(No Model.)

4 Sheets—Sheet 1.

J. P. HOLLAND.

HYDROCARBON ENGINE.

No. 337,000. Patented Mar. 2, 1886.

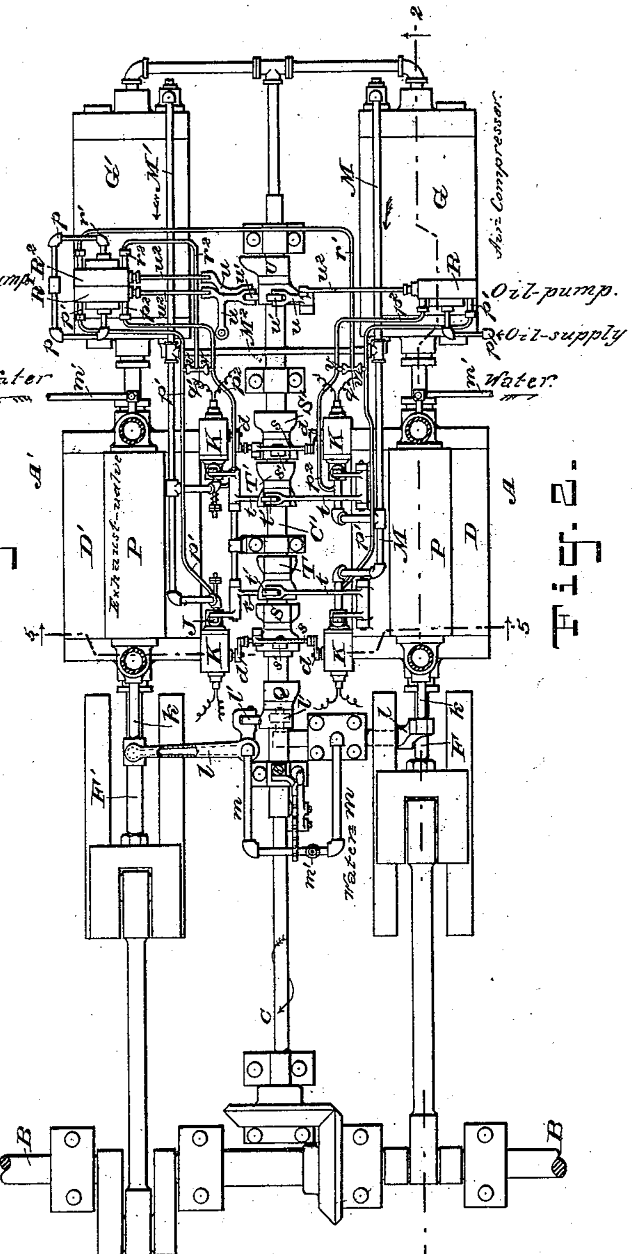

Fig. 1.

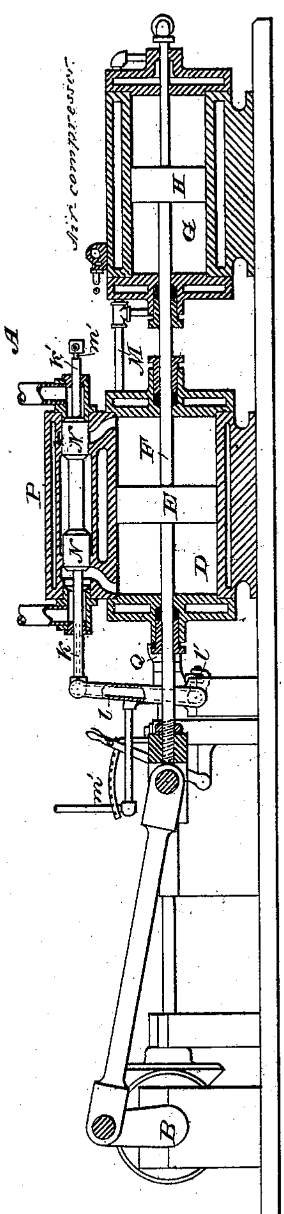

Fig. 2.

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Fig. 3.

