(No Model.)

4 Sheets—Sheet 1.

G. B. BRAYTON.

HYDROCARBON ENGINE.

No. 432,260. Patented July 15, 1890.

Fig. 1.

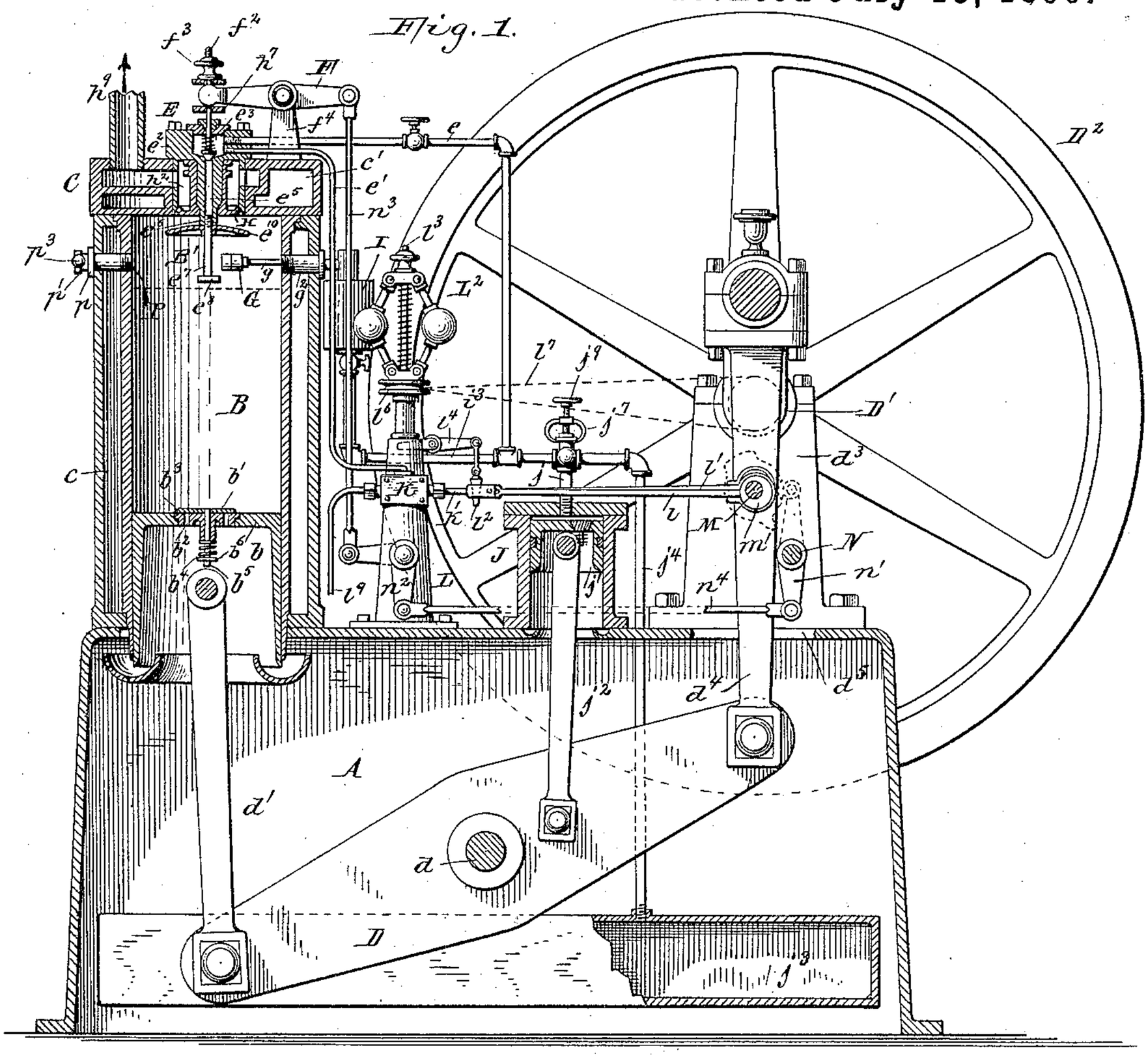
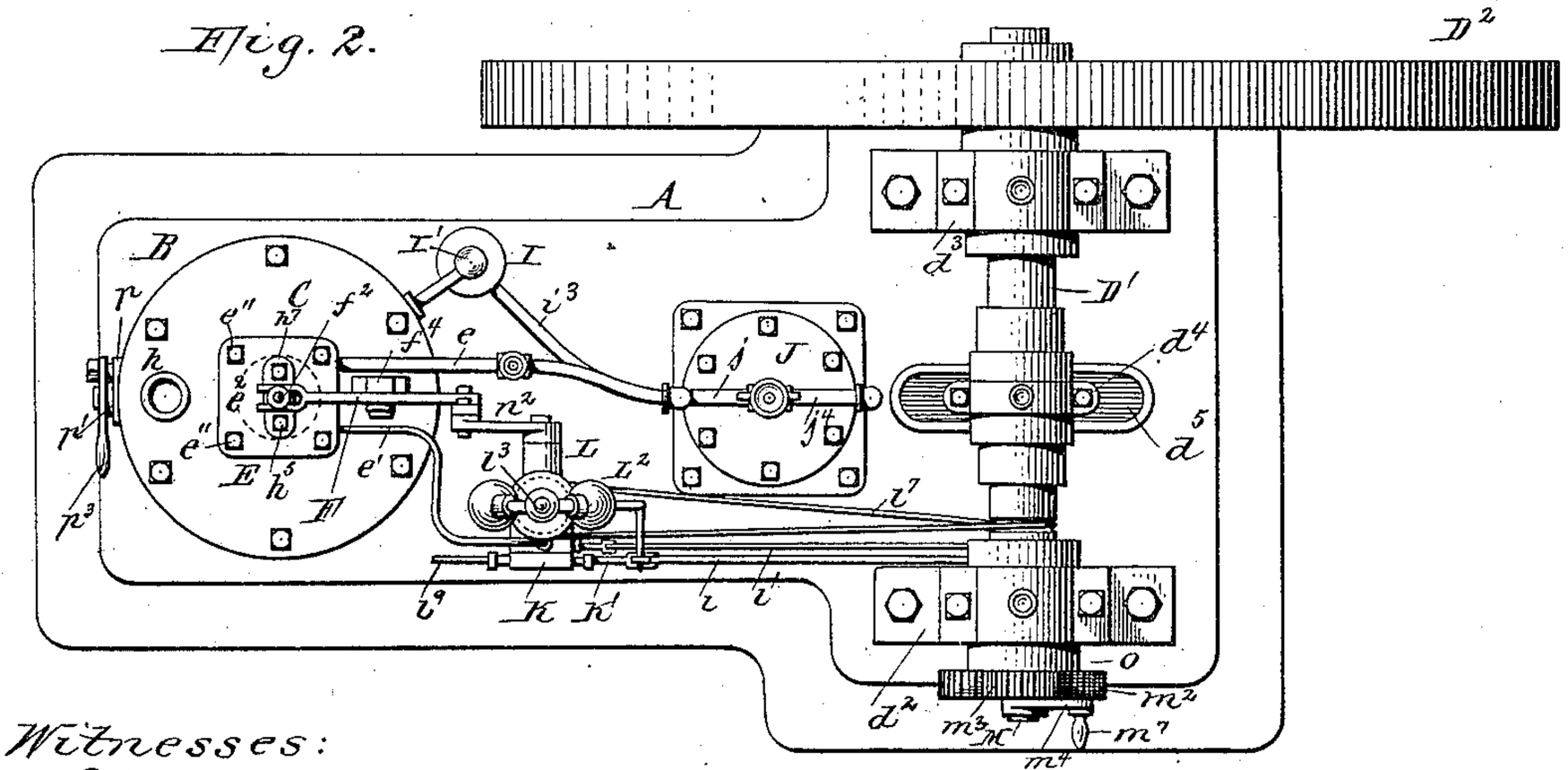


Fig. 2.



Witnesses:
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(No Model.) 4 Sheets—Sheet 2.

