite ends extended to support the bearings for the crank-shaft, enables me to materially reduce the weight of the motor, besides simplifying and cheapening the construction thereof.

I am aware that changes in the form and proportion of parts and in the details of construction herein shown and described as the preferred embodiment of my invention may be made by a skilled mechanic without departing from the spirit or sacrificing the advantages of my invention, and I would therefore have it understood that I reserve the right to make such modifications as fairly fall within the scope of my invention.

Having thus fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a gas-engine, the combination with a cylinder, of a valve-chest, a vaporizer communicating with said valve-chest and adapted to be heated, an oil-valve having a discharge-orifice opening into the chamber of said vaporizer, and the baffle-plate situated within said vaporizer and lying in the path of the jet of oil injected into the vaporizer from the oil-valve, for the purposes described, substantially as set forth.

2. In a gas-engine, the combination with a cylinder, of a valve-chest, the vaporizer communicating with the valve-chest, an oil-valve shell connected to the vaporizer and provided at its inner end with a plug having the oil-discharge orifice i^5 arranged to direct a jet of oil into the vaporizer-chamber, a valve fitted in the oil-valve shell, rods or stems attached to said oil-valve shell and extending into the vaporizer-chamber, the baffle-plate situated within the chamber of the vaporizer and attached to said fixed stems or rods, said baffle-plate lying in the path of the jet or stream of oil injected through the orifice i^5 and arranged within the vaporizer to leave a narrow space between the wall of the vaporizer and the edge of the baffle-plate, as and for the purpose described.

3. In a gas-engine, the combination with the power-shaft F, an oil-pump having a reciprocating piston, and an exhaust-valve, of a rotary member or gear b driven by the power-shaft F and provided with two cams, as c, d, a lever W lying in the path of one cam and arranged to actuate the piston of said oil-pump, another lever V lying in the path of the other cam, a rock-shaft having a finger which is adapted to open the exhaust-valve, and a rod connected to the lever V and to an arm on the rock-shaft, substantially as and for the purposes described.

4. In a gas-engine, the combination with a power-cylinder and oppositely-movable pistons therein, of a valve box or chest T applied centrally to and communicating directly with said power-cylinder, an independent chambered vaporizer-shell T′ adapted to be externally and internally heated and ap-

plied to and communicating with one end of said valve-box T, an oil-spraying device discharging to one end of said vaporizer-chamber, and an automatic air-admission valve g^9 carried by the valve-chest and arranged between the vaporizer and the power-cylinder, as and for the purposes described.

5. In a gas-engine, the combination with a power-cylinder and oppositely-movable pistons therein, of the valve-chest T applied centrally to and communicating directly with said power-cylinder, a vaporizer T′ carried by said valve-chest and provided with an oil-valve and with an internal baffle-plate, and the automatic air-admission valve mounted in the valve-chest between the power-cylinder and the vaporizer and opened only by the suction created by the outward movement of said pistons in the power-cylinder, as and for the purposes described.

6. In a gas-engine, the combination with a power-cylinder and oppositely-movable pistons therein, of a valve-chest T applied centrally to and communicating directly with said power-cylinder, a vaporizer T′ carried by said valve-chest and provided with an oil-valve and with an internal baffle-plate, a suction-operated air-admission valve g^9 mounted in one side of the valve-chest between the vaporizer and said cylinder, and a mechanically-actuated exhaust-valve g^{11} mounted in the opposite side of the valve-chest, as and for the purposes described.

In testimony whereof I affix my signature in presence of two witnesses.

EDUARD EUGENE LUDL.

Witnesses:
WM. H. KOOS,
JOSEPH F. MIESCHBERGER.