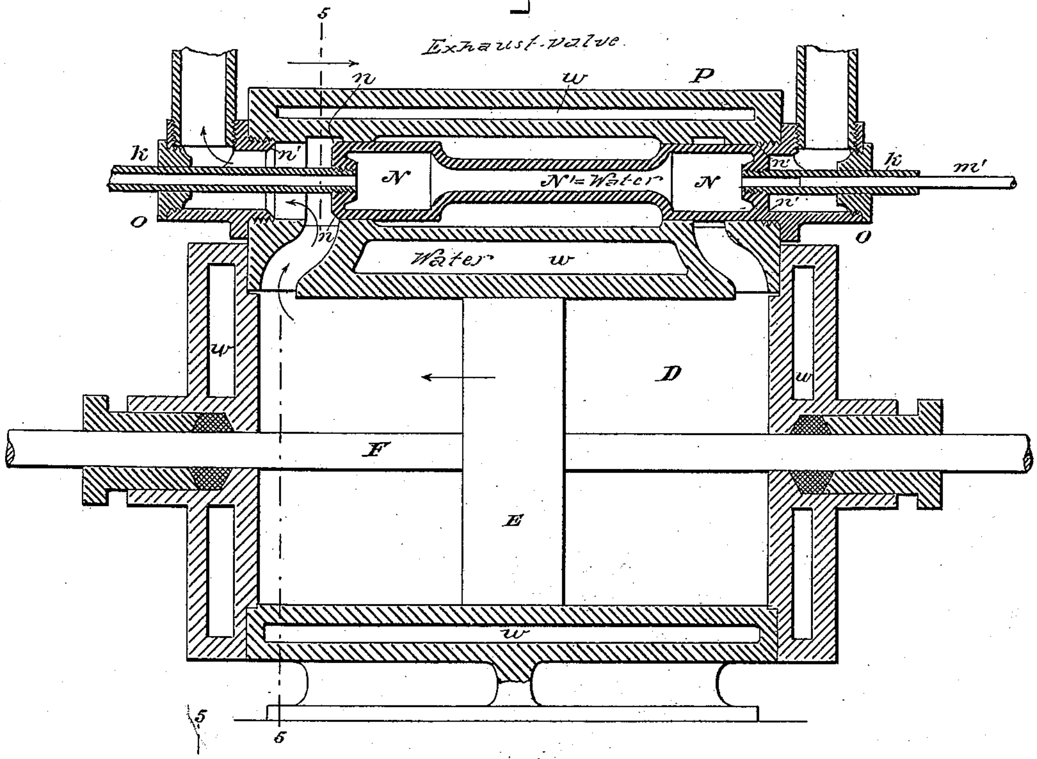
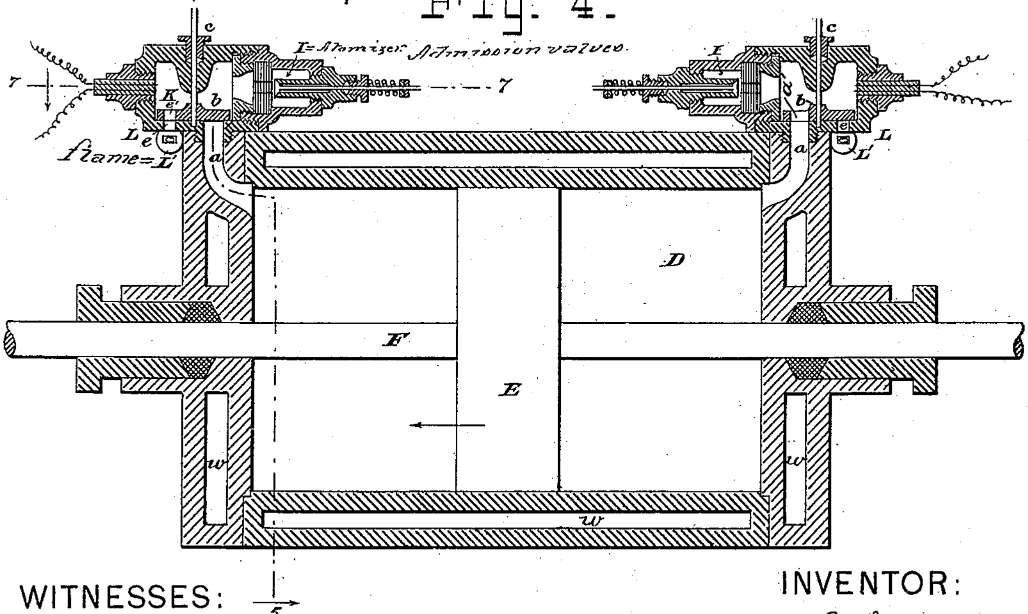


Fig. 4.



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(No Model.)