G. B. BRAYTON.

HYDROCARBON ENGINE.

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Fig. 3.

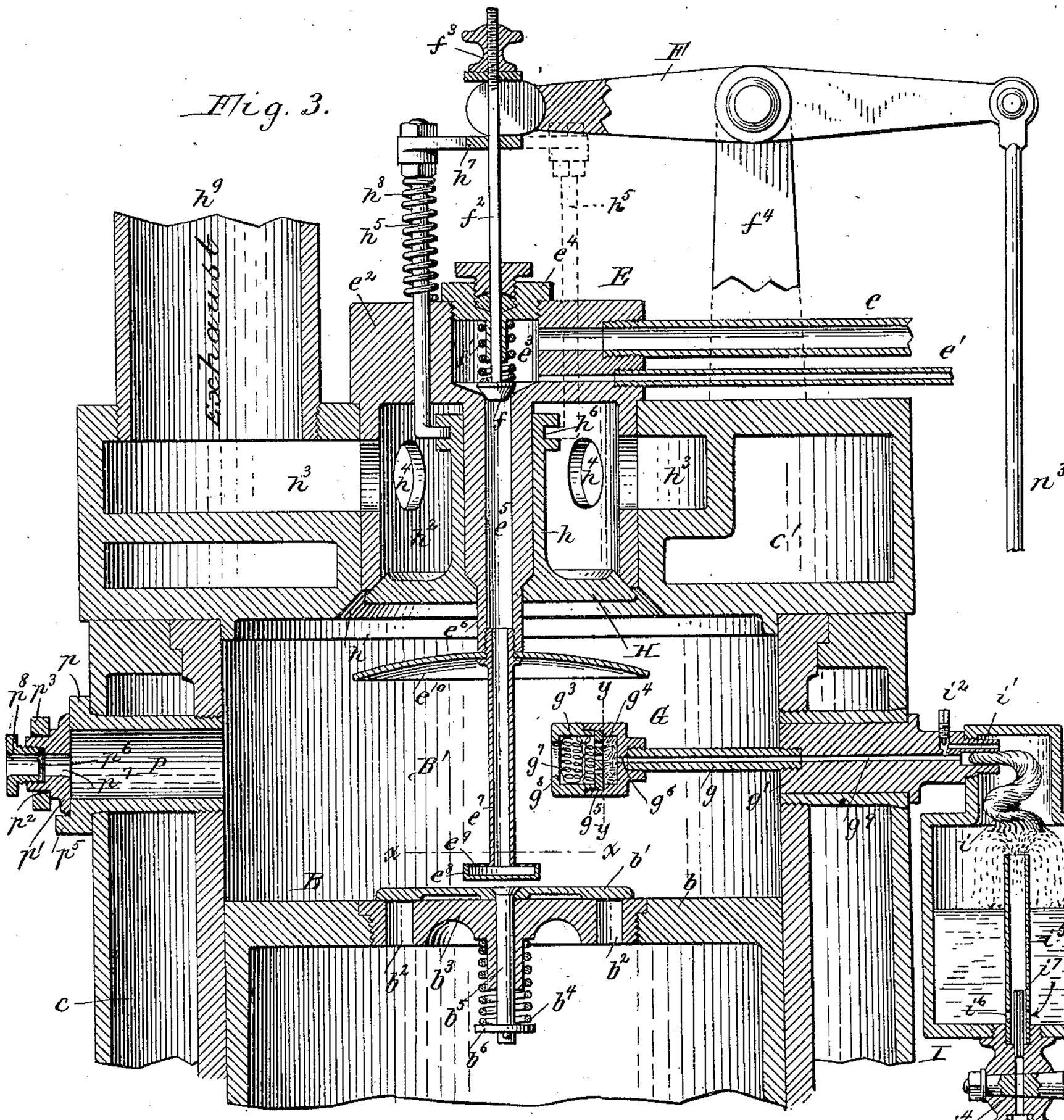


Fig. 4.

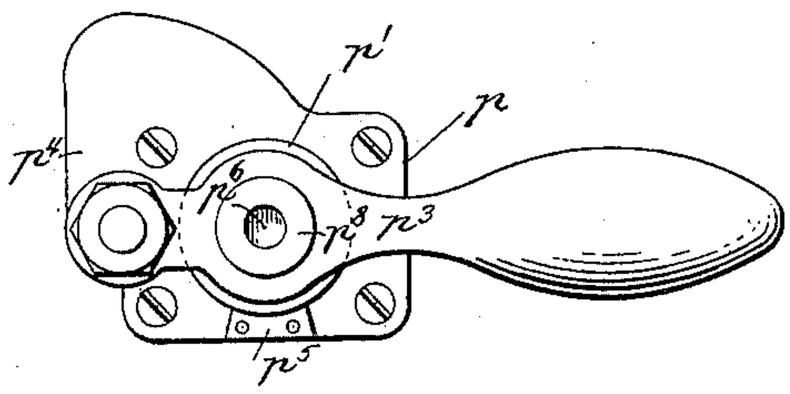


Fig. 5.

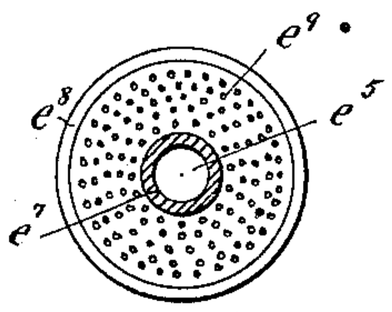
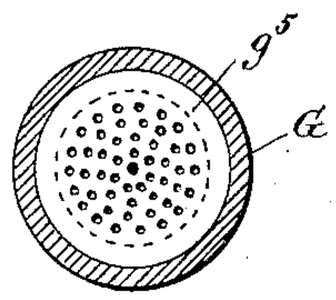


Fig. 6.



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(No Model.) 4 Sheets—Sheet 3.

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HYDROCARBON ENGINE.

No. 432,260. Patented July 15, 1890.

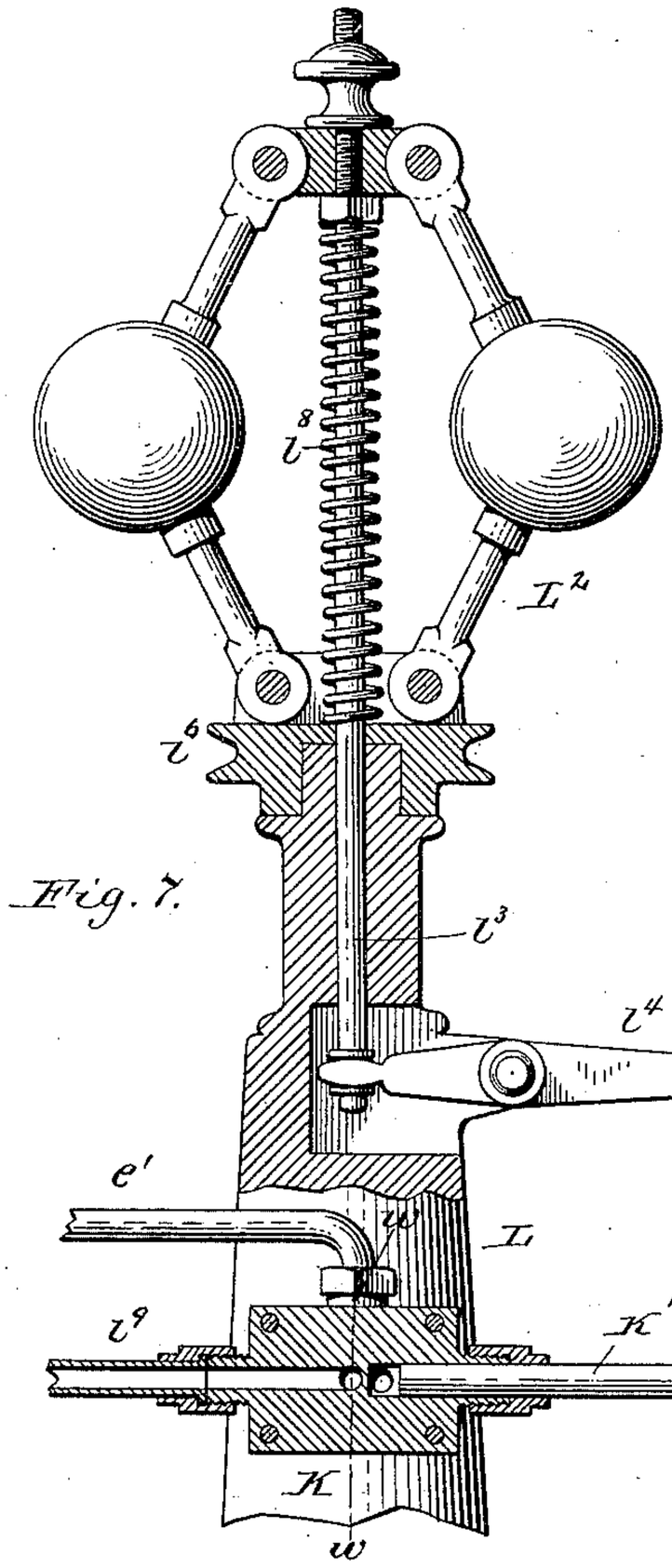


Fig. 7.

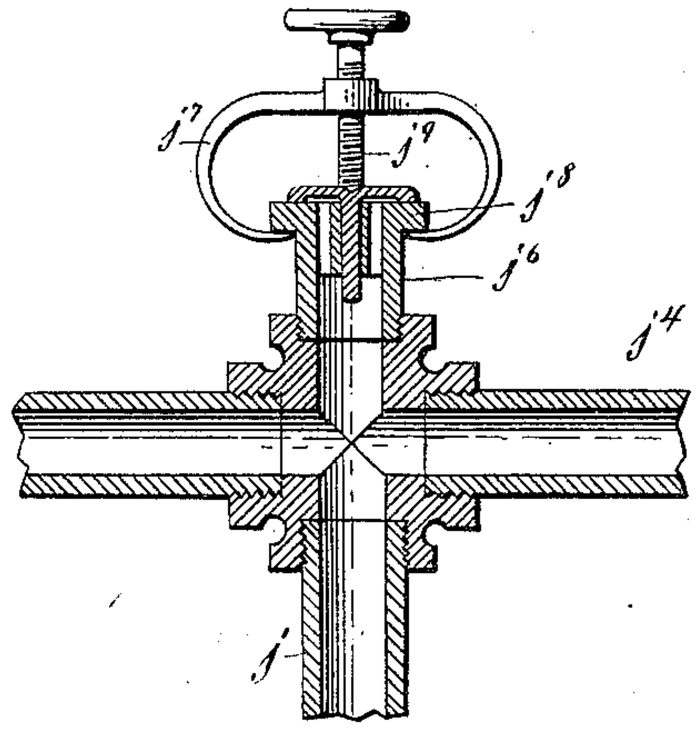


Fig. 9.

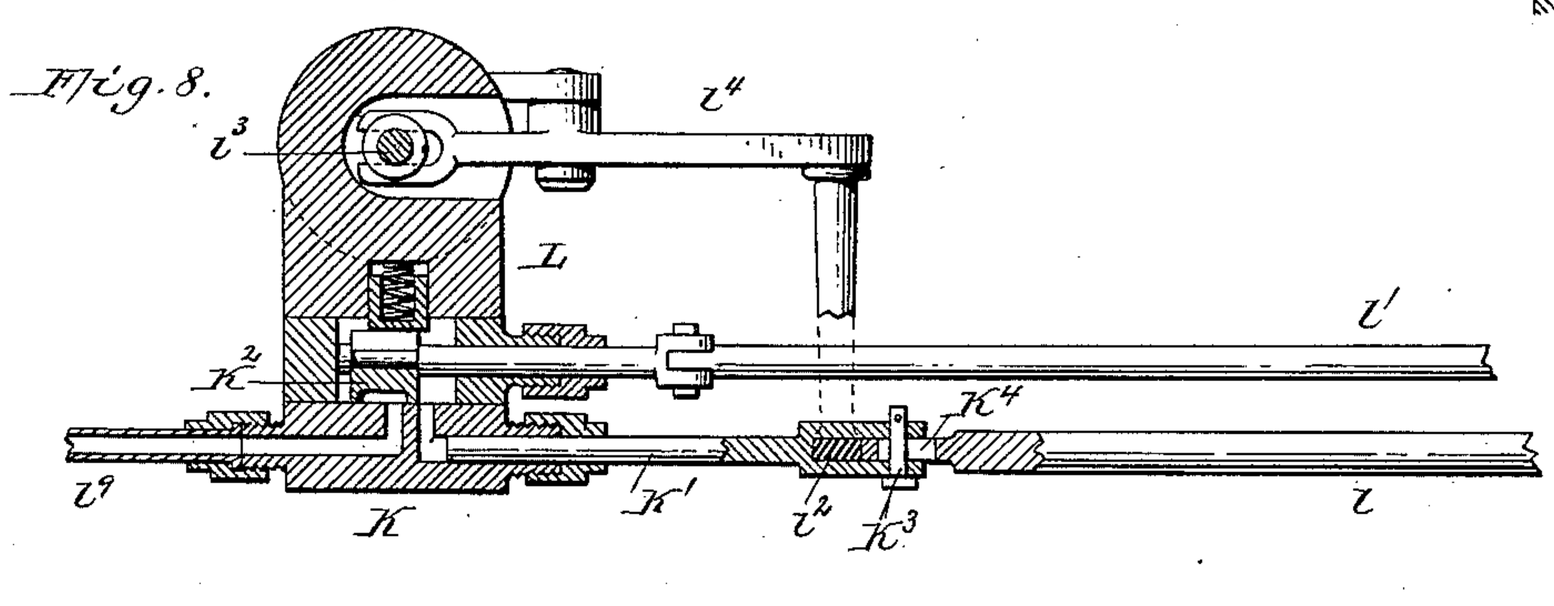
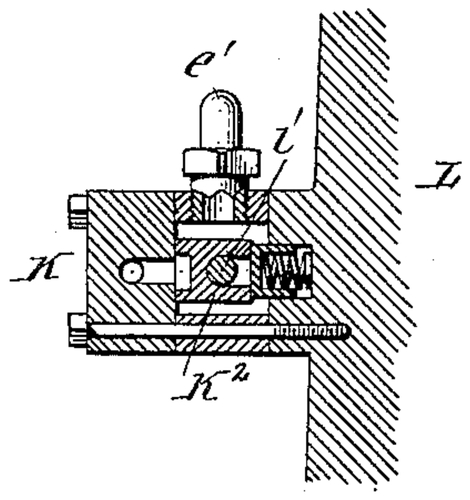


Fig. 8.



Witnesses:
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(No Model.) 4 Sheets—Sheet 4.

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HYDROCARBON ENGINE.

No. 432,260. Patented July 15, 1890.

Fig. 11.