4 Sheets—Sheet 3.

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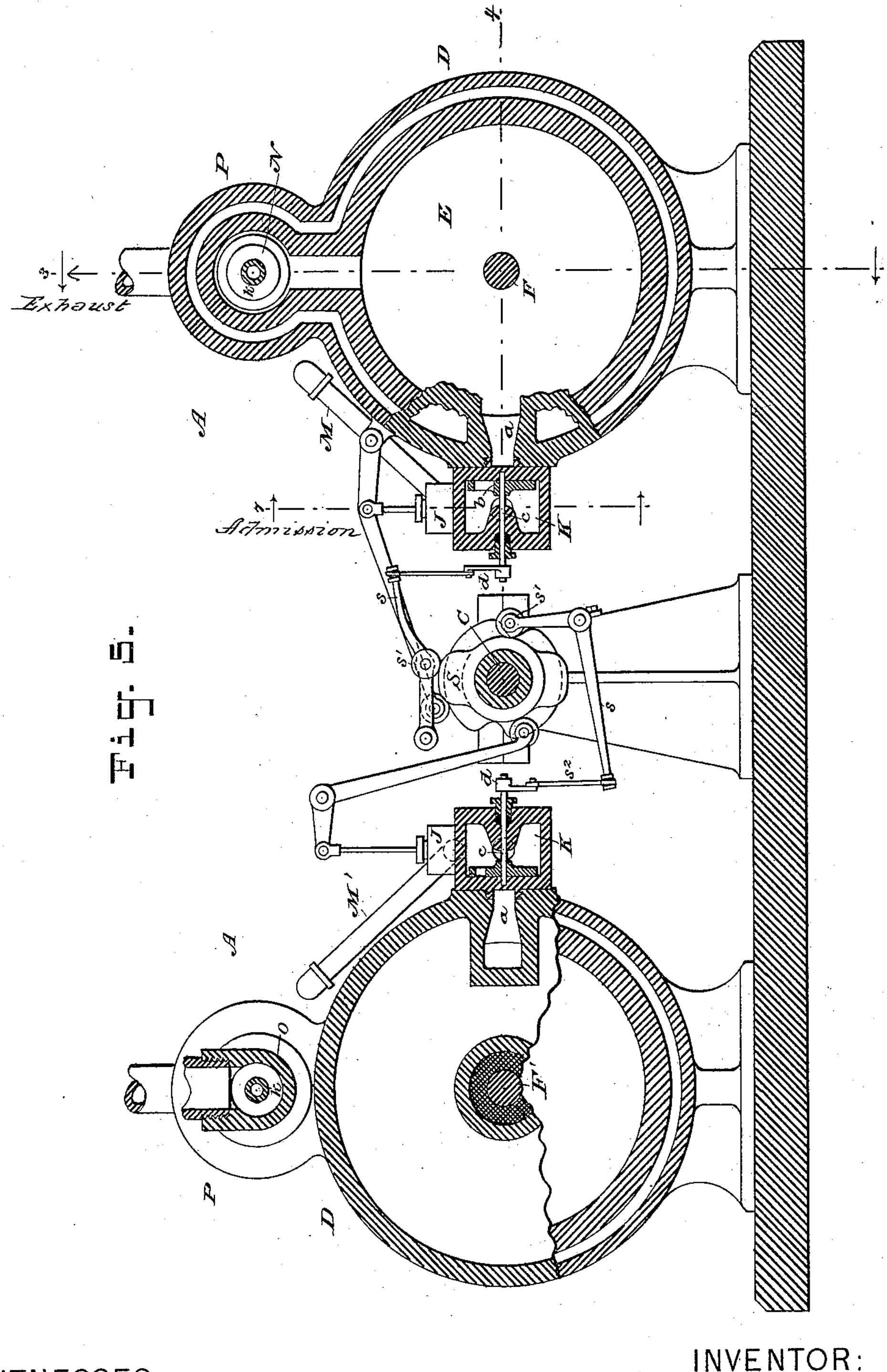

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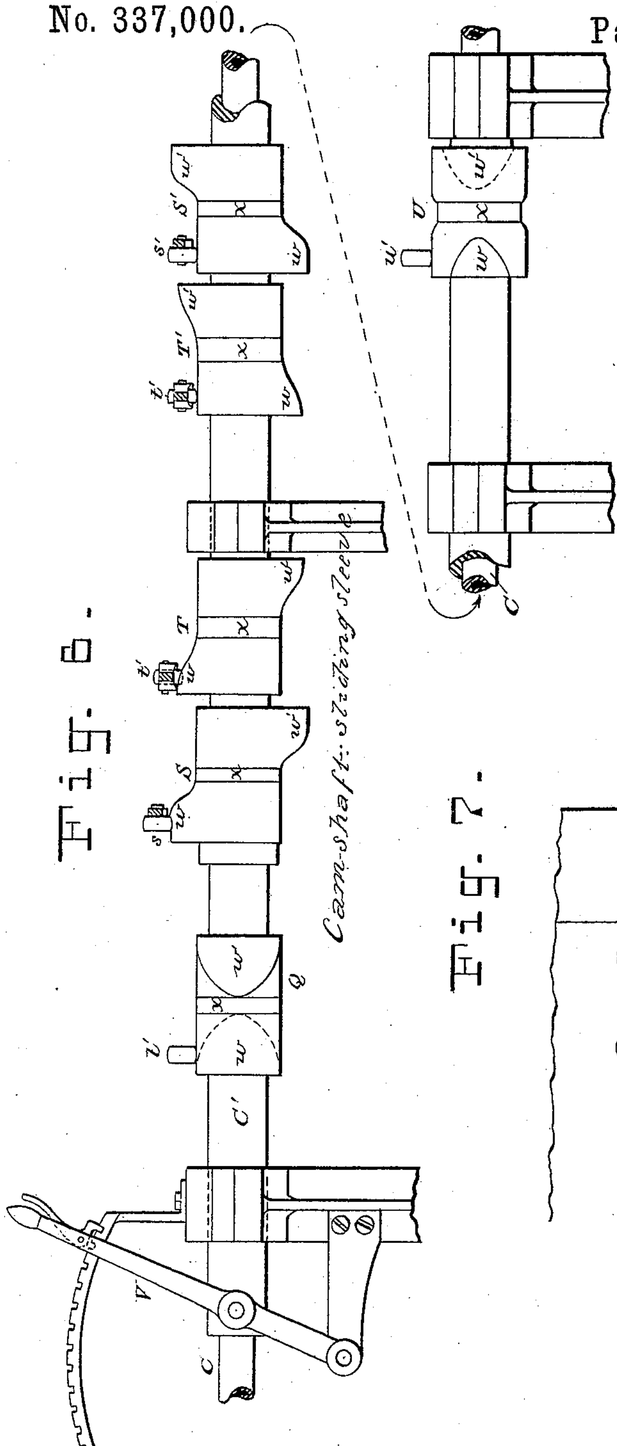

Fig. 6.