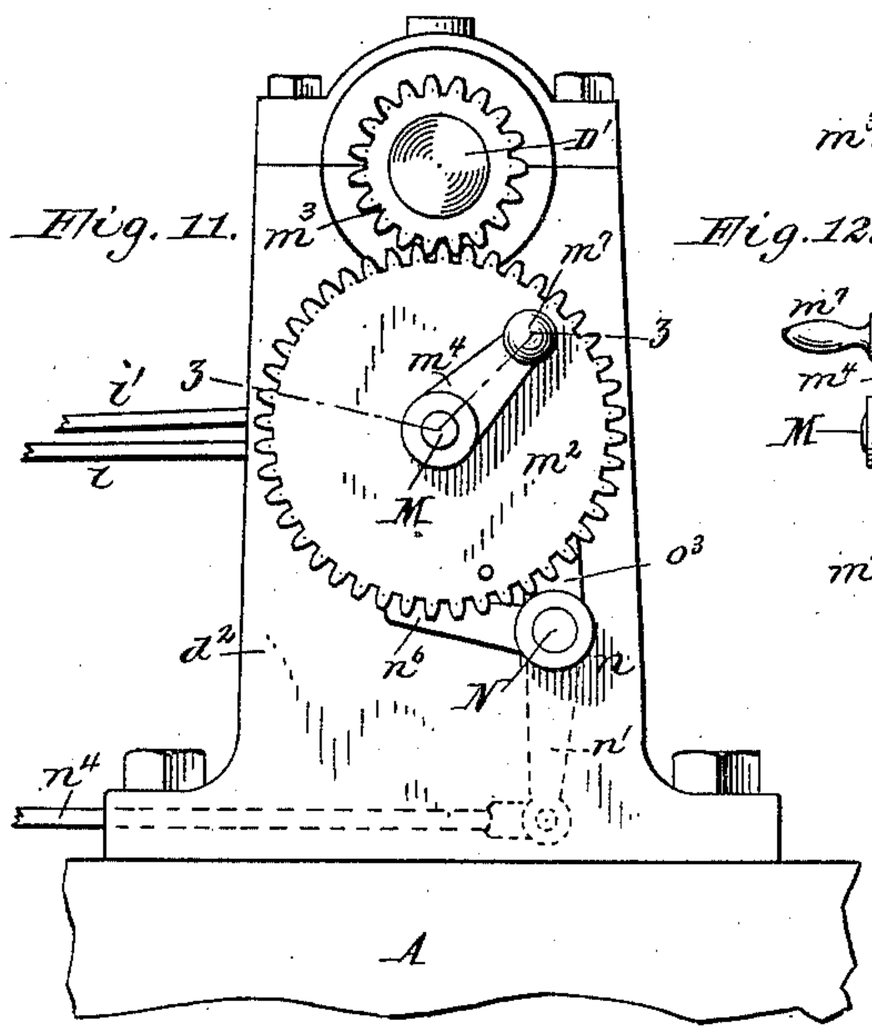


Fig. 12.

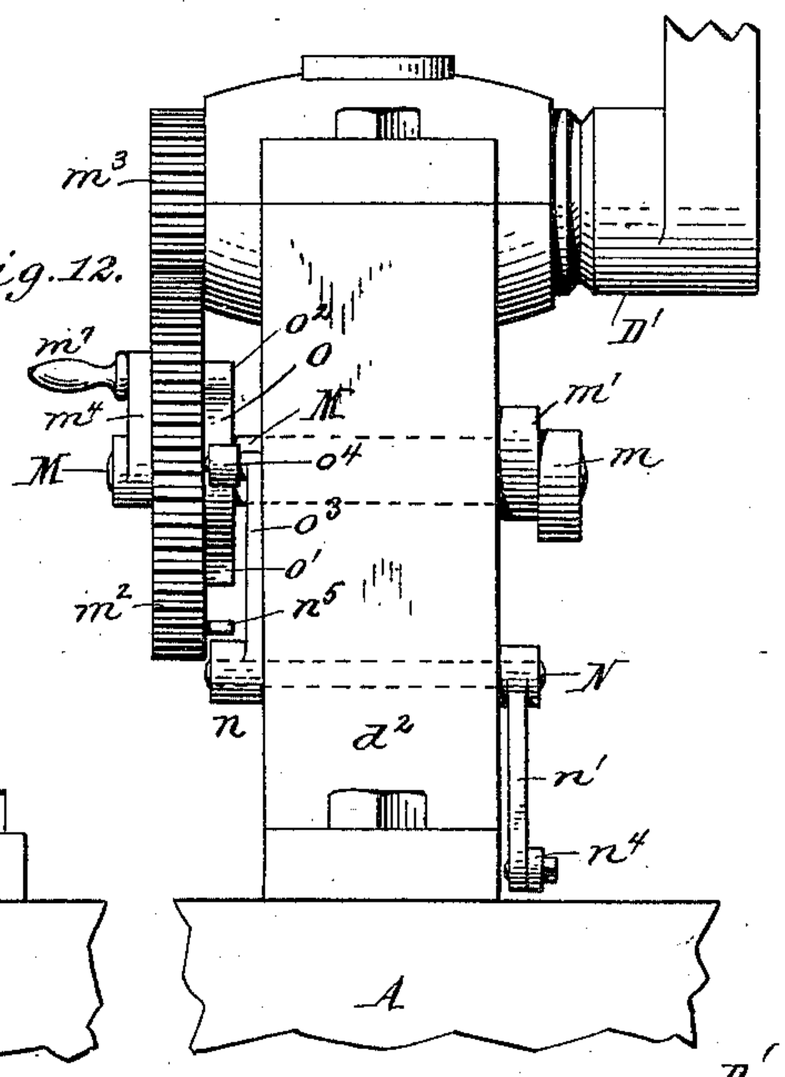


Fig. 13.

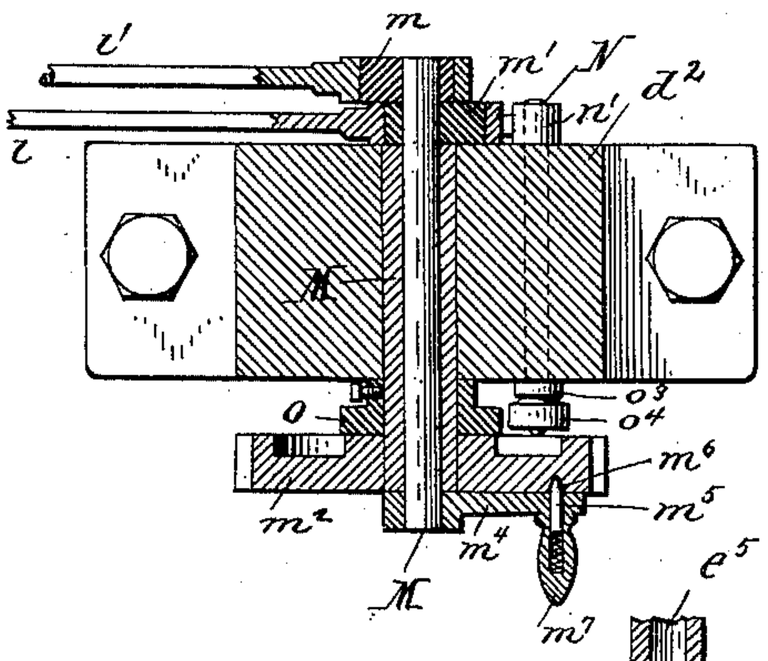


Fig. 14.

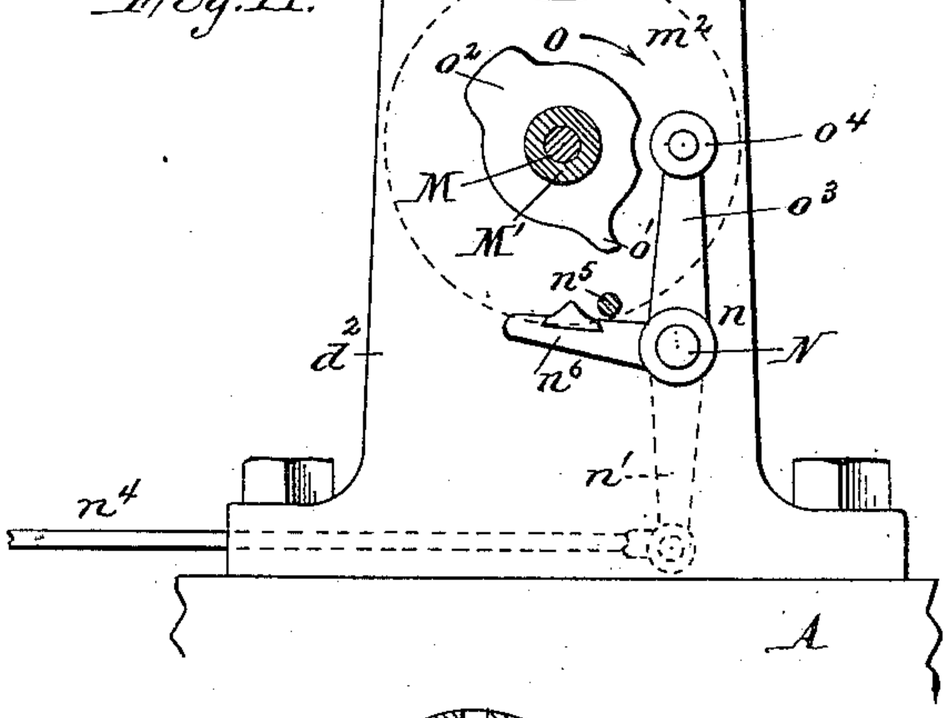
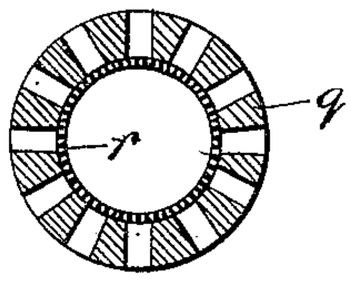


Fig. 15.

Fig. 16.



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UNITED STATES PATENT OFFICE.

GEORGE B. BRAYTON, OF BOSTON, MASSACHUSETTS.

HYDROCARBON-ENGINE.

SPECIFICATION forming part of Letters Patent No. 432,260, dated July 15, 1890.

Application filed January 16, 1890. Serial No. 337,141. (No model.)

To all whom it may concern:

Be it known that I, GEORGE B. BRAYTON, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Hydrocarbon-Engines, of which the following is a specification.

This invention relates to that class of engines which derive their power from the expansion produced by the combustion of sprayed or atomized hydrocarbon in the cylinder.

The objects of this invention are to insure an abundant supply of air to support combustion in the cylinder with the least expenditure of power; also, to provide means whereby the liquid fuel is delivered into the combustion-chamber in a finely-divided state most favorable to quick combustion; also, to provide novel means for regulating the speed of the engine by automatically varying the amount of liquid fuel which is fed to the combustion-chamber; also, to construct an incandescent burner which will instantly ignite the combustible mixture which is injected into the combustion-chamber; also, to improve the engine in various other respects, as will be hereinafter more fully described, and pointed out in the claims.

In the accompanying drawings, consisting of four sheets, Figure 1 is a longitudinal sectional elevation of my improved engine. Fig. 2 is a top plan view of the same. Fig. 3 is a fragmentary sectional elevation of the cylinder, combustion-chamber, burner, and valve mechanism, on an enlarged scale. Fig. 4 is a side elevation of the gate whereby access may be had to the interior of the cylinder for lighting the burner. Fig. 5 is a horizontal section in line $x\ x$, Fig. 3, showing the spraying device on an enlarged scale. Fig. 6 is a vertical section of the burner, on an enlarged scale, in line $y\ y$, Fig. 3. Fig. 7 is a sectional elevation of the governor which controls the oil-pump, on an enlarged scale. Fig. 8 is a horizontal section of the lower portion of the governor and of the oil-pump. Fig. 9 is a vertical cross-section of the oil-pump in line $w\ w$, Fig. 7. Fig. 10 is a sectional elevation of the safety-valve whereby an excessive pressure of air is relieved. Fig. 11 is a side elevation of the standard supporting the crank-shaft and gearing for operating the oil-pump and valves. Fig. 12 is a rear elevation of the same. Fig. 13 is a horizontal section of said standard in line $z\ z$, Fig. 11. Fig. 14 is a side elevation of the standard with gearing removed. Fig. 15 is a vertical section showing a modified construction of the spray-nozzle. Fig. 16 is a horizontal section of the same, on an enlarged scale, in line $x\ x$, Fig. 15.

Like letters of reference refer to like parts in the several figures.

A represents a hollow rectangular base, upon the front end of which is mounted a vertical cylinder B, provided with a piston b. The cylinder B is provided at its upper end with a jacketed head C, while its lower end is open and communicates with the interior of the hollow base. The upper end of the cylinder B extends about one-half of its diameter above the range of the upward stroke of the piston b, thereby forming a compression and combustion chamber B′, in which the explosive material is ignited. The piston b is of the cup-shaped pattern and provided centrally with an automatic self-opening valve b', which is closed when the piston is forced downwardly by the expansion of the gases in the combustion-chamber, but opens inwardly at every alternate downward stroke of the piston for the admission of air, which is compressed on the upward stroke of the piston, and supplies the necessary oxygen preparatory to another explosion. The valve b' consists of a disk, which closes an annular series of openings b^2, formed in a plate b^3, which is screwed into the piston-head. This valve is normally held on its seat by a spring b^4, surrounding the valve-stem b^5 and bearing with its ends against the plate b^3, and a collar b^6, attached to the lower end of the valve-stem.

D represents a walking-beam arranged inside of the hollow base and mounted on a rock-shaft d. This beam is connected at its front end with the piston b by means of a connecting-rod d'.

D′ represents a crank-shaft journaled in standards d^2 d^3, secured to the upper rear end of the base. The crank-shaft is provided on one side with a balance-wheel D^2, and is connected with the rear end of the beam D by a connecting-rod d^4, passing through an opening d^5 in the base. This opening also serves

to admit air into the base for supplying the combustion-chamber with oxygen.

E represents a cylindrical valve-casing fitted snugly in a correspondingly-shaped opening in the cylinder-head C. This casing contains the valve for controlling the oil and air passage which supplies the combustible fluid to the combustion-chamber B′, and also contains the exhaust-valve controlling the exhaust-ports through which the products of combustion are discharged.

e represents the supply-pipe for the compressed air, and *e′* is the oil-supply pipe, both of which enter the head e^2 of the valve-casing at its side and communicate with a central receiving-chamber e^3, formed in the head of the valve-casing, the oil-pipe being arranged near the bottom of the receiving-chamber and the air-pipe near the top thereof. The receiving-chamber e^3 is closed at its upper end by a head e^4, provided with a stuffing-box, and communicates at its bottom with a passage e^5, formed in a stem e^6, depending centrally from the head e^2.

f represents the oil and air induction valve arranged in the receiving-chamber e^3 and seated in the tapering bottom of the latter, so as to close the passage e^5. The valve *f* is held on its seat by a spring *f′*, surrounding the upwardly-extending valve-rod f^2 and bearing with its ends against the induction-valve and the head e^4. The valve-rod passes upwardly through the stuffing-box of the head e^4, and is provided at its upper end with a thumb-nut f^3, which bears on the upper side of a rock-lever F, pivoted to the standard f^4. The induction-valve *f* is raised from its seat at regular intervals by this lever, to allow the oil and compressed air to pass from the receiving-chamber into the passage e^5.

e^7 represents a tube secured to the lower end of the hollow stem e^6 and forming an extension of the passage e^5. The lower end of the tube e^7 is provided with a deflecting-cup e^8, which is arranged slightly below the open end of the tube and provided between the latter and its upturned marginal flange with a cover e^9, of finely-perforated sheet metal or wire-gauze. The cup receives the oil and air from the passage e^5 and tube e^7 and deflects the mixture upwardly, while the gauze cover divides the mixture into a finely-divided spray, which is the most favorable condition for instantaneous ignition and combustion.

G represents a burner secured to the side of the cylinder and arranged in the combustion-chamber directly in the path of the upwardly-sprayed oil, so as to ignite the same instantly.

e^{10} represents a concave disk about half the diameter of the cylinder and secured to the tube e^7 at its point of junction with the hollow stem e^6. This disk, which becomes intensely heated by the combustion of the successive charges in the combustion-chamber, intercepts any particles of the upwardly-sprayed fuel which may escape ignition, and instantly converts them into vapor and causes them to be consumed with the rest of the charge.