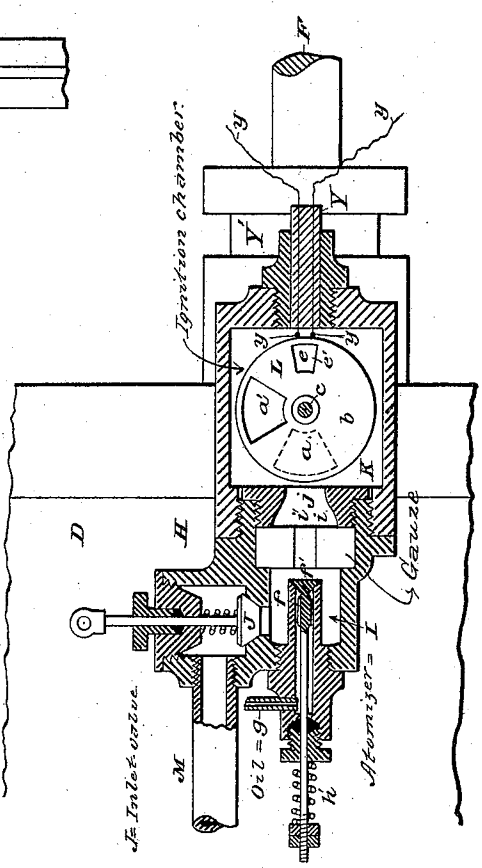

Fig. 7.

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UNITED STATES PATENT OFFICE.

JOHN P. HOLLAND, OF BROOKLYN, NEW YORK.

HYDROCARBON-ENGINE.

SPECIFICATION forming part of Letters Patent No. 337,000, dated March 2, 1886.

Application filed December 31, 1884. Serial No. 151,646. (No model.)

To all whom it may concern:

Be it known that I, JOHN P. HOLLAND, a citizen of the United States, residing in the city of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Hydrocarbon-Engines, of which the following is a specification.

The object of my invention is to produce a motor-engine, deriving its power from the combustion of hydrocarbons, which shall be economical, efficient, and reliable, not liable to stop unexpectedly, free from explosions and other jars and concussions, double-acting, and steady and continuous in its operation, and capable of being reversed and readily controlled in its speed and power.

To this end the improvements relate to various features of construction, most particularly the atomizer for spraying and introducing the hydrocarbon, the igniting device, the exhaust-valves, and the valve-operating mechanism.

The accompanying drawings are designed to show one type of engine constructed according to my invention, it being understood that the general arrangement of the elements of the engine and the application of my improvements may undergo such changes in form and construction as those to which engine-designs are commonly subjected.

Figure 1 is a plan of the engine, or rather of a pair of engines coupled to the same crank-shaft. Fig. 2 is a vertical longitudinal section through one of the engines, as denoted by the lines 2 2 in Fig. 1. Fig. 3 is a vertical section of the cylinder and exhaust-valve shown in Fig. 2, but on a larger scale. Fig. 4 is a horizontal section of one cylinder on the same scale as Fig. 3. Fig. 5 is a vertical transverse section, on the same scale, of both cylinders, cut through the inlet and exhaust ports, its general plane being denoted by the lines 5 5 in Figs. 1, 3, and 4. Fig. 6 is a side elevation, on the same scale, of the cam-shaft removed; and Fig. 7 is a vertical section, on a still larger scale, of one of the atomizers and igniters, cut in the plane of the line 7 7 in Figs. 4 and 5, and showing a portion of the cylinder in elevation.

For convenience the drawings show a stationary engine mounted on a bed-plate, although this particular engine was designed especially for propelling street-cars, and other similar purposes. For use as a motor for cars it will be suspended from the bottom of the car, instead of being supported from beneath. The general construction is much the same as that of any ordinary steam-engine. The two engines are coupled to cranks set one a quarter-revolution in advance of the other. Both engines are double-acting, receiving an impulse at each stroke of the piston in each direction, and exhausting the spent gases from one end of the cylinder while receiving power from the expansion of gases entering at the opposite end.

Let A A′ designate the respective engines, and B the crank-shaft and C the cam-shaft common to both. D D′ are the respective power-cylinders, E E′ the pistons, F F′ the piston-rods, G G′ air-compression cylinders, and H H′ the pistons thereof.

In the construction shown each piston-rod extends from the cross-head, where it connects with the usual pitman, through the power-cylinder and into the compression-cylinder, having both pistons fixed to it. At each end of each power-cylinder is a charging device, Fig. 4, which comprises an atomizer, I, an inlet-valve, J, Fig. 7, an ignition-chamber, K, and an igniter, L. The chamber K communicates with the end of the cylinder through an inlet-port, *a*, formed in the cylinder-head, as shown in Fig. 4. In it is arranged an oscillating disk-valve, *b*, mounted on a stem, *c*, bearing a crank, *d*. As shown in Fig. 7, this disk-valve has two holes or ports, *a′* and *e′*, set about ninety degrees apart, which coincide, respectively, with the cylinder-port *a* and an igniting-port, *e*, outside of which is arranged a lamp or gas flame, L′. The valve *b*, port *e*, and lamp L′ constitute the igniter L. The ports *a* and *e* are set at about one hundred and eighty degrees apart, so that in one position of the valve *b* its port *e′* coincides with port *e*, as shown in Fig. 7, and in its other position, after having oscillated ninety degrees, its port *a′* coincides with port *a*. One port is closed by the valve before the other begins to be opened.