H represents the circular exhaust-valve, provided with an upwardly-extending sleeve *h*, which surrounds the valve-stem e^6 and is capable of vertical movement thereon. The peripheral face of the exhaust-valve tapers upwardly and fits a correspondingly-shaped seat *h′*, formed at the lower end of the valve-casing. The interior cavity of this valve-casing, whose lower end is closed by the exhaust-valve, forms an exhaust-chamber h^2.

h^3 represents an exhaust-passage surrounding the valve-casing on the inside of the water-jacket of the cylinder-head, and h^4 are ports formed in the sides of the valve-casing, so as to establish communication between the exhaust-chamber and the exhaust-passage.

The cylinder B and its head C are both provided with water-jackets *c c′*, to avoid excessive heating. The cylindrical body of the valve-casing extends through the water-jacket of the cylinder-head, and is secured thereon by bolts *e″*.

h^5 represents two rods whereby the exhaust-valve is actuated, and which pass vertically through openings in the head of the valve-casing and engage with their lower hooked ends in an annular groove h^6, formed in the sleeve *h*. The rods h^5 are connected at their upper ends by a bar h^7, which bears against the lower side of the rock-lever F, and by which the rods are lowered and the exhaust-valve is opened. The latter is held on its seat by means of springs h^8, which surround the rods h^5 and bear with their ends against the cross-bar h^7 and the head of the valve-casing. The exhaust-valve is opened periodically by the descent of the lever F, and allows the products of combustion after each explosion to be discharged into the exhaust-chamber, thence into the exhaust-passage through the ports h^4, and thence into an exhaust-pipe h^9.

The induction-valve and exhaust-valve are actuated alternately by the rock-lever F. In the position shown in Fig. 3 the lever F is in its normal position, in which position both the induction and exhaust valves are closed. For the purpose of admitting the liquid fuel to the combustion-chamber, the rock-lever is quickly raised above its normal position and returned to the same. This movement of the rock-lever opens the induction-valve momentarily and causes a quantity of liquid fuel to be delivered into the combustion-chamber by a gust of compressed air. For the purpose of exhausting the products of combustion, the rock-lever is lowered beyond its normal position, whereby the exhaust-valve is opened.

The burner G for igniting the charges of sprayed fuel is arranged horizontally in the combustion-chamber and secured to the cylinder by means of a tube *g*, which supplies oil and air to the burner. The tube *g* is screwed into the end of a plug *g′*, which is

held by friction in a bushing g^2, that extends from the outer jacket c to the inside of the cylinder. The burner consists of a hollow shell divided into front and rear chambers g^3 g^4 by a perforated disk g^5, which is held in place by screwing both parts of the shell together. The rear portion of the burner-shell is provided with a screw-threaded socket, which is screwed upon the end of the oil-supply tube g and communicates by an aperture g^6 with the tube g. The rear chamber is closely packed with asbestus or other non-combustible material, which absorbs the oil. The front chamber g^3 is open and contains the incandescent medium g^7, preferably platinum wire, which is coiled and arranged loosely, so as to fill the front chamber g^3, the coiled platinum being retained therein by an inwardly-projecting annular flange g^8. The plug g' is provided with an axial passage g^9 in line with the tube g, and projects a short distance beyond the side of the cylinder-jacket.

I represents an oil-fountain, which contains the oil by which the burner G is fed.

i represents a wick of any suitable absorbent material secured with one end to the enlarged outer portion of the passage g^9, which opens into the upper portion of the oil-cup.

i' represents a branch passage formed in the plug g' parallel with the main passage g^9. This branch passage is elbow-shaped, and opens at its outer end into the upper portion of the oil-cup, while its inner end opens into the main passage on the inner side of the enlargement of the latter, in which the wick is arranged.

i^2 represents a needle-valve arranged in the branch passage i', and by which the amount of air necessary to maintain a flame in the burner can be regulated.

i^3 represents an air-supply pipe, which connects with the lower end of the oil-fountain, and is provided with a cock i^4, by which the air-supply is regulated.

i^5 represents a vertical tube secured centrally in the oil-cup and extending above the surface of the oil in the same. The tube i^5 is open at its upper end, and provided near the bottom of the oil-cup with openings i^6, which allow the surrounding oil to enter the tube.

i^7 represents a jet-pipe secured to the cock i^4 and arranged within the tube i^5, thereby forming a contracted extension of the air-supply pipe i^3. The jet-pipe extends a short distance above the oil-openings i^6 in the outer tube i^5. The compressed air issuing from the jet-pipe causes the oil in the surrounding tube to be carried upwardly and to be discharged from the upper end of the tube i^5 in the form a spray.

The wick in the plug g' is arranged to hang over the upper end of the spray-tube, and the effect of the air-current is to cause a constant spurting of the oil against the bottom of the wick, thereby providing for a certain supply of oil-moisture in the wick at all times.

It is immaterial whether the cup is full of oil or not, as the surplus oil which is not absorbed by the wick drops back into the body of the oil and enters the openings in the spray-tube, thereby maintaining a continuous circulation of oil through the injector and oil-cup. The particles of oil absorbed by the wick are deposited in the main passage leading to the burner, while the air issuing from the spray-tube enters first the branch passage and then the main passage, and carries the oil deposited therein forward to the burner, where it is absorbed by the asbestus packing of the burner.

The platinum in the front chamber, when heated, transmits its heat through the perforated disk to the asbestus and vaporizes the oil which is absorbed by the asbestus in the rear chamber. The air which passes through the burner conveys this vapor through the platinum, where the vapor becomes ignited and forms a flame, which issues from the front chamber of the burner into the combustion-chamber. The air passing through the burner supplies this flame with oxygen, and the constant supply of air and oil to the burner maintains the flame constantly.

The upper portion I' of the chamber I, in which the wick is arranged, is preferably contracted to limit the lateral movement of the wick as it is tossed about by the jet of oil and air and prevent it from escaping the spray of oil. Oil is supplied to the fountain, when necessary, through an opening which is closed by a thumb-screw i^8.

J represents a small condensing air-pump which supplies air under pressure for atomizing the liquid-fuel charges and forcing them into the combustion-chamber. This air-pump also supplies the jet of air for feeding the oil-wick in the fountain and the necessary oxygen for sustaining combustion in the burner. This air-pump is arranged upon the base between the cylinder and the crank-shaft, and has its delivery-pipe j connected with the air-pipe e, for atomizing the liquid fuel, and with the air-pipe i^3 of the oil-fountain. The air-pump cylinder is provided with a piston j', which is reciprocated from the walking-beam D by a pitman j^2 and provided with an air-inlet valve. The surplus air compressed by the air-pump is discharged into a storage-reservoir j^3, preferably located in the base of the engine and connected with the delivery-pipe j of the air-pump by a branch pipe j^4.

j^5 represents a safety-valve, which is connected with the air-pipes and prevents the air-pressure from becoming excessive. It consists, preferably, of a puppet-valve arranged in a casing j^6 and held in its seat by a bow-spring j^7, engaging with its free ends under an annular flange j^8, and bearing on the valve by means of an adjusting-screw j^9, which enables the pressure to be regulated.

K represents the oil-pump which injects the charges of oil consumed in the combus-

tion-chamber. The oil-pump is provided with the usual plunger K′ and slide-valve K², which insures a positive supply of oil to the receiving-chamber e^3. The latter is connected with the valve-chamber of the pump by the supply-pipe e'. The oil-pump is secured to a standard L, which also serves to support the governor for regulating the supply of oil. The valve and plunger of the oil-pump are actuated by eccentrics m m', mounted on the inner end of a short shaft M, journaled in the standard d^2 of the crank-shaft and connected with the plunger and valve by rods l l'. The rod l', actuating the slide-valve, is rigidly connected with its eccentric; but the rod l, which actuates the plunger K′, is jointed and capable of being automatically lengthened or shortened in order to vary the stroke of the plunger in accordance with the supply of oil demanded for maintaining a uniform speed. The inner end of the plunger-rod l is arranged between the jaws of the bifurcated outer end of the plunger K′, and held loosely therein by a transverse pin K³, which engages in a longitudinal slot K⁴ in the rod l, so as to permit a limited longitudinal movement of the rod l on the pin.

l^2 represents a wedge interposed between the bifurcated end of the plunger and the rear end of the rod l. This wedge is raised and lowered by the centrifugal governor L², the balls of which actuate a vertical rod l^3, engaging with its lower end with a rock-lever l^4, pivoted to the side of the standard L. The outer end of the rock-lever l^4 is connected with the wedge l^2 by a link l^5. The governor is provided with a pulley l^6, which is driven from the crank-shaft by a belt l^7. When the speed of the engine is below the normal, the spindle of the governor will be raised by the spring l^8, which causes the wedge to be depressed and to take up the lost motion between the plunger and the plunger-rod. This prevents the rod from moving lengthwise on the pin and enables the plunger to effect a complete stroke. When the speed of the engine increases above the normal, the wedge is raised by the action of the governor-balls and permits the connecting-rod l to move lengthwise on the pin to a greater or less extent without actuating the plunger, thereby reducing the amount of oil supplied to the combustion-chamber. The amount of lost motion is regulated at all times by the rise or fall of the wedge l^2, thereby regulating the amount of liquid fuel necessary to maintain a uniform speed of the engine.

l^9 represents a pipe which supplies oil to the pump K from any suitable source, and connects with the inlet-port of the pump, communicating with the slide-valve chamber. The cylinder of the pump is alternately placed in communication with the inlet-port and the valve-chamber by the slide-valve in a well-known manner. When the cylinder is placed in communication with the valve-chamber, the plunger forces a jet of oil through the pipe e, leading from the valve-chamber to the receiving-chamber e^3.

The shaft M of the oil-pump is arranged in a sleeve M′, provided on its outer end with a gear-wheel m^2, which meshes with a gear-wheel m^3, mounted on the end of the crank-shaft.

m^4 represents a crank secured to the outer end of the shaft M, and provided in its end with a spring-bolt m^5, which engages in a recess m^6, formed in the adjacent gear-wheel m^2, thereby locking the shaft M and sleeve M′ together and compelling them to rotate in unison. The crank m^4 can be disengaged from the gear-wheel m^2 by giving the handle m^7 of the crank a quick rotary movement, which releases the spring-bolt from the recess m^6, owing to its tapering end, and allows the oil-pump to be operated by hand, independent of the remaining parts of the engine, in order to inject the first charge of oil into the receiving-chamber for starting the engine. The gear-wheel m^3 is half the size of the gear-wheel m^2, so that the latter will make half the number of revolutions of the former, and consequently actuate the oil-pump so as to inject a charge of oil into the receiving-chamber e^3 at every alternate revolution of the crank-shaft.

N represents a short rock-shaft journaled in the standard d^2 of the crank-shaft, and provided on its front end with an elbow-lever n and on its rear end with a depending arm n'. The depending arm connects with the rock-lever F by an intermediate bell-crank n^2, supported on the governor-standard L and connected, respectively, with the rock-lever and depending arm by a vertical rod n^3 and a horizontal rod n^4.

The gear-wheel m^2 is provided on its inner side with a horizontal pin n^5, which is adapted to strike the lower arm n^6 of the elbow-lever and depress the same at every revolution. When the arm n^6 is depressed, it moves the depending arm outwardly and raises the rock-lever F above its normal position by means of the intermediate bell-crank n^2 and connecting-rods, and thereby opens the induction-valve.

O represents a cam mounted on the sleeve M′ between the standard d^2 and gear-wheel m^2. This cam is provided with a short projection o' and a long projection o^2, which engage alternately with the upper arm o^3 of the elbow-lever and force the same outwardly. When the projections o' o^2 engage against the roller o^4 on the end of the arm o^3 and force the latter outwardly, the depending arm n' is moved inwardly. This movement of the latter depresses the rock-lever F below its normal position by means of the intermediate bell-crank and opens the exhaust-valve. The rock-lever F is alternately moved above and below its normal position by the horizontal pin and cam, which oscillate the elbow-lever connected with the rock-lever by the intermediate devices and alternately open and

close the induction and exhaust valves. When the short projection o' of the cam strikes the elbow-lever, the latter opens the exhaust-valve and holds it open during about one-half of the upward stroke of the piston, so as to permit about one-half of the amount of air to escape through the exhaust before compression in the cylinder takes place. When the piston terminates its upward stroke, the pin n^5 strikes the lower arm of the elbow-lever, which opens the induction-valve and injects a spray of oil by air-pressure into the combustion-chamber. The expansion resulting from the combustion forces the piston downwardly. When the return upward stroke of the piston begins, the long projection o^2 of the cam strikes the elbow-lever and opens the exhaust-valve and holds it open during the entire upward stroke of the piston, whereby the products of combustion are allowed to be discharged from the cylinder.

P represents a port formed in the side of the cylinder diametrically opposite the burner, through which access is afforded for lighting the burner when it is desired to start the engine. The port is formed of a cylindrical bushing, which extends through the water-jacket to the cylinder. The bushing is screw-threaded at its inner end and engages with a screw-thread in the cylinder, while its outer end is provided with a flange p, which bears against the water-jacket.

p' represents a gate adapted to slide over the port P, so as to open or close the same. The gate is of circular form and seated loosely in a socket p^2, formed in a hand-lever p^3. The hand-lever is pivoted on one side of the port to an extension p^4 on the flange p by a nut and bolt, which also permit the gate to be tightened.

p^5 is a stop secured to the lower side of the flange p, which limits the downward movement of the gate.

p^6 represents a glass disk secured in a central opening p^7 of the gate by means of a hollow screw-thimble p^8. This glass disk enables the flashes to be distinctly seen in the combustion-chamber, and also permits the condition of the incandescent burner to be determined.

The burner G is lighted by a torch of asbestus soaked with oil or alcohol, and which is introduced through the port P and held under the burner until the coil of platinum has become thoroughly heated. The gate is then closed and a preliminary charge of oil is injected into the combustion-chamber for the purpose of propelling the engine through the first cycle. This preliminary supply of oil is supplied by disengaging the crank m^4 from the adjacent gear-wheel m^2 and rotating the same by hand, whereby the first charge of oil necessary is supplied for injection into the combustion-chamber. The first downward and upward movement of the piston must be effected by turning the fly-wheel by hand in order to compress the first charge of air in the combustion-chamber, or compressed air for starting may be supplied from a reservoir. After the engine has been started, the operation through one cycle is as follows: When the spray of oil has been injected into the charge of compressed air contained in the combustion-chamber and the combustible mixture has been ignited, the expansion in the combustion-chamber forces the piston downwardly. During its returning upward stroke the exhaust-valve opens and allows the gases resulting from the combustion to escape. As the piston propelled by the momentum of the balance-wheel again descends during the next non-firing stroke, the central air-inlet valve of the piston opens automatically and allows the fresh air to enter the cylinder. During the first part of the return upward stroke after the non-firing downward stroke the exhaust-valve is again opened, so that any part of the gaseous products of combustion which remains in the upper part of the cylinder is discharged from the top of the cylinder with the excess of air. The exhaust-valve is then closed and the fresh air confined in the cylinder is compressed by the piston while it completes the last half of its upward stroke. At the same instant that the piston terminates its upward stroke the induction-valve is quickly opened and closed, whereby the compressed air contained in the receiving-chamber in the head of the valve-chamber drives the charge of oil out of the receiving-chamber and down the central passage into the cup at the lower end thereof and upwardly through the perforated plate, covering said cup in a finely-divided spray into the combustion-chamber, where it is instantly ignited and exploded. This is done so quickly and effectually that the ignition and full expansion are effected at the very commencement of the downstroke. The charges of oil may be delivered to the receiving-chamber at any convenient time during the period in which the induction-valve remains closed, so that when the latter is opened and closed by a quick movement the force of the blast or gust of compressed air drives the oil all out of the chamber and into the combustion-chamber in a finely-divided spray most suitable for instantaneous combustion. The piston alternately reciprocates with a firing and non-firing stroke. The incandescent burner in the combustion-chamber is burning at all times; but no explosion can take place until the charge of atomized fuel is driven into the combustion-chamber. By injecting the oil charges in an atomized condition into a body of compressed air in this manner an excess of oxygen is present above what is necessary to burn the entire oil charge, which insures complete combustion. Much advantage is gained by arranging the oil-discharge nozzle in the center of the cylinder, as it affords a protection from the cooling effect of the side of the cylinder, which is surrounded by the water-jacket. By locating the valve for the