The atomizer I consists of a device for spraying and vaporizing the oil or combustible liquid, and so combining it with a current of compressed air. The air is compressed in the compression-cylinder or air-pump G or G′, and is conveyed through pipes M M′ to the respective inlet-valves J J, as shown in Fig. 1. The inlet-valve is shown as a conical puppet-valve pressed to its seat by a spring, and closing the opening from a chamber into which the pipe M opens to the atomizer I. On lifting the valve the compressed air enters the atomizer-chamber. Projecting into the atomizer-chamber is a tube, *f*, into which oil enters through a pipe, *g*. The inner end of the tube *f* is coned, and in it fits a conical valve, *f*′, the stem *h* of which extends through the tube *f* out through a stuffing-box, and is provided with a strong spiral spring, *h*′, which acts to draw the valve *f*′ closely to its seat against considerable pressure. This construction is best seen in Fig. 7. In front of the valve *f*′ is a series of foraminous diaphragms, *i*, of wire-gauze or perforated metal, with preferably a central opening, *i*′, through them. In front of these diaphragms is a nozzle-piece, *j*, at the entrance to the chamber K.

The operation of these parts is as follows: While the gases in one end of the cylinder are being expelled through the exhaust during the return of the piston the inlet-valve J is closed and the disk-valve *b* is turned, as shown in Fig. 7. The oil entering through the pipe *g* is under sufficient pressure to cause a small quantity to press through the valve *f*′, and a small stream of air enters through a small hole formed through the valve J. The air and oil pass together through the heated diaphragms *i*, and the oil is vaporized, forming a combustible mixture, which fills the chamber K and flows out through the ports *e*′ *e*. It is then ignited by the lamp L′ and burns back into the chamber K, filling the latter with flame. At this instant the piston in the power-cylinder reaches nearly the end of its stroke, at the end of the cylinder supplied by this charging device, and begins to cushion, whereupon the disk-valve *b* is quickly oscillated, first closing the port *e* and then opening the port *a*. At about the same time the inlet-valve J is opened, which admits a strong current of compressed air into the atomizer, and simultaneously the pressure of the oil entering through pipe *g* is so much increased that it presses the valve *f*′ far enough open to escape through it in a conical spray of oil, which is cut by the impinging current of air and carried with the air through the heated diaphragms, being thereby vaporized, and entering the chamber K through the nozzle *j*. From the chamber it flows through the port *a* into the power-cylinder, igniting and carrying the flame with it, and by the expansion due to its rapid combustion as it enters the cylinder it exerts a powerful, uniform, and continuous pressure upon the piston until the inlet-valve J is closed. The valve will close sooner or later in the stroke, according to the amount of cut-off provided for by the valve-operating mechanism. After it has closed the small stream of air continues to flow through it, the same as before it was opened, and unites with the small stream of oil forced through the atomizer, as before, the vapor burning in the cylinder, and after the piston reaches the farther end of the stroke, and the exhaust-valve at this end of the cylinder is opened, its products escape freely through the exhaust. This continues until about mid return-stroke of the piston, when the disk-valve *b* is oscillated back to its first position again, in order to open the ignition-port and insure the reignition of the vapor. Thus the igniter is open during one quarter, or less, of one revolution of the engine, and during the remainder of the time the chamber K is in communication with the cylinder. A stream of vapor is always flowing through the chamber K, the stream being largely augmented during the period of impulse upon the piston, and the remainder of the time being only sufficient to insure a preservation of the flame.

It will readily be understood that after the engine was once started the ignition might in this manner be maintained without employing any relighting device, and this, in fact, is the case; but I provide the relighting device in order to insure against the accidental blowing out of the flame, which might cause the stoppage of the engine. I have provided an additional means of relighting by means of an electric spark, which may be employed in connection with the flame L′, or in substitution therefor. Of this device I have shown only the electric igniting-wires, (lettered *y y*,) which enter the chamber K through a plug, Y, of insulating material, confined in a head, Y′, which is screwed into the wall of the chamber K. The wires *y y* have platinum tips, between which the spark passes, and they are connected, respectively, to opposite terminals of a battery, a magneto-electric machine, or an induction-coil, and the circuit of which they form a part will be provided with suitable means for breaking and closing it at the proper instant in the revolution of the engine, in order to cause sparks to pass between the points of the wires *y y* at the time for insuring the ignition of the vapors in the chamber K.