admission of fresh air in the piston the fresh cool air, owing to its greater specific gravity, remains at the bottom of the cylinder immediately over the piston, while the hot gaseous products of combustion remain in the upper portion of the cylinder and in the combustion-chamber and are first to be discharged on opening the exhaust-valve. A further advantage is gained by arranging the air-inlet valve in the piston, as it opens readily inwardly during the non-firing downward stroke of the piston and offers little resistance to the latter, thereby supplying a sufficient quantity of fresh air with the least expenditure of power. The automatic air-valve also opens when there is a partial vacuum in the combustion-chamber, so as to relieve the piston from any back-pressure due to a light charge of sprayed oil. The central arrangement of the exhaust-valve affords a free escape for the products of combustion, which is important, as an admixture of the same with the air would materially impair the energy of the engine by reason of an imperfect combustion. Any leakage of gases through and around the piston escapes into the base of the engine, and a decided advantage is gained in ventilation by drawing the fresh-air supply for the combustion-chamber from the base of the engine, thereby avoiding any unpleasant odors resulting from leakage. By constructing the incandescent burner of platinum and asbestus or other substance capable of being highly heated it will wear a long time without injury from the inflammable charges.

The products of combustion generated by the burner are very small in volume, so that they have no appreciable effect upon the force of the expanding charges, and as no ignition can take place until the charge of atomized oil enters the combustion-chamber, there is no necessity for withdrawing the burner from the combustion-chamber after ignition, as is usual in explosive-gas engines, and thus much complication is avoided.

In the modified construction of the spray-nozzle represented in Figs. 15 and 16 the nozzle is composed of a steel cylinder *q*, provided with radial perforations, and secured to the lower end of the hollow depending stem e^7. The interior of the cylinder is lined with finely-perforated sheet metal *r*. The perforations in the outer cylinder are comparatively large, while those of the lining are very fine and divide the oil more minutely as it is forced through the same by the blast of air. By this means the finely-perforated sheet metal is protected from the combustion in the combustion-chamber by the enveloping thick-steel cylinder, while the latter serves as a firm support for the sheet metal. This spray-nozzle delivers the oil radially into the combustion-chamber all around the nozzle in jets of very fine spray. Each of the large openings in the enveloping cylinder emits a separate jet composed of numerous fine jets, and, the several jets being separated by air-spaces, a very effective combustion is obtained.

I do not wish to claim anything in this application which is claimed in my pending application, Serial No. 333,846, filed December 14, 1889.

I claim as my invention—

1. The combination, with the engine-cylinder, its piston, and an air-inlet through which air is admitted to the cylinder, of an oil-receiving chamber having an outlet into the engine-cylinder, a conduit through which compressed air is admitted to said chamber, a conduit through which oil is admitted to said chamber, and a discharge-valve applied to said chamber, whereby the charge of oil is blown out of said chamber and delivered into the cylinder by the compressed air upon opening the valve, substantially as set forth.

2. The combination, with the engine-cylinder having an air-inlet and valve, and a piston which moves forward while said inlet is open and rearward after it is closed for compressing the admitted air, of a spray-pipe arranged within the cylinder, an oil-receiving chamber communicating with said spray-pipe, an oil-pump which feeds oil to said chamber, a conduit through which compressed air is supplied to said chamber, and a valve which is opened for permitting the compressed air to drive the oil from said chamber through the spray-pipe into the cylinder, substantially as set forth.

3. The combination, with the engine-cylinder, its piston, and an air-inlet and valve which is opened during the forward stroke of the piston for admitting the air and closed during the return-stroke for compressing the air, of a burner arranged within the cylinder, an oil-receiving chamber provided with a discharge-valve and with a spray-pipe terminating near the burner, an air-compressor communicating with said chamber, an oil-pump connected with said chamber, and an automatic regulator whereby variable charges of oil are fed to said chamber, substantially as set forth.

4. The combination, with the engine-cylinder, its piston, and an air-inlet and valve, of a burner arranged within the cylinder, a chamber having a spray-pipe terminating near the burner, an oil-pump and an air-pump feeding oil and compressed air to said chamber, and a valve whereby the discharge of oil from said chamber is controlled, substantially as set forth.

5. The combination, with the engine-cylinder, its piston, and the air-inlet and valve, which is open during the forward stroke of the piston for admitting the air and closed during the return-stroke for compressing the air, of a burner arranged within the combustion-chamber of the cylinder, a receiving-chamber provided with a spray-nozzle within the combustion-chamber, and oil and air conduits through which oil and air are supplied to said chamber, substantially as set forth.

6. The combination, with the engine-cylinder open at one end, of a piston provided with an air-inlet valve, a burner arranged within the cylinder near the closed end thereof, a receiving-chamber arranged at the closed end of the cylinder and having a spray-nozzle within the cylinder near the burner, conduits for oil and compressed air entering said chamber, and a valve which is opened at intervals for discharging the oil from said chamber, substantially as set forth.

7. The combination, with the engine-cylinder provided at one end with an oil-receiving chamber and a spray-pipe extending from said chamber into the cylinder, of an exhaust-passage through which said spray-pipe extends, and an exhaust-valve which is seated in said passage and which surrounds said spray-pipe, substantially as set forth.

8. The combination, with the engine-cylinder provided at one end with an oil-receiving chamber and having a spray-pipe extending into the cylinder, of an exhaust-passage in which said spray-pipe is arranged, an exhaust-valve surrounding said spray-pipe and seated in said passage, a discharge-valve arranged in the oil-receiving chamber, and an actuating-lever connected with both valves, substantially as set forth.

9. The combination, with the engine-cylinder and the burner arranged therein, of an oil-supply pipe extending into the cylinder and provided on one side of the burner with a spray-nozzle and on the opposite side of said burner with a vaporizing-shield, substantially as set forth.

10. The combination, with the hollow base provided with an unobstructed opening, through which the external air can freely enter said base, of an engine-cylinder connected with its open end to said base, a piston provided with an air-inlet and valve, through which air is taken from the hollow base into the cylinder, an oil-supply conduit and valve arranged at the upper end of the cylinder, and a burner arranged within the cylinder, whereby the open base is ventilated into the engine-cylinder, substantially as set forth.

11. The combination, with the engine-cylinder provided with a fuel-supply valve and an exhaust-valve, of an actuating-lever connected with both valves and a rotating cam and pin, whereby said lever is moved three times in succession for every two revolutions of the engine-shaft, the first movement opening the exhaust-valve partly and discharging the surplus air, the next movement opening the fuel-supply valve, and the last movement opening the exhaust-valve for discharging the products of combustion, substantially as set forth.

12. A burner composed of a shell provided with an oil and air supply, an absorbent packing arranged in said shell, a perforated plate for holding said packing in place, and an incandescent medium for preserving the flame, substantially as set forth.

13. The combination, with the burner and the passage through which oil is supplied thereto, of a wick arranged in said passage and an air-jet device, whereby a spray of oil is delivered on said wick, substantially as set forth.

14. The combination, with the burner and the passage through which oil is supplied thereto, of a wick arranged in said passage, an oil-reservoir, and a blast-pipe arranged in said reservoir and provided with inlets through which the oil enters said pipe, substantially as set forth.

15. The combination, with the burner and the passage through which oil is supplied thereto, of an oil-reservoir communicating at its upper end with said passage, a wick arranged at the upper end of said reservoir and entering said passage, a branch passage whereby air is conducted from the upper portion of said reservoir past the wick into the passage leading to the burner, and a blast-pipe arranged in the lower portion of the reservoir and provided with inlets for the oil, substantially as set forth.

Witness my hand this 1st day of January, 1890.

GEORGE B. BRAYTON.

Witnesses:
CHAS. C. KURTZ,
ALBERT G. HALL.