The exhaust-valves (shown best in Fig. 3) are a combination of piston and puppet valves. They consist of a single pair of piston-valves, N N, working in a cylindrical chamber, P, formed along the top of the power-cylinder. The pistons N N are hollow, and are connected by a tubular stem, N′, which may be formed in one casting with them, or they may be cast in two separate castings and joined to the tube N′. The pistons N N have conical ends *n n*, which form puppets and fit against conical seats *n*′ *n*′, formed on the cages O O. The exhaust-pipes extend out from these cages to convey away the exhaust products which flow through the seats *n*′. The power-cylinder and the valve-chamber P are both surrounded by a water-jacket, *w*, through which a stream of water is kept flowing to cool them, and a stream of water is caused to pass through the valves N N and their connecting-stem N′, in order to keep them cool enough to prevent burning or sticking on account of the high temperature to which they are exposed. The valves are operated through a hollow valve-stem, *k*, and the stems *k k* of the respective valves are jointed to the ends of levers *l l*, the opposite ends of which bear rollers *l′ l′*, which run on the surface of a cam, Q, mounted on the shaft C. This cam causes each pair of exhaust-valves to move from one end of their stroke to the other at each stroke of the piston, so that the exhaust will close in advance of the piston the instant before it completes its stroke, and thereby cushion it, and by the continued movement of the valves the other end of the cylinder will be opened to the exhaust before the piston begins its return-stroke. The water for cooling the exhaust-valves enters by a pipe, *m*, to the bearings of the levers *l l*, enters the journals of these levers, which are made tubular, flows through the long arms of the levers, and enters through a hollow joint into the valve-stems *k k*, through which it flows to the valves, and from the valves it passes out through tubular stems *k′ k′* at their opposite ends, escaping through stationary pipes *m′ m′*, which enter and slide in the stems *k′*. The air-pump or compression-cylinders G G′ are also provided with water-jackets, and the air-pipes M M′, leading from them, are connected together by a cross-pipe, M^2, to equalize the pressures. The oil which is forced under pressure through the atomizer is supplied by three oil-pumps, R, R′, and R^2. Each pump R R′ draws in oil from a reservoir (not shown) through a pipe, *p*, and expels it on the forward stroke through a pipe, *p′*, and on the return-stroke through another pipe, p^2. The pump R^2 also draws in oil through a pipe, *p*, and expels it through two opposite pipes which are lettered *r′* and r^2. Thus the pipes *p′* and p^2 convey charges alternately, and they are connected, respectively, to atomizers at opposite ends of one power-cylinder, entering each atomizer at *g*, Fig. 7. The pipes *p′* p^2 from the pump R lead to the atomizers of the cylinder D, while those pipes from the pump R′ lead to the atomizers of the cylinder D′. It is while the charges from these pumps are entering the atomizers that the valves *f′* of the latter are pressed open far enough to discharge a spray of oil, as described, and at the same time the inlet-valve J is opened and the compressed air enters. The small quantity of oil which forces its way into each atomizer during the return-stroke or exhaust from its end of the cylinder, in order to secure ignition and maintain the flame until the inlet-valve is opened, is supplied by a third pump, R^2, the pipes *r′* and r^2 from which extend, respectively, to short cross-pipes *q* and *q′*. The pipe *q* connects the two pipes *p′* and p^2 leading from pump R, to atomizer of cylinder D, and the pipe *q′* connects the pipes *p′* and p^2, leading from pump R′, to atomizers of cylinder D′. Each pipe *q q′* contains two check-valves, *v v*, each arranged between where the pipe *r′* or r^2 from pump R^2 joins it, and where it joins the respective pipes *p p′*, both valves closing toward the former. Thus oil may flow from the pipe *r′* or r^2 into either pipe *p′* or p^2, but oil cannot flow from either pipe *p′* or p^2 into the other or into the pipe *r′* or r^2. The pumps R and R′ are set one a quarter-revolution in advance of the other, corresponding to their respective engines A A′ and the pump R^2 is set one-eighth of a revolution in advance of or behind either of the pumps R or R′, so that while one of the latter pumps is at end stroke and the other is at mid-stroke the pump R^2 will be at quarter-stroke. It then is supplying oil to the atomizers in connection with the pump which is at end stroke, and on its return-stroke it will supply oil to the atomizers connected with the other pump, thus forcing a small quantity of oil through each atomizer during the period when the latter is not receiving oil from its own pump.

The exhaust-valves N N, the inlet-valves J J, the oscillating disk-valves *b b*, and the pumps R, R′, and R^2 are all operated from a series of cam-cylinders fixed on the shaft C, or rather on a sliding sleeve, C′, feathered on this shaft. The exhaust-valves are worked by a cam-cylinder, Q, as already described. The valves *b b* at opposite ends of the cylinders are worked by cam-cylinders S S′, respectively, through levers *s s*, bearing rollers *s′ s′*, and connected through pitmen s^2 s^2 with the respective cranks *d d*. As the rollers *s′ s′* rise and fall on the cams S S′ the cranks *d d* are oscillated through an arc of about ninety degrees. The inlet-valves J J at opposite ends of the cylinders are worked, respectively, by cam-cylinders T T′, through levers *t t*, bearing rollers *t′ t′*, and connected directly to the valve-stems, which they lift and drop. The pumps R, R′, and R^2 are all worked by a cam-cylinder, U, through levers *u u*, bearing-rollers *u′ u′*, and connected to the piston-rods u^2 u^2 of the respective pumps.

The cam-cylinders Q, S S′, T T′, and U (shown best in Fig. 6) have each two cams or projections, *w w′*, formed upon them on diametrically-opposite sides, and on opposite sides of a vacant space or zone *x*, which extends radially around each cam-cylinder. One set of cam projections *w w w* are so arranged relatively to the rollers *l′*, *s′*, *t′*, and *u′* that when the sliding sleeve C′, upon which all the cam-cylinders are keyed, is moved so as to place them under these rollers the engine will work forward, and when the sleeve C′ is moved in the other direction, so as to bring the cam projections *w′ w′ w′* under these rollers, the engine will work backward. When the sleeve is placed in an intermediate position, so as to bring the neutral bands *x x x* under the respective rollers, the engine will stop, because the cam projections cannot touch the rollers, and the valves consequently are not moved.

The cam projections w and w' on the cam-cylinders T T' and U are formed to rise gradually from the neutral zone x, so that they are highest toward the end of the cam-cylinders. Thus the farther the sleeve C' is moved in either direction from its neutral or middle position the higher will the several rollers be lifted, the wider will the inlet-valves be opened, and the longer stroke will the oil-pumps make, thus admitting richer charges of combustible vapor to the cylinders. Thus it is evident that the position of the several cams with reference to the rollers determines the direction of motion of the engine and both its speed and the power it develops. When a governor is to be used, it will be applied on the shaft C, and will act to draw the sleeve C' in one direction or the other, according as the speed varies. I have shown only a starting and reversing lever, V, in connection with a quadrant, which lever engages the sleeve C' and serves to slide it longitudinally on the shaft C.

My improvements remedy the chief defects to which engines employing gas, petroleum, or other hydrocarbons have proved themselves to be more or less liable—that is to say, to stopping without apparent cause, to heavy shocks which cause excessive wear, and finally disable the machine, to occasional difficulty in starting, to failure of the power, even though the ordinary amount of combustible be injected, and to explosions, which are liable to destroy the engine.

Besides remedying the above defects, the engine provided with these improvements can have a charge of combustible burned and expanded in each end alternately—making it double-acting—thus reducing both the weight and bulk of the machine as compared with gas-engines. Unlike them, it is as well adapted to the largest as to the smallest powers. Unlike them, also, there is never any combustible charge held unburned in the machine. The charge is not forced into a special chamber and then burned all together, but it is forced in gradually, like steam into the cylinder of a steam-engine, and it is mixed, burns, and expands as it enters, thus avoiding the heavy shocks and strains to which said engines are subjected, and rendering explosions impossible.

The particular advantages due to each one of these improvements and to their combination may be pointed out.

The atomizing device renders it possible to employ kerosene and heavy crude petroleum in the engine, instead of the lighter oils hitherto employed.

On account of the sliding motion of the exhaust-valve and its peculiar design, the defective action of the common puppet exhaust-valve, which produces shocks and stoppage, is prevented. The water passing through it keeps it cool enough to prevent burning and warping—the ordinary cause of failure of power and of difficulty of starting in petroleum-engines. It is also perfectly balanced.

Destructive explosions, due to late firing, are prevented by causing the igniter to act only at the beginning of each stroke.

Besides the advantage, already noted, of having no combustible charge present, either in the engine or in a reservoir, the two double-action air-pumps delivering compressed air into the same tube leading directly to the atomizing devices, dispense with the compressed-air reservoir, from which the charges of air are drawn to supply the burners in petroleum-engines.

One of the chief advantages of this combination of atomizers, igniters, valve and regulating apparatus is that the engine is capable of being reversed, which operation has not so far been possible in petroleum or gas engines.

It will readily be understood that my invention is susceptible of considerable modification without departing from its essential features. As instances of such modifications I may mention the following:

In lieu of variable-stroke oil-pumps but a single pump may be used, pumping into a reservoir of oil under pressure, and each atomizer will be provided with an oil-valve, which will admit a small stream of oil to leak through, and which valves will be opened to admit a larger stream of oil by cams corresponding to the cam-cylinder U.

The chambers K K and valves b b may be omitted, and the atomizers I I may discharge the vapor directly into the clearance in the ends of the cylinder, in which case the electric-lighting wires will be arranged in the cylinder.

The exhaust-valves may be made independent of each other, with a divided tubular stem through one passage, in which water will enter the valve, and through the other passage of which it may flow out.

The exhaust-valves may be operated by eccentrics on the crank-shaft, like the slide-valves of an ordinary steam-engine, instead of being operated by cams.

My engine may be run by inflammable gas, instead of oil, by supplying the gas to the atomizer under sufficient pressure, which may be attained by means of the pumps R R' R². The atomizers will in that case answer admirably for effecting a thorough mixture of the gas with the compressed air. There will be no explosion, as with gas-engines now used, but a uniform and steady expansion as the inflammable mixture flows in and burns.

For burning hydrocarbon oils the use of my engine is not confined to the lighter products, but it is well adapted also to burning the heavier illuminating-oils.

I claim as my invention—

1. In a hydrocarbon-engine, the combination, with the power-cylinder, of a compressed-air passage communicating therewith, means for compressing air into said passage, and an atomizer consisting of a contracted space or

opening entering said passage, and means for forcing the charge of combustible through said opening into the compressed-air passage, whereby the combustible is sprayed or finely divided and intimately mingled with the compressed air, substantially as set forth.

2. In a hydrocarbon-engine, the combination, with the power-cylinder, of a compressed-air passage communicating therewith, means for compressing air into said passage, an atomizer consisting of a contracted space or opening entering the compressed-air passage, means for forcing the charge of combustible under pressure through such opening into the compressed-air passage, and a series of foraminous diaphragms arranged to obstruct said passage between the atomizer and the entrance to the cylinder, whereby the spray of combustible from the atomizer is carried by the air-current into the diaphragms, and is thereby vaporized, substantially as set forth.

3. In a hydrocarbon-engine, the combination, with the power-cylinder, of a compressed-air passage communicating therewith, means for compressing air into said passage, an atomizer consisting of an opening entering said air-passage, a spring-seated valve closing said opening, and means for forcing the charge of combustible under pressure through said opening against the yielding side of said valve, whereby the valve is forced open and the combustible is discharged in a finely-divided condition into the air in said passage, substantially as set forth.

4. In a hydrocarbon-engine, the combination, with the power-cylinder, of an inlet-port at one end thereof, an ignition-chamber communicating with said port, a compressed-air passage entering said chamber, means for compressing air into said passage, an atomizer consisting of a contracted space or opening entering said compressed-air passage, and means for forcing the combustible under pressure through said opening into the compressed-air passage, and a series of foraminous diaphragms arranged to obstruct said passage between said atomizer and ignition-chamber, substantially as set forth.

5. The combination of power-cylinder having inlet-port *a*, chamber K, having ignition-port *e*, valve *b*, having ports *a'* and *e'*, atomizer I, and compressed-air-inlet valve J, substantially as set forth.

6. In a hydrocarbon-engine, the combination, with the power-cylinder, of a cylindrical exhaust-valve chamber formed longitudinally upon one side thereof, with exhaust-ports opening into said chamber from opposite ends of the cylinder, of exhaust-valves consisting of two hollow pistons working in opposite ends of said chamber and connected together by a tubular stem, with a hollow valve-stem passing out through a stuffing-box in the end of the valve-chamber, and means for forcing a stream of water to flow through said stems and pistons, whereby the pistons are kept cool and their expansion and consequent sticking are avoided, substantially as set forth.

7. In a hydrocarbon-engine, the combination, with the power-cylinder, of an exhaust-valve therefor, consisting of a pair of piston-valves adapted to move longitudinally and to seat themselves alternately on fixed seats, in the manner of puppet-valves, substantially as set forth.

8. In a hydrocarbon-engine, the combination of the power-cylinder, independent inlet-valves communicating with its opposite ends, the longitudinal exhaust-valve chamber P, and exhaust-ports leading thereto from the opposite ends of the cylinder, an exhaust-valve consisting of balanced pistons N N, adapted to close said exhaust-ports alternately, connected both to one valve-stem and adapted to be moved longitudinally, and mechanism for shifting said valve at each end of the stroke of the piston independently of the inlet-valves, substantially as set forth.

9. In a double-acting hydrocarbon engine, the combination, with the power-cylinder, of an atomizer at each end thereof, a pump for forcing the hydrocarbon into said atomizers, two delivery-pipes from said pump, one leading to one and the other to the other atomizer, and means for operating said pump synchronously with the strokes of the engine, whereby it forces the hydrocarbon alternately through said pipes to said atomizers, whereby alternate charges of combustible are supplied to opposite ends of the cylinder, substantially as set forth.

10. The combination, with two double-acting hydrocarbon-engines coupled to the same crank-shaft, one in advance of the other, of an atomizer at each end of the cylinder of each engine, two oil-pumps, each arranged to supply on alternate strokes the atomizer of one engine, and a third oil-pump, with its delivery-pipes joining the delivery-pipes from the two other pumps and adapted to supply oil to the respective atomizers during the periods when they are not supplied by the other pumps, substantially as and for the purposes specified.

11. In a hydrocarbon-engine, the combination of the independent inlet-valves communicating with opposite ends of the power-cylinder, the alternately-acting exhaust-valves independent of the inlet-valves, and the pump or pumps for injecting the charges of combustible, with a cam-shaft and the several cams thereon for operating the said valves and pump or pumps, each of said cams being formed with cam projections adapted to operate said valves and pump in proper succession, and the cams for operating the inlet-valves and pump or pumps having projections graduated or tapered from end to end, whereby the longitudinal displacement of the cams alters the throw or duration of opening of the inlet-valves and the stroke of the pump or pumps, and with means under the control of the op-

erator for longitudinally displacing the said cams simultaneously, substantially as set forth, whereby the cut-off and the amount of the combustible charges are varied simultaneously and to like extent for controlling the engine.

12. In a hydrocarbon-engine, the combination of independent inlet-valves communicating with opposite ends of the power-cylinder, the alternately-acting exhaust-valves independent of the inlet-valves, and the pump or pumps for injecting the charges of combustible with the cam-shaft, and the several cams thereon for operating said valves and pump or pumps, each of said cams being formed with diametrically-oppositely-arranged cam projections *w* and *w'*, and a longitudinally-intermediate neutral zone or space, *x*, and all of said cams being capable of simultaneous longitudinal displacement, thereby actuating the several valves and the pump or pumps in opposite succession and causing the engine to reverse its movement, and with a reversing mechanism under the control of the operator for longitudinally displacing the said cams, substantially as set forth.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

JOHN P. HOLLAND.

Witnesses:

ARTHUR C. FRASER,
HENRY CONNETT.